

**Harnessing Micro-Topics Arranged in Learning Pathways for Spaced Retrieval, Reading,
and Collaborative Note-taking**

by

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DEDICATION

This dissertation is affectionately dedicated to my parents, Lily and Daryoush, whose unwavering support and unconditional love have been the bedrock of my journey. From the earliest days of my childhood, they instilled in me the values of hard work, perseverance, and the relentless pursuit of knowledge. Their sacrifices, often silent and unnoticed, laid the foundation upon which I built my dreams. They have been my steadfast companions through every challenge and triumph, offering wisdom, encouragement, and comfort. Their belief in me, even in moments when I doubted myself, has been a source of endless motivation.

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ABSTRACT

This dissertation explores the utilization of a Knowledge Graph of “Micro-topics” arranged into “Learning Pathways” (KGMLP) through three learning activities: spaced retrieval, reading, and collaborative note-taking. The objective is to enhance four (out of six) levels of Bloom’s digital taxonomy of cognitive processes: remembering, understanding, analyzing, and evaluating.

The research initiates with the introduction of a novel spaced retrieval practice tool, crafted to synchronize with a course’s existing knowledge graph. Chapter 2 unveils a two-fold study; firstly, it examines the correlation between students’ engagement with this tool and their academic performance, revealing significant improvements in exam scores. Secondly, it scrutinizes the “counting days” incentive scheme, designed to encourage consistent tool usage. Through a semester-long randomized controlled trial (RCT) within a class and a separate RCT involving 71 instructors, findings demonstrate the efficacy of this mechanism in enhancing students’ motivation for spaced retrieval, which subsequently leads to improved academic outcomes, particularly notable in students with lower GPAs.

Chapter 3 transitions to the structural representation of KGMLP, debating whether to emphasize the visualization of relationships between entire paragraphs or to dissect paragraphs into shorter phrases for detailed relational visualization. A meticulously conducted experiment with 419 participants showcases the superior efficacy of KGMLP formats that encapsulate entire paragraphs, outperforming traditional Novakian concept maps in enhancing both factual and inferential comprehension and recall capabilities, immediately, as well as in subsequent evaluations conducted three days and a week later. Feedback analysis indicates a strong preference for visual connections between complete paragraphs, with an emphasis on having all content accessible on a single page.

Chapter 4 explores the creation and refinement of KGMLPs within a collaborative framework. The introduction of “1Cademy,” a pioneering platform, marks a significant stride in enabling social learning through collaborative note-taking over extended periods. This chapter addresses the challenges inherent in such collaborative environments, including motivating student engagement in peer content refinement and consensus building in micro-topics and learning pathways. Four distinct design elements are put forward and empirically tested: a proposal system for content modification with a voting-based approval process, a mandatory inclusion of a learning pathway in new node proposals, and a novel community-specific contribution scoring system. Through an

extensive longitudinal study and field trials, the research demonstrates the adaptability of students to these design features, ensuring effective collaboration without the fragmentation or privatization of the knowledge graph. 1Cademy has successfully engaged 1,754 students and researchers from 208 institutions since its inception four years ago, resulting in a comprehensive KGMLP consisting of 50,947 nodes and 271,836 proposals.

This dissertation presents a multifaceted exploration of KGMLP in educational contexts, highlighting its potential to enhance key cognitive processes and foster a collaborative learning environment. The studies and results within offer significant insights into the effective integration and application of KGMLP in modern educational settings.

CHAPTER 1

Introduction

And this our life, exempt from public
haunt, finds tongues in trees, books in the
running brooks, sermons in stones, and
good in everything. I would not change it.

William Shakespeare, As You Like It

In the dynamic sphere of education, traditional methods of delivering extensive, static content are increasingly being reconsidered. The emergence of “micro-topics” marks a significant shift, providing a more palatable, concentrated, and adaptable method of learning. These micro-topics, which are concise knowledge units, allow learners to interact with content in brief, manageable portions. This aligns with the working memory’s capacity and enhances attention and retention. For instance, instead of covering a broad topic like “The History of World War II” in a single lengthy session, a micro-topic approach would break this down into smaller segments such as “The Most Important Event of 1941 in World War II” or “The Impact of Pearl Harbor on U.S. Involvement.” This granularity in learning content not only fosters active engagement but also mitigates cognitive overload, paving the way for personalized learning experiences. These experiences are tailored to meet individual needs and learning speeds, ensuring that each learner can absorb and understand the material at their own pace.

However, the efficacy of micro-topics hinges not only on their size but also on their organization into coherent “learning pathways.” Without structured pathways, learners may find themselves navigating through a disjointed assemblage of information, akin to a deck of flashcards, which lacks context and coherence. The absence of a structured learning trajectory can lead to fragmented knowledge, where learners struggle to connect discrete concepts and fail to develop a comprehensive understanding of the subject matter. Learning pathways provide the necessary scaffolding, guiding learners through a sequence of micro-topics that build upon each other, thereby facilitating the construction of a well-organized and interconnected knowledge base.

The motivation for this dissertation is rooted in the recognition of the potential of micro-topics

to revolutionize learning and the critical need to structure these micro-topics into effective learning pathways. This dissertation proposes and examines the utilization of a Knowledge Graph of Micro-topics arranged into Learning Pathways (KGMLP) to support three learning activities that lead to four (out of six) cognitive processes in Bloom’s digital taxonomy (8): “remembering,” “understanding,” “analyzing,” and “evaluating.”

- Chapter 2 delves into “spaced retrieval,” where the KGMLP of a course syllabus is leveraged to promote spaced retrieval practice, thereby enhancing “remembering.”
- Chapter 3 focuses on “reading,” where the representation of a KGMLP can augment “remembering,” “understanding,” and “analyzing.”
- Chapter 4 discusses “collaborative note-taking,” where the discovery and linking of learning pathways before creating any new micro-topic nodes can enhance “understanding” and “analyzing.” Also, a need to coordinate on a single communal version of each micro-topic node engages students in “evaluation” of peers’ work.

In my future research, I hope to also target the other two cognitive processes in Bloom’s digital taxonomy: “applying” and “creating.”

Bloom’s Digital Taxonomy (BDT) and Bloom’s Taxonomy are distinct yet complementary frameworks used in education for developing learning objectives and activities. BDT, an adaptation of the original taxonomy for the digital age, integrates technology into education, focusing on the use of digital tools and skills. This modern taxonomy includes digital verbs such as editing, creating, sharing, and interacting, which are central to digital activities. It emphasizes the navigation through a vast array of digital tools to enhance learning experiences. The adaptation helps teachers shift the focus from teacher-centered to student-centered activities, encouraging the development of both lower- and higher-order thinking skills using digital tools. This approach aligns with today’s technological advancements and the need for students and teachers to be proficient in using digital tools for effective academic outcomes (8).

On the other hand, the original Bloom’s Taxonomy, a widely recognized educational framework, categorizes cognitive skills into hierarchical levels ranging from basic knowledge to higher-order thinking skills like evaluation and creation. The revised version of this taxonomy, updated by Anderson and Krathwohl, further refines these categories and provides a more dynamic model of classifying educational objectives and activities. The revised taxonomy is still highly relevant in traditional learning environments and forms the basis for developing a wide range of educational activities and assessments (8).

This dissertation is structured into four main chapters, each addressing a specific aspect of learning with micro-topics and learning pathways. Figure 1.1 presents a visual outline of the dissertation’s structure, guiding the reader through the journey of this research. Chapter 2 explores

“spaced retrieval” to enhance remembering; chapter 3 focuses on KGMLP representations for “reading” to augment remembering, understanding, and analyzing; and chapter 4 discusses “collaborative note-taking” to enhance understanding, analyzing, and evaluating. For the first four effects, solid experimental results, and for the last three effects (visualized using dashed lines), exploratory results are reported.

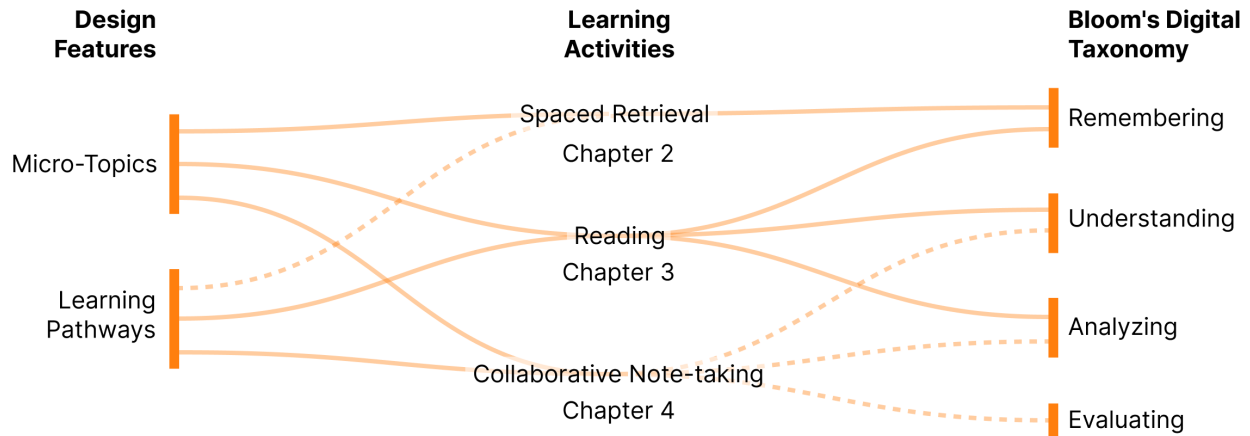


Figure 1.1: The visual dissertation outline.

In chapter 2, detailed in two studies, I investigate how to ensure the long-term retention of micro-topics through their designated learning pathways. To tackle this, I designed a spaced retrieval practice tool that harnesses the power of retrieval practice by sequentially prompting students with questions to solidify their learning. It strategically distributes these sessions across many days of a semester, aligning with the course syllabus (as the learning pathway) and adapting to the students’ mastery levels of each micro-topic.

In chapter 3, I investigate the ideal size for micro-topics within a KGMLP. Here, I report on a controlled experiment that tests two formats: the “Hybrid Map,” which presents micro-topics as short paragraphs, and the Novakian Knowledge Model, which divides each paragraph into smaller nodes of a Novakian Concept Map.

In Chapter 4, I introduce “1Cademy,” a system that reimagines collaborative note-taking, structured as a KGMLP. 1Cademy empowers learners to:

- Extract and synthesize micro-topics from diverse sources, including texts and multimedia
- Merge these into comprehensive micro-topics, each with a paragraph and accompanying visuals
- Collaboratively map out and visualize learning pathways, offering clear routes for any learning objective

- Continuously enhance learning pathways, making education progressively more accessible and engaging
- Engage in peer evaluation through voting and commenting to refine content quality
- Gain reputation points, rewarding the value of their contributions to the learning community

Over four years, 1Cademy has actively involved 1,700 students from 208 institutions, leading to the creation of 51,000 micro-topics arranged in learning pathways through 272,000 proposals.

1.1 Chapter 2: Spaced Retrieval Practice

Chapter 2 focuses on “spaced retrieval practice,” a technique that leverages the temporal distribution of retrieval practice to enhance memory retention. The purpose of this chapter is to explore how micro-topics organized in learning pathways can be used to facilitate “remembering,” the foundational cognitive process in Bloom’s taxonomy. The chapter presents two studies that utilize the content of an introductory Python programming course, which is divided into micro-topics, each represented by a sub-chapter in an interactive textbook. However, the linear relationship between the sub-chapters did not provide perfect learning pathways. This limitation is visually represented in Figure 1.1 by a dashed arrow, indicating the need for a more non-linear structure to support alternative learning pathways.

Enhanced long-term learning outcomes are often observed when study sessions are both succinct and regularly distributed. This phenomenon, known as “spacing”, demonstrates its effectiveness, particularly in scenarios where learning subjects are concise (micro-topics) and their interconnections are clearly delineated (learning pathways) (165; 130). Despite the proven benefits of spacing, its practical application faces resistance, as both students and instructors may perceive it as a hindrance to immediate learning gains (102; 46; 45). To address this, I have developed a practice tool that employs a structured approach to spaced, interleaved, retrieval practice. This tool is uniquely designed to align with the pre-existing KGMLP of a course syllabus. The initial study presented herein details the key design aspects that contribute to the tool’s effectiveness in facilitating learning and maintaining student motivation. These aspects include: incentivized spacing through daily point allocation for answering a set number of questions, the application of a modified spaced repetition algorithm that focuses on micro-topic scheduling (as opposed to individual questions) in accordance with the course syllabus, the incorporation of a visual tool to assist students in meta-cognitive planning, and the integration of various gameful elements to enhance user engagement.

In the second study of this chapter, I examined the effectiveness of only one of the above-mentioned design elements to motivate students to space out their retrieval practice: a simple

grading incentive that I called “counting days,” and tested it in two RCTs: one randomizing 143 students in a semester of a course and the other randomizing 71 instructors, in introductory computer programming courses. In the first experiment, under the counting days treatment, 83 students received grading points for each day of answering ten questions correctly. Under the counting questions control condition, 60 students earned grading points on a per-question basis rather than per day. The counting days group earned higher exam scores, which was mediated by spacing practice over more days. Spacing was especially beneficial for lower-GPA students: the correlation between prior GPA and exam scores was significantly lower for the counting days group. In the between-instructor experiment, we only had access to the number of questions practiced per day. Both the number of days and questions practiced were significantly higher under the counting days condition.

1.2 Chapter 3: Reading and Knowledge Representation

Chapter 3 delves into academic “reading” and explores alternative representations of KGMLPs to improve “remembering,” “understanding,” and “analyzing.”

Multiple meta-reviews (156; 132; 87) have shown the benefits of studying preconstructed Novakian concept maps compared to the linear representation of these knowledge graphs. While linear text remains the predominant medium for education, its comparative advantages have been overlooked in studies that treat both linear text and concept maps as monolithic entities, neglecting the distinct benefits of linear text features. Furthermore, concept maps’ effectiveness in enhancing learning wanes with longer or more intricate texts. I investigate whether visual maps may be even more effective with somewhat larger chunks of text rather than short phrases as nodes in Novakian concept maps. I introduce a new representation of KGMLPs, where full paragraphs are visually linked to each other, all on one page. We compared them to Novakian Knowledge Models, which link concept map pages (each including information of almost one paragraph) also represented as a visual concept map. For comparative clarity, such a KGMLP is termed “Hybrid Map” within this chapter, highlighting the fusion of hierarchical concept map visuals with the rich, linear text’s narrative and complexity.

In a controlled experiment, each participant (n=419) studied two passages, one represented as a Hybrid Map, the other as a Knowledge Model. Both recognition and recall (remembering) scores were higher for the Hybrid Maps while reading, and also three days later and one week later. These results hold for both factual (understanding) and inferential (analyzing) recognition. Thematic analysis of subject feedback revealed a preference for visualization of relations between full paragraphs, and for all paragraphs to be displayed on a single page.

1.3 Chapter 4: Collaborative Note-Taking

Chapter 4 explores the concept of collaborative note-taking as a tool to enhance “understanding,” “analyzing,” and “evaluating.” It draws on Lev Vygotsky’s social constructivism theory (175) that underscores the influence of culture and social interactions on cognitive development and learning. I introduce “1Cademy,” a platform designed to foster social learning through collaborative note-taking in the form of a large KGMLP when many learners collaborate asynchronously over many months. Distinct from note-taking platforms like Google Docs (181), which typically produce isolated documents created by individuals or small groups, 1Cademy centralizes a single gigantic KGMLP shared among all the contributors, where individuals curate and modify only small sub-graphs of the shared KGMLP. This approach mirrors the collaborative dynamics found in crowd-sourcing platforms such as Wikipedia (176) and StackExchange (71), necessitating a cohesive and integrated knowledge graph characterized by uniquely identifiable nodes. The core philosophy of 1Cademy is to provide students with a sense of making permanent contributions that benefit a broader community, distinguishing it from platforms catering to short-term or individualistic note-taking needs. My objective, in this chapter, is to address the challenges of motivating students to read and improve others’ work, and reaching a consensus on micro-topics and learning pathways in settings where numerous learners are involved over several months. To overcome these challenges, I propose four design features: a proposal mechanism for changes to a node or its links, a requirement that new node proposals also include at least one learning pathway to reach, a vote-dependent acceptance threshold for proposals, and community-specific contribution scores.

The effectiveness of 1Cademy is evaluated through a longitudinal study and a field trial. The results demonstrate that students can adapt to the constraints on their note-taking imposed by the platform’s design choices, without getting discouraged or creating their own private sections of the graph. This is evidenced by sustained use by large communities of learners, both in a quasi-course format and in a volunteer community format. The trials also show that the KGMLP did not fragment or have near-duplications, indicating successful collaborative learning. The 1Cademy platform has supported a large collaborative effort since its inception *four* years ago, in addition to its class deployments. This effort has involved 1,754 students and researchers from 208 institutions, culminating in an expansive KGMLP comprising 50,947 nodes and their links through 271,836 proposals.

1.4 Chapter 5: Conclusion and Future Directions

The final chapter of this dissertation summarizes the insights gained from the studies discussed in the preceding chapters. It outlines my future research and development plans, aiming to further the

understanding of how KGMLPs can be effectively utilized in educational settings.

In conclusion, this dissertation explores the effectiveness of KGMLPs in enhancing key cognitive processes in Bloom's digital taxonomy—remembering, understanding, analyzing, and evaluating—through three learning activities: spaced retrieval, reading, and collaborative note-taking. The integration of KGMLP with a spaced retrieval tool, enhanced by the Counting Days incentive, has shown particular benefits for knowledge retention, especially for lower-achieving students, demonstrating its inclusivity. The results of a controlled experiment reveal KGMLP's superiority over Novakian concept maps in improving reading comprehension and knowledge retention. Finally, the development of 1Cademy as a collaborative note-taking platform marks a significant advancement in social learning, effectively managing the complexities of student interactions in knowledge construction. 1Cademy's unique design features, including its linking constraint, proposal mechanism, and community-specific contribution scores, have proven to promote meaningful engagement in collaborative learning activities.

CHAPTER 2

Motivating Students to Space Retrieval Practice of Micro-Topics Based on Their Learning Pathways to Improve Their Retention

Every phrase and every sentence is an end
and a beginning, Every poem an epitaph.
And any action Is a step to the block, to
the fire, down the sea's throat Or to an
illegible stone: and that is where we start.

T.S. Eliot

This chapter delves into *spaced retrieval practice*, a pivotal technique that exploits the timing of retrieval exercises to bolster “remembering,” a crucial cognitive process at the base of Bloom’s digital taxonomy (8). It showcases two studies: the first, already published (185)¹, and the second, currently under review², both employing the content from an introductory Python programming course. This course is broken down into micro-topics, each forming a sub-chapter in an interactive textbook, with learning pathways shaped by the linear progression of these sub-chapters as outlined in the course syllabus.

The *spacing effect* indicates that learning outcomes are significantly improved when study sessions are brief yet consistently spread out. This is particularly evident when dealing with concise learning subjects, like micro-topics, and when their interconnections are clearly established, as seen in structured learning pathways (165; 130). Despite its proven effectiveness, spacing is often met with skepticism by both students and instructors, who may view it as a barrier to immediate academic progress (102; 46; 45). To counteract this, I have developed a structured practice tool

¹This section is based on YeckehZaare et al. (185), co-authored with Paul Resnick and Barbara Ericson. The contents are only lightly edited.

²This section is based on an under-review paper, co-authored with Paul Resnick. The contents are only lightly edited.

that integrates spaced, interleaved retrieval practice within the existing KGMLP framework of a course syllabus. This tool's design, aimed at enhancing learning and sustaining student motivation, includes features such as:

- Presenting one question at a time to focus student attention;
- Immediate feedback on answers, reinforcing learning and correcting mistakes;
- A dynamic sequencing of micro-topics, starting with those covered in lectures and revisiting them based on a tailored spaced repetition algorithm that schedules micro-topics rather than questions;
- Metacognitive data providing insights into daily progress, points earned, and remaining practice sessions;
- Visual displays of micro-topic mastery, aiding students in their metacognitive planning;
- An incentive system where students earn points daily by correctly answering ten questions;
- Animations to celebrate the completion of daily goals

The second study in this chapter investigates the impact of one specific design element—referred to as *Counting Days*—on motivating students to distribute their retrieval practice over time. Conducted through two RCTs, the first involved 143 students over a semester, and the second encompassed 71 instructors in introductory computer programming courses. In the first RCT, 83 students under the *counting days* condition received points for each day they correctly answered ten questions, while a control group of 60 students earned points on a per-question basis. The *counting days* group not only achieved higher exam scores, but this improvement was more pronounced in students with lower GPAs, indicating a unique benefit of spacing in leveling the academic playing field.

2.1 Study 1 - A Spaced, Interleaved Retrieval Practice Tool that is Motivating and Effective

Our beliefs regarding the ways that we learn are often flawed. They are informed by subjective impressions rather than learning studies. For example, even though 90% of college students performed better after spaced practice (practicing over several days) than massed practice (studying the night before an exam), 72% of the students reported that massed practice was more effective (106). Bjork and Soderstrom found that individuals' incorrect beliefs lead them to manage their

learning or instruct others in less than ideal ways (26; 159; 25). They have conducted numerous experimental studies that demonstrate that the conditions of instruction that accelerate initial learning performance often fail to support long-term learning and transfer. Conversely, some interventions that appear to create difficulties for the learner during initial knowledge acquisition often optimize long-term learning and transfer (105). Bork has labeled these “desirable difficulties” (25). Soderstrom and Bjork (26; 159; 25; 12) have identified the following techniques that improve long-term learning, but negatively impact initial learning performance:

1. Retrieval practice (vs. passive review of previous content)
2. Spacing (vs. massing) study/practice
3. Interleaving (vs. blocking) distinct topics to study/practice
4. Generating (vs. being exposed to) the learning content
5. Varying (vs. keeping steady) the environmental context

We created a learner-centered retrieval practice tool for an introductory Python programming course that spaces practice and interleaves topics. We used the tool in a semester-long course with 193 undergraduate students. This allowed us to observe variations in the tool usage and how it correlated with final exam grades. We followed a design-based research approach, iteratively improving the tool during the semester in response to observing students using the tool, anonymous feedback, and usage data.

We designed the tool to provide motivators to reduce the typical negative student reaction to desirable difficulties. We also devised a grading scheme to motivate students to space their practice out over the semester, while still giving students significant autonomy in when and how much they used the practice tool.

We hypothesized that the grading incentives and the features designed to motivate students might lead students to use the tool throughout the semester, not just to cram for exams. Our first research question is:

- **RQ1:** Do students space or mass their use of the tool?

Because the course and design included both intrinsic and extrinsic motivators, we cannot fully tease apart their separate effects. However, any usage that did not help students earn points towards course grades is an indication of intrinsic motivation. Thus, our second research questions is:

- **RQ2:** Do students use the practice tool more than they were required to?

Finally, we analyzed the overall effectiveness of the practice tool with respect to performance on the final exam:

- **RQ3:** Does the practice tool usage correlate with higher final exam grades?

We begin with a summary of the theories of desirable difficulties, self-determination theory, and gameful design that inspired the development of our tool, as well as prior research using desirable difficulties in computing education, research on other practice systems for introductory programming, and research on procrastination. Next, we describe the setting of the study and the specific features of the tool and the grading system, including the evolution of some of the features over the course of a semester-long deployment. Then, we describe the data sources and analysis methods for our quantitative analysis of the research questions and report the results of those analyses. Finally, we discuss the limitations of this study and our conclusions.

2.1.1 Related Work

This work is inspired by work on desirable difficulties, self-determination theory, gameful design, practice tools, and procrastination.

2.1.1.1 Desirable Difficulties

Many experiments show that desirable difficulties result in superior long-term learning, but may negatively affect short-term learning performance. Soderstrom and Bjork (159) provide a comprehensive review of these experiments. In this study, we report the design of our practice tool around three of these techniques: spacing, interleaving, and retrieval practice.

Spaced Practice Spreading out practice sessions over a period of time, usually over many days, is called spaced practice. It can be contrasted with massed practice, which is “cramming” just before an exam. Massed practice is successful in the short-term, but it leads to very rapid forgetting. In contrast, spaced practice negatively affects short-term performance, but significantly improves long-term learning (159; 60; 28; 108; 31; 19; 149).

Interleaving Intermixing different topics in a practice session is called interleaving (60). In contrast, blocking means practicing the same topic. Students often prefer blocked practice because it provides a sense of fluency while interleaving leaves a sense of confusion (183). Blocked practice is also pervasive. Textbooks only cover one topic at a time (105) and the end of chapter exercises focus on that topic. Most curricula are designed with problem sets covering only one topic, with no questions from earlier chapters.

Retrieval practice (testing) Practice which forces the learner to retrieve the information from memory is called retrieval practice or testing. An example would be flashcards where the student sees a question on one side and has to recall the answer on the other side. It can be contrasted with studying by rereading a section of a textbook. Retrieval practice helps modify memory which makes the information more recallable. Testing also provides better feedback as to what has or has not been learned than rereading material (159).

2.1.1.2 Self-determination Theory (SDT)

SDT characterizes two main types of motivation: intrinsic and extrinsic (151). Intrinsic motivation is driven by internal rewards (enjoyment of a subject) rather than external (e.g., grades). SDT identifies autonomy, or letting someone choose how and when to perform a task, as the most important factor for increasing intrinsic motivation. SDT advises providing students with more autonomy rather than external rewards (151). In our design, students decide when, where, and how they use the practice tool, which may support their intrinsic motivation.

2.1.1.3 Gameful Design

Gameful design is the process of redesigning core elements of a learning environment to support intrinsic motivation (5). Providing students with extrinsic motivation by earning grades or rewards can reduce their intrinsic motivation (115). Through three studies, Aguilar et al. (5) found a positive correlation between gameful design and students spending more time studying and feeling more in control. Gameful design “requires simultaneously increasing the opportunities for students to have autonomy and mitigating the impact of failure, such that learners are empowered to exert effort in spaces that they might otherwise have avoided” (5).

2.1.1.4 Prior Work on Practice Tools

Several practice tools have been created for helping students learn to program. CodeLab is a commercial tool that instructors can use for programming assignments (20). Epplets (110) is a tool for solving mixed-up code (Parsons) problems (143). Problem Roulette asks random questions from previous exams (70), but students choose the topics. None of these tools provide automated support for spaced and interleaved retrieval practice.

Intelligent Tutoring Systems (ITS) provide personalized practice (10). These systems provide feedback either after the student has solved a problem or while the student is solving a problem (55). Some systems select the next task or problem based on a student model that indicates if the student has mastered the current topic (55). ITS have been used successfully in programming (9).

However, they typically support initial learning and blocked practice and do not include support for spaced or interleaved practice.

2.1.1.5 Procrastination

Multiple studies (161; 72; 179) have reported a significant negative correlation between procrastination and course grades. Kazerouni et al. (98) analyzed a dataset of 6.3 million program edits and software tests from a programming course and found a significant negative correlation between procrastination and programming project grades. In a retrieval based practice tool, Problem Roulette, students primarily used the tool just before exams as shown in Figure 2.4, which indicates procrastination.

2.1.2 System Design and Development

We designed a practice tool for an introductory Python programming course for informatics and non-CS majors. Most, but not all, of these students have no prior programming experience. The course serves as a pre-requisite for an upper-division major that involves additional programming courses, but much less programming than is typical for computer science majors.

The course pedagogy is based on active learning. Students are expected to study specific sections of an interactive e-book prior to attending lectures. Both lectures and discussions involve frequent opportunities for students to answer questions and interact with each other. Furthermore, the e-book itself provides many interaction opportunities, as described in subsection 2.1.2.1. Grades are assigned on an absolute scale rather than on a curve. Students accumulate points throughout the semester from problem sets and other activities. The final exam was worth 25% of the total course points. The practice tool was worth 5%; how students earned those points is described in subsection 2.1.2.3 and 2.1.2.6.

2.1.2.1 Underlying Platform

The practice tool was incorporated into Runestone Interactive³, which is an open-source platform that enables authors to create e-books. Instructors can assemble assignments from the interactive elements. An e-book page can include text, images, videos, and external links. Pages can also include interactive elements, such as:

- **Multiple-choice** questions, appropriate for quick practice;
- **Fill-in-the-blank** questions;

³<https://runestone.academy/runestone/static/overview/overview.html>

- **Parsons** (mixed-up) code questions, where students have to rearrange code blocks in the correct order and with the correct indentation (143);
- **CodeLens** questions, which allow step-by-step code execution and visualization of variables;
- **Active-code** questions, where students can write programs and edit code (Figure 2.1).

Figure 2.1: Runestone Interactive Sample Active Code

9. Create a list of numbers 0 through 40 and assign this list to the variable `numbers`. Then, accumulate the total of the list's values and assign that sum to the variable `sum1`.

Save & Run Show CodeLens

```

1 numbers = list(range(41))
2 sum1 = 0
3 for num in numbers:
4     sum1 += num1

```

Error

NameError: name 'num1' is not defined on line 4

Description

A name error almost always means that you have used a variable before it has a value. Often this may be a simple typo, so check the spelling carefully.

To Fix

Check the right hand side of assignment statements and your function calls, this is the most likely place for a NameError to be found.

The interactive elements provide students with immediate feedback. For example, the active-code questions can include unit tests which test submitted solutions. Assignments can be created using these interactive elements. The practice tool reuses Runestone's database of questions. Students could access the practice tool through a direct link from Canvas, the learning management system used to organize the course materials, or through a menu link on each Runestone textbook page.

2.1.2.2 Basic Design: Retrieval Practice

The practice tool presents a web page with a single question on it, either multiple-choice, fill-in-the-blank, Parsons, or ActiveCode, as illustrated in Figure 2.2. When a question is presented in the practice tool, the student's previous answers are hidden, unlike presentations of those same questions elsewhere in the textbook, where students can access their past history of answers.

2.1.2.3 Interleaving Algorithm

Each time the practice page was loaded, the system automatically chose which question to display. We modified the SuperMemo 2 algorithm (182), which automatically interleaves topics, repeating topics less and less frequently as the student demonstrates mastery of them. It optimizes learning by reducing forgetting and overlearning (restudying what you have already mastered). Supermemo 2 defines three factors that get updated for question y when student x answers it. These factors are:

- $i_interval_{xy}$: demonstrates the number of days remaining to ask question y from student x ;
- e_factor_{xy} : indicates how easy question y is for student x .
- q_{xy} : measures the correctness of student x 's answer to question y . Supermemo 2 updates the other two factors based on the value measured for q_{xy} , which is an integer from 1 to 5.

We customized Supermemo 2 in two ways to make it appropriate for use in our practice tool:

- SuperMemo 2 was designed for language learning, in which it makes sense to space repetitions of retrieving the meaning of each word. However, when it comes to STEM courses, it becomes boring to repeatedly answer the same question about a formula or a programming algorithm. We wanted students to learn generalizable skills, rather than just memorizing the answer to a specific question. Therefore, instead of applying the algorithm to individual questions, we applied it to topics, with each topic potentially having many questions. When the algorithm suggests answering a question from any specific topic, the practice tool asks one of the questions for that topic using Round-robin scheduling (16).
- While Supermemo 2 sets q_{xy} based only on whether a student gets the question right, we use multiple factors:
 - d_{xy} : demonstrates the duration of the time student x spent answering question y , measured in minutes.
 - t_{xy} : indicates the number of attempts student x made before submitting their final answer for question y .

- v_{xy} : shows the number of other textbook pages viewed while answering question y ; more page views indicate that student x needed to look up information rather than recalling it.

Over the first two weeks of the semester, we monitored each of these measures based on the students' answers to practice questions and iteratively modified our algorithm. Eventually, we settled on the following:

1. $q_{xy} = 5$ if $v_{xy} == 0$, $t_{xy} \leq 1$, and $d_{xy} \leq 2$;
2. $q_{xy} = 4$ if $t_{xy} \leq 2$ and $d_{xy} \leq 2$;
3. $q_{xy} = 3$ if $t_{xy} \leq 3$ and $d_{xy} \leq 3$;
4. $q_{xy} = 2$ if $t_{xy} \leq 4$ and $d_{xy} \leq 4$;
5. $q_{xy} = 1$ if correct, but other conditions were not met;
6. $q_{xy} = 0$ if the final answer was incorrect.

2.1.2.4 Grading System: per Day, not per Question

A student could earn one point for each day of completing a set of practice questions. Beyond that, they could keep answering questions, but would not earn any additional points that day. A student could earn a point for a maximum of 45 days during the semester; beyond that, they could continue to use the tool, but would not earn additional course points. Students started using the tool about three weeks into the semester, so they needed to complete a practice set about four days per week in order to earn all of the available points. This system was intended to create an incentive for students to space their use of the practice tool out over the semester, rather than only to cram for exams.

On each question, a student could make unlimited attempts, getting automated feedback each time. If a student submitted a wrong answer, the system asked the corresponding question again until they submitted a correct answer. However, during participant observations with students early in the semester, we discovered that this feature could leave a student “stuck” on a question that they could not answer, which was frustrating for students. In response to that, we introduced an escape valve, the option to postpone a question to the next day (by clicking the red button on the bottom part of Figure 2.2). That allowed them to ask their peers or instructors about the question before it was asked again. Postponed questions were asked again the next day that the students used the tool, though the students could postpone them again if they wanted.

Initially, students were required to answer all of the available questions in order to earn that day's point. However, we found that if a student got behind in using the practice tool, they might have dozens of questions to answer, and the task seemed insurmountable. We changed the daily goal to be the minimum of either ten questions or all of the questions that were available that day.

2.1.2.5 Progress Tracking and Celebration

In the initial deployment, students did not receive any feedback about their progress towards the daily goal. Only after completing the daily goal did the page confirm that they had completed it. So, students asked us to add information to the practice tool including the number of questions they needed to answer to gain that day's point, the number of questions that were available to answer which is the same or more than the required number, the number of days that they needed to practice to gain the maximum points, and the number of days remaining in the semester. In response, we added a section to the top of the practice page, as shown in Figure 2.2.

We also implemented an animated fireworks feature to celebrate students' completion of the daily goal. Students who finished all the available questions for a day were shown extended fireworks. Following SDT, these features were intended to maintain students' motivation and autonomy while building their sense of competence, as they could see their progress toward the daily goal and anticipated a celebration when they finished. In group office hours soon after introducing the fireworks, we saw students' faces light up. They reported that it was very motivating. However, this enthusiasm seemed to wane as the novelty wore off later in the semester.

2.1.2.6 Schedule Information to aid Metacognition

From the beginning of the semester to spring break, some students only used the practice tool a couple of times and some students did not use it at all. To investigate the reason, we interviewed some of the students who used it only a few times. They explained that they thought the practice tool asked them random questions. One explicitly told us: "I don't like to answer random questions. I prefer to go through the pages of the textbook and only practice those questions that I think I may have difficulty with." To solve this issue, we developed a visualization of the practice tool's predictions of the number of days remaining before they would be asked a question about each topic in the syllabus. We added the visualization below the display of the question in the practice tool interface (Figure 2.3). In addition, in one of the lectures the instructor explained this visualization and gave an overview of how the algorithm predicts the student's optimal review day for each topic. As shown in Figure 2.5, the total number of questions practiced per day shows a decreasing trend from the beginning of the semester to spring break. However, introducing the schedule visualization after spring break, we see the trend becomes more level, which suggests a positive effect of the visualization on students' practice.

2.1.3 Analysis and Results

We deployed the practice tool in a course running from January to April 2018. To answer the three research questions, we assembled usage data from the practice tool and other parts of the interactive

Figure 2.2: The Practice Tool Sample Interface

7 questions left to get today's point.

48 more questions available to practice today.

You have completed 19 days out of 45 days of your review practice.

24 days are remaining to the end of the semester.

modules-2-1: The correct code to generate a random number between 1 and 100 (inclusive) is:

- A. `prob = random.randrange(1, 101)`
- B. `prob = random.randrange(1, 100)`
- C. `prob = random.randrange(0, 101)`
- D. `prob = random.randrange(0, 100)`

Check Me

Compare me

Done! Claim my completion point!

I want to postpone this to tomorrow! Ask me another question.

e-book used in the course, students' final exam scores, and information about the students provided by the registrar's office, such as GPA and demographics.⁴

2.1.3.1 Student Demographics

- **Gender:** 85 (44.04%) male; 108 (55.96%) female.
- **Year:** 75 frosh; 52 sophomore; 28 junior; 38 senior.
- **Native language:** 150 (77.77%) English; 43 (22.28%) other.

⁴This study is exempted under IRB HUM00144387.

Figure 2.3: Schedule visualization example, only showing the first five topics. For each topic, there is an indicator of how many days until a question will be asked on that topic. The color indicates the student's mastery of the topic. Green indicates the highest mastery and red is the lowest.

Questions from the following topics will be asked again in the specified number of days:

- **GeneralIntro**

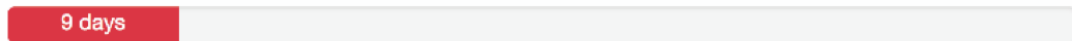
- **What is Debugging?:**



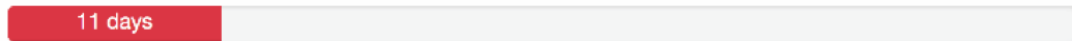
- **Syntax errors:**



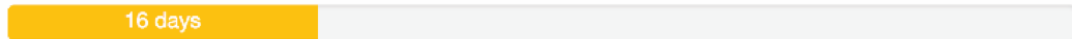
- **Runtime Errors:**



- **Semantic Errors:**



- **Experimental Debugging:**



- **Race/Ethnicity:** 120 (62.18%) White, 48 (24.87%) Asian, and 25 (12.95%) other.
- **Math score:** university-wide test (only 184 students) Mean (18.84), SD (4.41), Range [5.00, 25.00], Quartiles {16.00, 19.00, 23.00}.
- **Pass/Fail:** 168 (87.05%) took the course for a grade and 25 (12.95%) took it for pass/fail.
- **GPA:** cumulative GPA excluding this course: Mean (3.42), SD (0.36), Range [2.36, 4.01], Quartiles {3.22, 3.45, 3.68}.

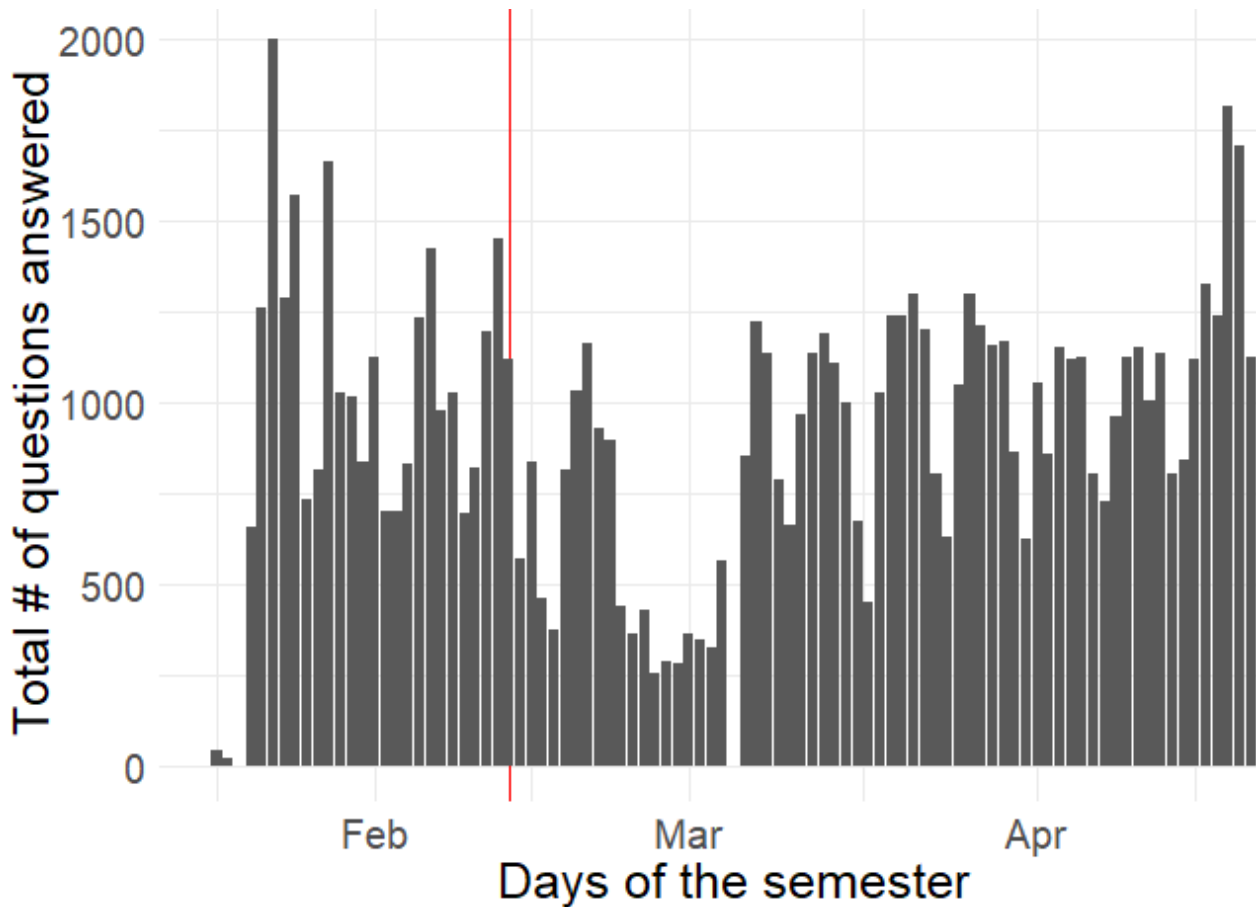
2.1.3.2 RQ1: Do students space or mass their use of the tool?

Previous studies reported that students massed their use of practice tools. Figure 2.4 shows the activity log reported by “Problem roulette” (70), which indicates a low usage rate over the semester and spikes on the days before each of the four exams. In contrast, our usage log showed usage throughout the semester (Figure 2.5).

Figure 2.4: Number of visitors to the Problem roulette website per day over Fall 2012, which indicates low usage over the semester, but spikes on the days before each exam (70).



Figure 2.5: Total number of questions answered by the students each day. The red line indicates the midterm. At the end of February and early March, there was a week-long school holiday. On March 5th our server went down and the students were not able to access the practice tool.

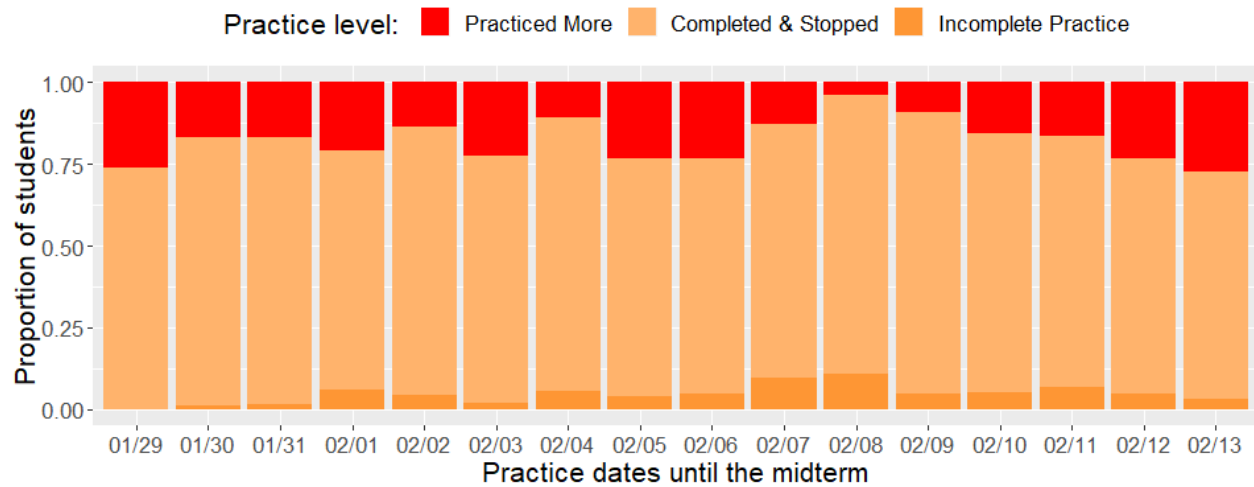


2.1.3.3 RQ2: Do students use the practice tool more than they were required to?

For RQ2, our first analysis examines if students kept answering questions on individual days even after earning the point for that day. Students had to practice only a total of 45 out of 81 days to

earn the maximum points. So, we consider only days when students viewed the practice tool, and classify each of those practice days as “incomplete” (student did not earn the point), “stopped” (the student answered exactly the number needed to gain the point for that day) or “more” (the student answered at least one more question after earning the point for the day). Figure 2.6 shows the frequency of each of those outcomes for the two weeks leading up to the midterm. Over the entire semester, 5.16% of all student practice days were incomplete, 86.99% were stopped immediately after completing the required number of questions, and 7.86% concluded with the students voluntarily completing extra practice questions.

Figure 2.6: In two weeks before the midterm, among those students who viewed the practice tool each day, the proportion who had incomplete practice, stopped after earning the day’s point, or practiced more after earning the point.

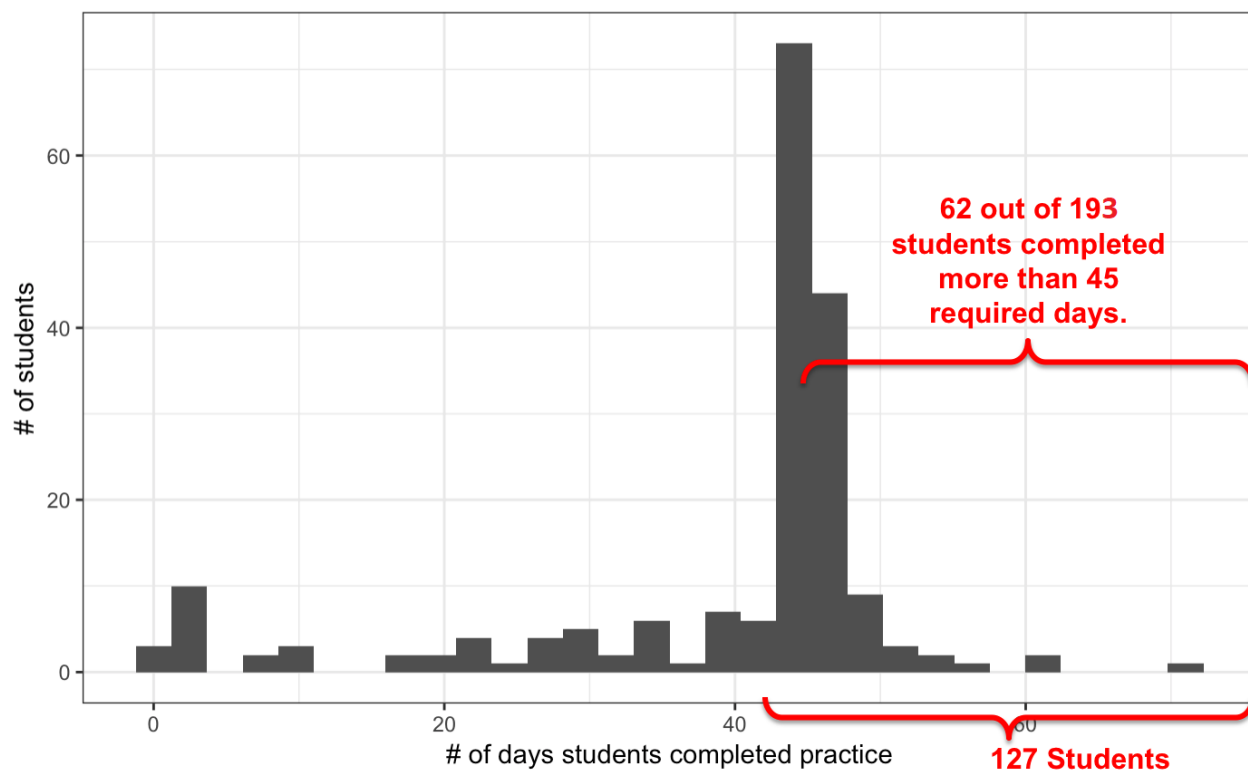


Our second analysis examines whether students completed more than 45 days of practice, the maximum that they could earn points for. Figure 2.7 depicts a histogram showing the number of students who completed different numbers of days of practice. In this class, 127 (65.8%) out of 193 students completed at least 45 days of practice and received the maximum points. Among those 127 students, nearly half of them, 62, completed at least one additional day even though they did not receive any extra points for it. That means nearly one-third of the class used the practice tool more than the required number of days.

2.1.3.4 RQ3: Does the practice tool usage correlate with higher final exam grades?

Ideally, we would like to estimate the causal effect of using the practice tool on exam grades. It is not possible, however, to do so with confidence given the within-classroom design of this study, with students self-selecting how much to use the practice tool. Even if there is an observed correlation between the two, there could be many unmeasured confounders. In particular, it is

Figure 2.7: Histogram of the number of days each student completed practicing the required number of questions.



likely that students with better general study habits would both be likely to use the practice tool more and likely to do better on the final exam even if the practice tool were unavailable.

The best that we can do is control for the many potential confounds that we *can* measure. We conducted an Ordinary Least Squares (OLS) regression analysis with the final exam score as the dependent measure. In addition to the number of hours of practice tool use, we included independent variables for several potential confounds, including some that may be proxies for general study habits, such as GPA, hours spent using the textbook outside of the practice feature, and a measure of students' tendency to procrastinate on assignments.

Some of the variables come from the student demographics provided by the registrar's office, as described in subsection 2.1.3.1. Others come from usage logs, as described below.

Hours of Using the Practice Tool We collected the timestamps when the student was presented each practice question and when they submitted a final answer. We recorded the duration of practicing that question as the maximum of the elapsed time or ten minutes, and also treated the session as ten minutes long if the student never submitted a final answer. This leads to an overestimate of the length of sessions when the student loaded the page and then closed it, or took a long break

and then answered the question quickly; it underestimates the length of sessions when the student genuinely worked on a question for more than ten minutes. We calculated the total number of hours the student spent using the practice tool by summing the duration of all of these practice sessions over the semester. The distribution of this measure was: Mean (8.68), SD (5.21), Range [0.00, 23.35], Quartiles {5.05, 8.07, 12.10}.

Hours of Studying the E-book We started the timer for an e-book “session” with each page load. We marked the end of a session when another page was loaded, or after five minutes without a logged interaction on the page. Thus, our measure of session length probably slightly overestimates the length. We then added up the hours of studying the e-book for all of the sessions for each student over the semester, excluding the pages for the problem sets. The distribution of this measure was: Mean (37.49), SD (16.20), Range [3.00, 91.12], Quartiles {26.68, 35.20, 46.82}.

Speed To get a measure of prior skill, we measured the students’ speed at working on problem sets early in the course. The first five weekly problem sets were completed in the e-book, where we were able to measure the amount of time students spent. We define a student’s speed as the number of points earned per hour of working on problem sets. The distribution of speed was: Mean (13.32), SD (6.18), Range [4.13, 43.19], Quartiles {8.82, 11.80, 15.93}.

Earliness To get a measure of general study habits, we evaluate students’ tendency to procrastinate, or rather its inverse, their earliness in working on problem sets. We encouraged students to submit by a soft deadline of Friday afternoons but offered a two-day grace period. We calculated the average number of hours from every interaction with any of the problem set questions to the corresponding problem set deadline. Students who procrastinate will have a low score on this measure, whereas students who complete the majority of the work early will have a high score. This measure was computed only for the first five problem sets, where actions were recorded in Rune-stone. After this period, the course switched to using Jupyter notebook for problem sets and the log files were not available. The distribution of earliness was: Mean (58.20), SD (30.93), Range [2.27, 175.42], Quartiles {36.92, 50.93, 73.38}.

We released each problem set approximately a week before the deadline. The mean of 58.20 was a little more than two days before the hard deadline and ten hours before the soft deadline; note that this was the average timestamp for all work, not for the last work that each student completed on each problem set (the turn-in time).

Final exam grade The final was a pencil and paper exam, with multiple choice, short answer, and code writing questions. The distribution of exam grades was: Mean (69.65%), SD (15.87%),

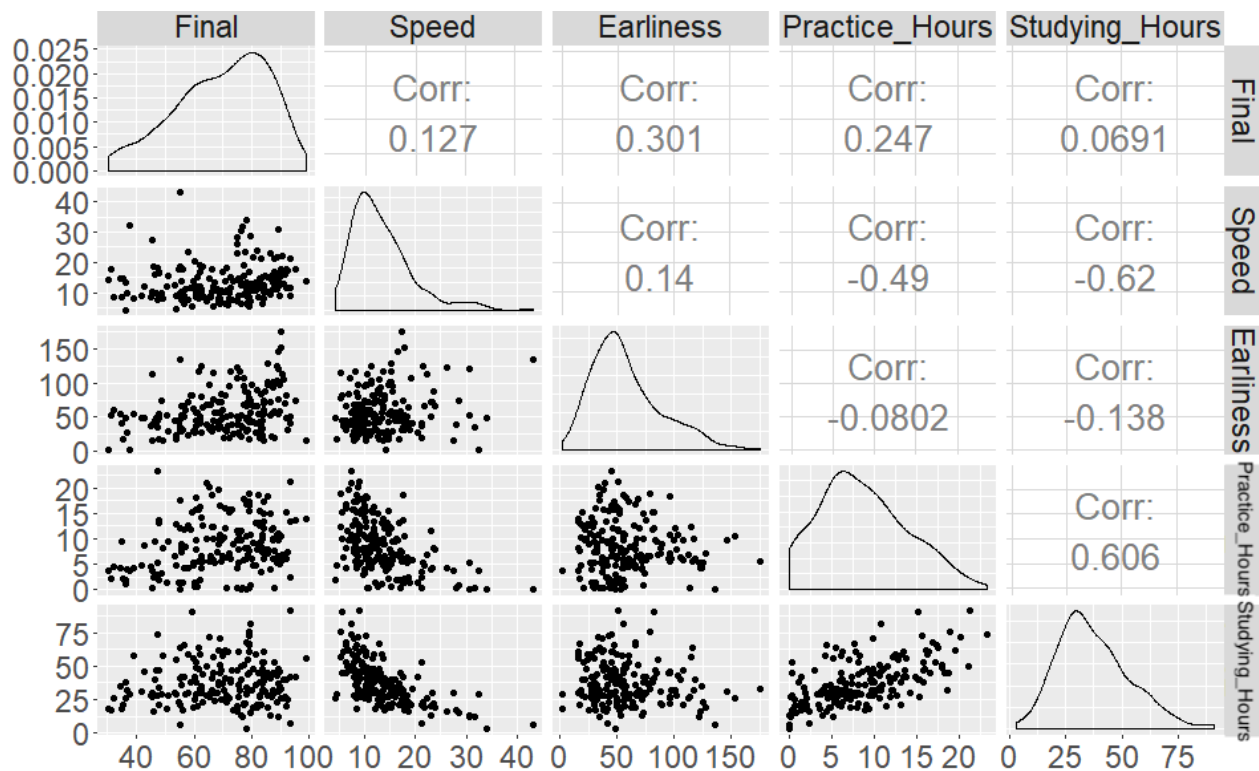
Range [30.20%, 98.80%], Quartiles {59.50%, 71.60%, 82.80%}.

2.1.3.5 Distributions and Correlations

Figure 2.8 presents distributions for the key variables and their correlations. The diagonal entries show the distributions for individual variables. The upper right cells summarize pairwise correlations as Pearson correlation coefficients, while corresponding cells on the lower left side provide scatterplots. Some of the interesting correlations include:

- Answering problem sets faster (higher speed) significantly correlated with less studying ($r=-.62$) and practicing ($r=-.49$), but not higher final exam grades ($r=.127$).
- Earliness (less procrastination) correlated with final exam grades ($r=.301$) but not speed ($r=.14$) or studying hours ($r=-.138$).
- More studying correlated with more practicing ($r=0.606$).

Figure 2.8: Distributions of the key variables and their correlations. The rows and columns are labeled by the corresponding variable names.



Regression Analysis Table 2.1 shows the coefficients of the Ordinary Least Squares (OLS) regression model, with the final exam percentage as the dependent variable. It shows the results for 181 students. Twelve of the students were excluded from this model because we did not have all of their data. Several independent variables were categorical: the base (left out) or comparison categories were White, female, native English speakers, and taking the course for a grade. The results show that, after controlling for other factors:

- Each extra hour using the practice tool was associated with a 1.04% increase in the final exam score.
- Each extra hour using the e-book, excluding the practice tool usage, had no significant residual correlation with exam scores.
- As expected, measures of prior preparation (GPA, Math score) were positively correlated with exam score, as was earliness.
- The effect of speed on early problem sets was non-significant after controlling for other covariates.

We note that the positive coefficient for gender may be misleading. Overall, exam scores did not differ significantly by gender. However, when controlling for all the other covariates, males performed better. In another study (184), we identified three pathways correlated with success in this course: studying more, speed in completing the problem sets, and not procrastinating. We also found that male and female students achieved similar final exam grades, but female students got higher grades through studying more, and male students through completing problem sets faster. No gender difference in procrastination on problem sets was observed.

2.1.3.6 End of Course Survey

To examine students' perceptions about the practice tool and its features, we asked them to fill out a survey near the end of the course. To encourage honest feedback, there were no incentives for completing it and responses were anonymous. Eighty-three (43%) of the 193 students filled out the survey. The survey contained 20 questions on what the students found helpful, what could be improved, and student experiences with other practice tools.

Learning Students were positive about the practice tool and its effect on their learning. One student wrote, "Overall, the practice tool had helped me tremendously and I wouldn't have done this well in the course if there was no such tool." Another one wrote, "I am definitely stronger in the things I learned on the practice feature." They recognized the importance of practice. "I

	Effect on Final Grade	Std. Error
(Intercept)	-10.30	(11.17)
Practice Hours	1.04***	(0.25)
Studying Hours	0.05	(0.09)
Speed	0.36	(0.22)
Earliness	0.11***	(0.03)
GPA	10.34**	(3.18)
Math Score	0.91***	(0.24)
Pass/Fail (vs. Graded)	-7.93	(4.27)
Male (vs. Female)	5.17*	(2.17)
Junior (vs. Freshman)	9.11**	(3.00)
Senior (vs. Freshman)	10.28**	(3.72)
Sophomore (vs. Freshman)	5.87*	(2.41)
Asian (vs. White)	3.79	(2.38)
Other Ethn. (vs. White)	0.58	(2.95)
Non-native English	-2.04	(2.56)
Adj. R ²	0.39	
Num. obs.	181	
RMSE	12.60	

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 2.1: OLS regression results.

think classes like these require a lot of practice and then the concepts become easy, but most of the time there aren't enough resources to do so. This practice tool equipped us with ample amounts of practice!"

Spacing Algorithm Student responses suggest that students found the spacing algorithm useful. "I also like that it waits a certain number of days before asking you questions about specific concepts after you complete them the first time." Students also recognized the usefulness of revisiting previous topics. "The repetitive structure of the practice tool allowed me to reinforce older topics."

Spacing Feature More importantly, as opposed to previous studies that report students' dislike of the desirable difficulties, many students in our study found our design of spacing helpful. They were particularly interested in how they are incentivized to space their practice. "Having exposure to python every day is key to learning how to code. It's not like other things where you can just do work once a week." The other student wrote: "after I started getting used to doing the questions everyday I really wanted to keep up with it." Other students noticed how it helps them get more fluent in programming: "I like that it's a way for us to make sure we do a little work every day and keep concepts fresh in our minds. I find that helpful to keep me on top of things." The other one wrote: "I enjoyed the coding questions and having to use it around every other day, it helped a lot with fluency and problem solving."

Interleaving Feature Most studies on interleaving have notably reported that students prefer blocking. The way we modified SuperMemo 2 algorithm based on topics made interleaving enjoyable for students. They especially liked "the variety of different questions, because it helps remind me of/relearn past topics" Another student wrote, "The rotation of questions was extremely helpful." The other one noted, "I enjoyed the range of topics covered by the practice feature throughout the semester, especially those that would have potentially could have been forgotten if not practiced." They also mentioned, "It also kept me thinking about the smaller topics we learned at the beginning of the semester."

Schedule Visualization Several students found the schedule visualization shown in Figure 2.3 useful. "I found the progress meters for each topic to be helpful, indicating areas which I needed to review or practice more." However, some students did not recall seeing this feature. One student, who received an A in the course, still didn't use the practice tool much since that student still thought that the questions were selected at random. This indicates that this visualization could be improved so that more students notice it and understand that the spacing algorithm is not just selecting questions at random.

Progress Tracker Students found the progress tracker shown in Figure 2.2 useful. “I like that it gives you a countdown of how many days are left, and tells you how many questions you’ve answered so far that day.” Students also found the progress tracker motivating. “The number of questions on the screen that I have to complete - it motivates me to keep practicing.”

Other Practice Tools Multiple students preferred our practice tool to Problem Roulett. One of them wrote: “I started using the ‘Problem Roulett’ practice tool from Stats 250 after I realized the impact that this practice tool had on my knowledge of python. This tool had many more questions than the statistics tool and the encouragement for students to complete just 10 questions a day motivated students to use the tool more, rather than just leading up to the exam (which is mostly when I used the statistics tool).”

2.1.4 Discussion

RQ1: The practice tool and grading scheme were designed to encourage spaced (rather than massed) practice. To gain the maximum possible points, students had to use the tool on at least 45 days during the semester. It was possible that students still mass their practice in a block of days before the midterm and final, but as shown in Figure 2.5 practice was spread out over the entire semester. This provides evidence of the effectiveness of the tool and grading scheme for encouraging spaced practice over massed practice.

RQ2: Of the 193 students, 62 (32%) used the practice tool for more than the required number of days. The end-of-semester survey provided evidence that students found the practice tool useful, perceived that it improved their understanding, and helped them track their progress. These findings provide evidence that the practice tool design and grading system which incorporated elements from self-determination theory and gameful design overcome students’ typically negative reaction to desirable difficulties.

RQ3: The regression analysis showed that every hour of using the practice tool correlated with on average 1.04% increase in their final grades, even after controlling for potential confounds. Besides, there was no significant correlation between the number of hours the students used the e-book outside of the practice tool and their final grades. This suggests that not all time on task is equivalent; there appears to be something special about the practice tool. Since the time using the e-book outside of the practice tool may include preparation for lecture, review after lecture, and student-directed practice, we can not make strong conclusions about exactly what was better about using the practice tool. However, the theory of desirable difficulties predicts that spaced, interleaved, and retrieval practice should improve long-term retention of concepts.

2.1.5 Limitations

We conducted this study on undergraduate students in an introductory programming course at the University of Michigan. The results may not be generalizable to other courses, universities, or countries. More studies should be done to verify these findings in a wide variety of contexts.

Students who used the practice tool may have also practiced outside of the e-book environment, for example, with flashcards or in study groups. More studies should be done to verify that the correlation with exam grades is not at least partially due to unmeasured external practice.

It is well known that practice can improve learning (33). This study does not separate the effect of more practice of all kinds from the effect of the particular kind of practice embodied in this tool: spaced, interleaved, retrieval practice. Additional studies should be done to isolate the effect from this type of practice.

2.1.6 Conclusion

Desirable difficulties impede short-term learning but significantly enhance long-term learning and transfer. These techniques include spacing practice, interleaving topics during practice, and retrieval practice (testing). However, students tend to hold negative perceptions about these techniques.

We improved the SuperMemo 2 algorithm and used ideas from gameful design to create a practice tool that was integrated into an e-book platform. The tool automatically reused the interactive exercises in the e-book to provide personalized spaced and interleaved retrieval practice. Students earned points per day of use, rather than per question, to encourage spacing activity out over the entire semester. We replaced questions with topics of questions and refined the measure of assessment in SuperMemo 2. Gameful features included unlimited attempts at answering each question with no penalty, feedback about progress toward the daily and semester-long goals, and celebration of the completion of daily goals.

The tool successfully encouraged spaced practice, a high percentage (32%) of the students used the tool more than required, and use of the tool correlated with higher exam grades. This tool is already integrated into an open-source e-book platform, Runestone, which has over 25,000 users a day. We encourage others to use and test this tool in their programming courses.

2.2 Study 2 - Counting Days: A Spacing Incentive that Unlocks Low-GPA Students' Potential

The science of learning and memory has identified a set of “desirable difficulties,” so-called because they contribute to learning. Students find them challenging and may not recognize their value (46; 84; 30; 191; 29). Zepeda et al. (191) argued a need for mechanisms to motivate students “to embrace or, at minimum cope, with [these] difficulties.”

Spacing is one of these desirable difficulties. The spacing effect is “one of the most robust and reliable effects in all of memory research” (159). The “new theory of disuse” explains it as long-term learning resulting from forgetting between study sessions (29; 27).

However, students incorrectly perceive that spacing leads to lower performance (46; 84; 30; 191; 123; 102); massing, by contrast, creates an “illusion of mastery” (46; 29). Although massing may help with short-term retention, when it comes to long-term learning, spaced practice delivers higher scores as compared to massed learning the same material (165; 130). Both students and instructors also find spacing challenging and they tend to think that more effort means less effective learning, which negatively affects their willingness to use spacing (102; 46; 45). Even if instructors encourage spacing and students set an intention to do so, they rarely maintain the habit (30). Left to their own devices, students cram for exams rather than studying a little every day (30; 83; 163; 128). Students who were asked about their judgment of learning reported massing as more effective than spacing, even after experiencing the effectiveness of spacing (102; 46). Changing beliefs is not a swift or straightforward process, particularly through singular actions like demonstrating a learning method just once (193; 105; 44). For lasting impact, it’s crucial to integrate sustained interventions within the educational framework, allowing for consistent application of effective strategies and an opportunity to observe their long-term results (23; 46; 44).

Insufficient spacing may be especially problematic for low-performing students. A large-scale observational study (47) on a psychology MOOC found that low-ability students, and those who are more likely to leave assignments incomplete, benefit more from spacing. Hartwig and Dunlosky (83) discovered that students with lower GPAs are more likely to make their study decisions based on deadlines and engage in cramming. Finn (73) identified differences in study habits as one factor that explains differences in student performance. Thus, interventions that lead students to successfully engage in spacing may help lower-GPA students to achieve up to their potential.

Incentives for frequent activity have been implemented in video games (77), language learning (89), and fitness (129). The most common form is a gamification of “streaks,” where missing a day of activity breaks the sequence, restarting the counter at zero. This can motivate people to extend streaks, especially once they are long. For example, on Duolingo, learners with longer streaks were more likely to extend their streaks for another day (89). Another form counts days of activity

without requiring an uninterrupted streak. For example, one exercise app encouraged participants to set a goal for the number of days in a week that they would exceed a step-count threshold (129).

Following the latter idea, we designed a grade-based incentive that rewards the number of active days. Students earn course points for each day with sufficient activity; we call this mechanism “counting days.” The rationale behind this incentive design is that it only rewards spaced activity. An equivalent amount of total activity massed on the few days just before the exams would not earn the same number of course points. We designed the spacing to be daily because it was found that spacing is more beneficial at 24-hour intervals rather than shorter ones such as 30 minutes (192).

We implemented the counting days incentive in a retrieval practice tool. Retrieval practice happens when previously learned information is retrieved from memory, typically by answering a question. It has been found to improve long-term learning (95; 96; 146) and protect memory against acute stress (158). Retrieval practice is especially helpful when spaced rather than massed (29; 159; 107).

In the first semester of deployment (the first study in this chapter), all students had the counting days grading incentive. More practice was correlated with higher exam performance (185). Here, we report on randomized controlled experiments, where some students or entire classes were assigned to a counting days condition and others to a control condition that incentivized more practice rather than practice on more days.

2.2.1 Experiments Design

Both experiments used the same technical apparatus, a retrieval practice tool that is built into the [Runestone online textbook platform](#) (185). It presents a student with one question at a time, drawn from a bank of questions associated with a textbook, divided into topics defined by that textbook. Once a topic is covered in the course, it is scheduled to be visited in the practice tool.

When a student loads the webpage for the practice tool, they see a question selected from one of the topics scheduled to be visited or revisited that day. If a student answers questions from a topic quickly and correctly, the topic is scheduled to be revisited many days later; if not, it is scheduled for sooner. The algorithm spreads topics over multiple sessions but does not automatically induce students to engage in many practice sessions on different days.

The first experiment involved students in a single offering of an introductory Python programming course at a large public university who were randomized to either the counting days condition or a control condition. The textbook’s question bank had 400 questions covering 177 topics.

Ten percent of the course grade, 100 points, was based on the use of the practice tool. Students were randomly assigned to one of two treatment conditions that varied the spacing incentive:

- Counting Questions (control): each student could earn a quarter of a point per question for correctly answering up to 400 questions. Above the question that was presented, the student saw text like the following:

48 more questions are available to practice today.

So far, you've received 60 points out of 100 possible points for answering 240 questions out of 400 questions to complete your practice.

30 days are remaining until the end of the practicing period this semester.

- Counting Days (treatment): each student could earn two and a half points each day that they correctly answered either ten questions or questions on all the topics scheduled for practice on that day, for up to 40 days during the semester. Students did not earn additional points for correctly answering more than ten questions on a single day. When a student loaded the web page for the practice tool, above the question that was presented, they saw text like the following:

7 questions left to get today's point.

48 more questions are available to practice today.

So far, you've received 60 points out of 100 possible points for completing 24 days out of 40 days of your review practice.

30 days are remaining until the end of the practicing period this semester.

The supplementary document includes details of random assignments and course dropout rates. We restricted our analysis to the 143 undergraduates who were enrolled as full-time students, completed the course for a letter grade, and had a prior GPA (i.e., not first-semester students).

Final exam scores were the primary outcome measure. We first conducted a t-test to examine whether exam scores were higher in the counting days group. To assess whether the counting days treatment reduced the gap in performance between low- and high-GPA students, we estimated a Beta regression model with an interaction term between the treatment and GPA.

To better understand the mechanism by which the treatment helped low-GPA students, we conducted a mediation analysis using Generalized Structural Equation Modeling (GSEM). We assume that prior GPA, as an indicator of the effectiveness of the student's normal study habits, affects the amount and spacing of practice and, through other unobserved study behaviors, also affects the final exam score. The full model specifications are included in the supplemental materials. The path diagram (with results) is shown in Figure 2.11.

The models include control variables for sex, ethnicity, academic level, and native language (English or not). Because of randomization, both controls and GPA are drawn from the same

distributions in both conditions. However, the relationship between GPA and exam scores may be affected by the controls, and thus it is appropriate to include controls in the models. For robustness checks, in the supplementary material, we report our results with and without controls.

We conducted a second RCT to check the robustness of the behavioral impact of the treatment on spacing. In this between-instructor experiment, randomization occurred at the level of instructors, with random assignment of 71 high school and college instructors teaching introductory computer programming courses to 1,653 students. All instructors covered the same fundamentals of Java programming course in the United States, using identical learning materials, practice questions, weekly assignments, and exams.

In the counting days treatment group, 44 instructors taught 996 students who earned grading points for each day they answered ten questions correctly. In the counting questions group, 27 instructors taught 657 students who received grading points on a per-question basis rather than per day⁵. If an instructor taught multiple classes in the same semester or across different semesters, all their students were assigned the same condition.

For the second experiment, we received anonymized data and did not have access to GPAs, exam scores, or control variables. As such, we only compared the effects of the counting days and counting questions conditions on the number of days and questions practiced throughout the corresponding semester. For statistical tests, we conducted t-tests and Wilcoxon rank-sum tests.

2.2.2 Results

We begin with the results of the within-class controlled experiment. The mean final exam score in the counting days treatment was 85.33%. In the counting questions condition, it was 81.73%. The difference was significant ($z = -2.282, p < 0.05$).

⁵The difference in sample sizes between the two conditions is because post-randomization several instructors only created test courses or decided not to teach the course after creating it.

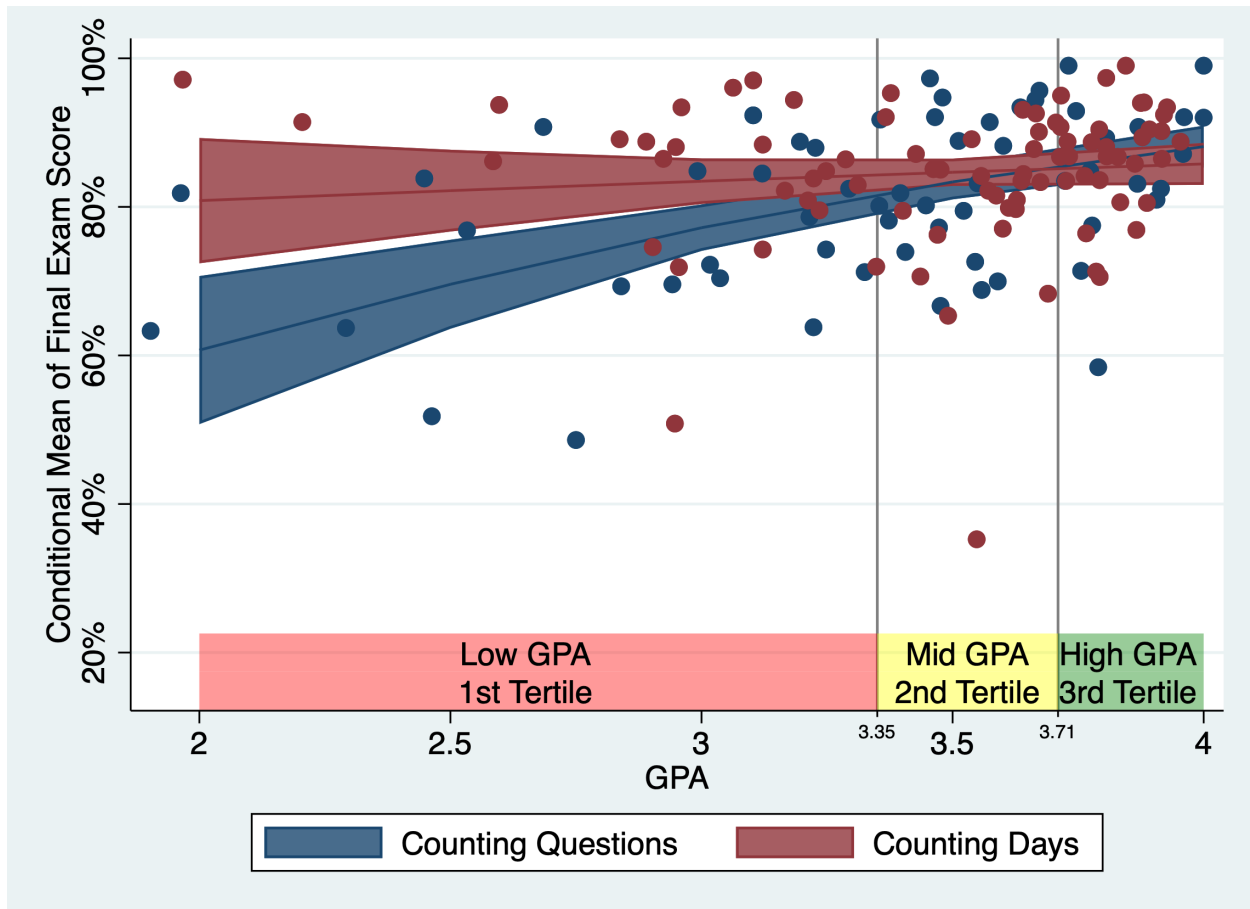


Figure 2.9: Predicted final exam scores with 95% Confidence Intervals. The estimated effect of GPA on final exam scores across the experimental conditions based on the Beta regression model predictions of the within-class experiment.

Figure 2.9 plots the predicted means of final exam score as a function of GPA. The counting days incentive was helpful overall, and especially helpful to lower-GPA students. Regression results in Table A.8 in the supplementary materials confirm that the coefficients on the treatment and the interaction of treatment with GPA were both significant ($p < 0.05$).

Figure 2.10 shows that the counting days incentive was effective at influencing student behavior to space out their practice, while counting questions students procrastinated until late in the semester. It plots the difference in the average number of questions answered by students in the two conditions, on each day. On most days, students in the counting days condition answered more questions. At the end of the semester, this was reversed.

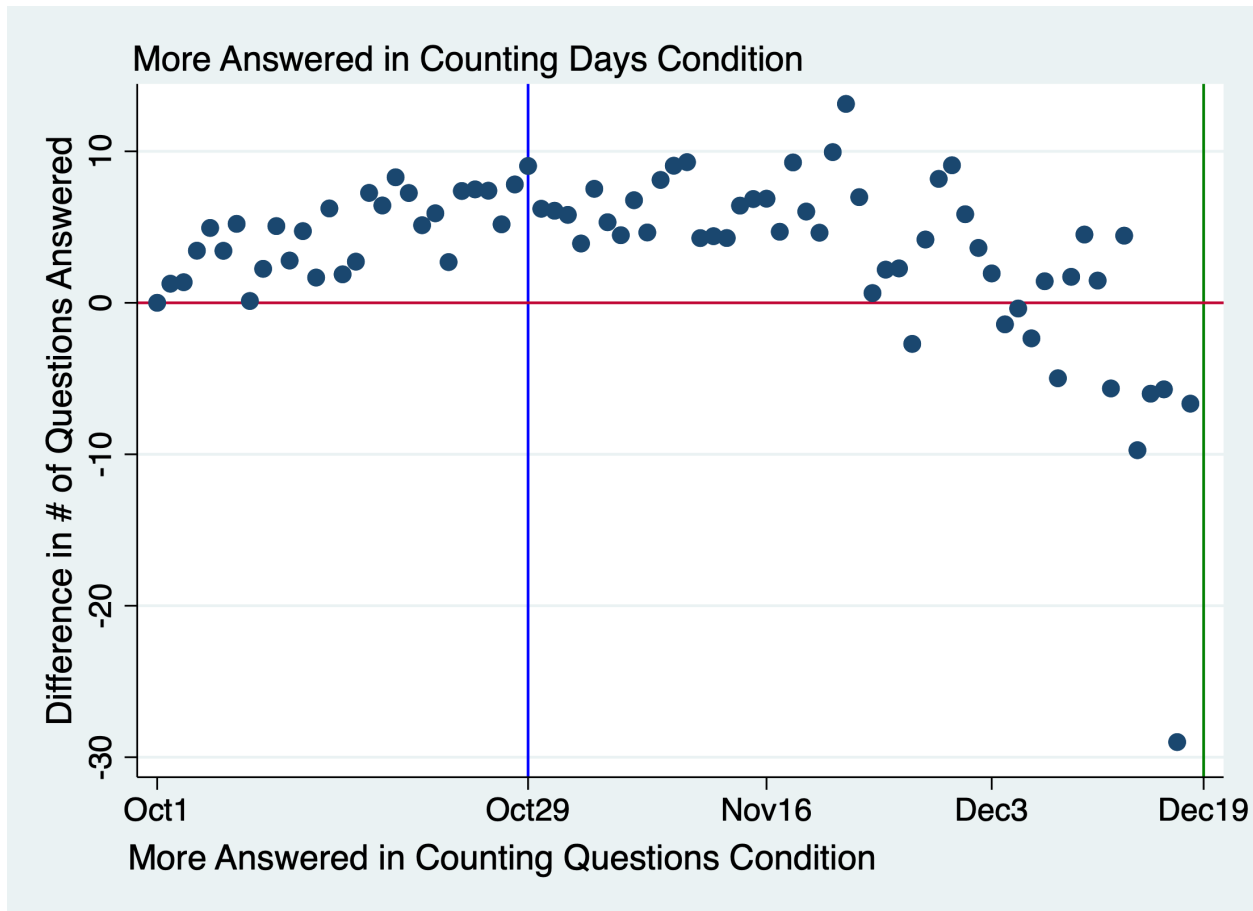


Figure 2.10: Comparing procrastination patterns between students in the counting days and counting questions conditions in the within-class experiment. Each dot represents the daily difference between the average number of questions answered by students in the counting days and counting questions groups. Dots above the red line indicate that more questions were answered, on average, in the counting days than in the counting questions condition. The blue line shows the midterm exam date and the green line the final exam date.

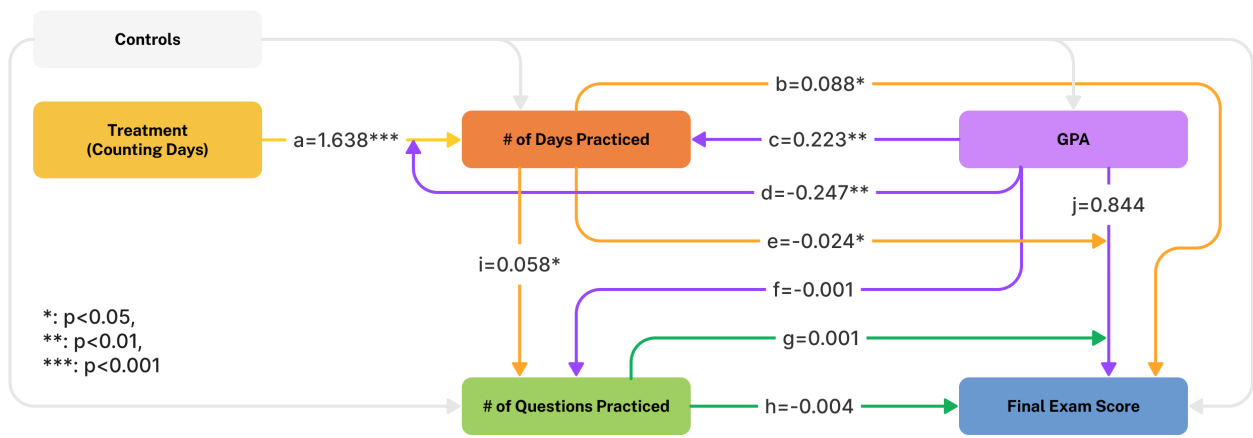


Figure 2.11: GSEM of the mediated effects of the treatment in the within-class experiment. Each box represents a variable. The arrows illustrate the direction of the effect. The arrows pointing to other arrows indicate interaction effects.

Figure 2.11 shows the results of the GSEM analysis. The treatment had a large impact on the number of days practiced (*a*). Students with higher GPA practiced on more days (*c*) but the effect of the treatment on practice days was smaller for those with higher GPA (*d*). More days of practice was positively correlated with the total number of questions practiced (*i*). More days of practice increased exam scores (*b*) and *decreased* the correlation between GPA and exam scores (*e*). We do not observe any significant effect of the number of questions practiced on the final exam score (*h*) or its interaction effect on the correlation of GPA and final exam score (*g*). Overall, the analysis shows that the treatment's impact on both exam scores and the correlation between prior GPA and exam scores were mediated almost entirely by the number of days practiced.

Note that the effects shown in the figure of more days of practice are controlling for the number of questions answered. Thus, the positive coefficient $b = 0.088$ implies that, for a pool of students with the same GPA who answered the same total number of questions, spacing out that practice over more days was associated with higher exam scores. Similarly, spacing out practice over more days was associated with a reduction in the correlation of prior GPA with exam scores ($e = -0.024$).

To provide intuitions about the mediation, we plot estimated effects based on marginal means post-estimation from the GSEM analysis. Figure 2.12 shows the effects of GPA and treatment on the number of days practiced. The counting days incentive was highly effective at altering student behavior at all levels of GPA: the number of days practiced more than doubled.

In the between-instructor experiment, students in the counting days condition practiced on 17.336 days on average, while those in the counting questions condition practiced for 11.927 days on average. Both the t-test and rank-sum test confirm that the difference was statistically significant, as shown in Table A.7. Also, similar to the within-class GSEM results, there was no statistically significant difference observed in the number of questions practiced across the two conditions.

2.2.3 Conclusion and Discussion

Our results establish two surprising findings. First, a small change in incentives led to a large change in the number of days of practice, as evidenced by both within-class and between-instructor experiments. From the within-class experiment, we find that it had a slightly larger behavioral effect for lower GPA students, but the effect was large for the high GPA students as well.

Second, in the within-class experiment, spaced practicing nearly equalized exam performance for students with low and high GPAs in prior courses. For the highest GPA students, the spacing incentive was not correlated with higher exam performance, even though it was effective at inducing more spaced practice. This may indicate that higher-GPA students with lower practice days

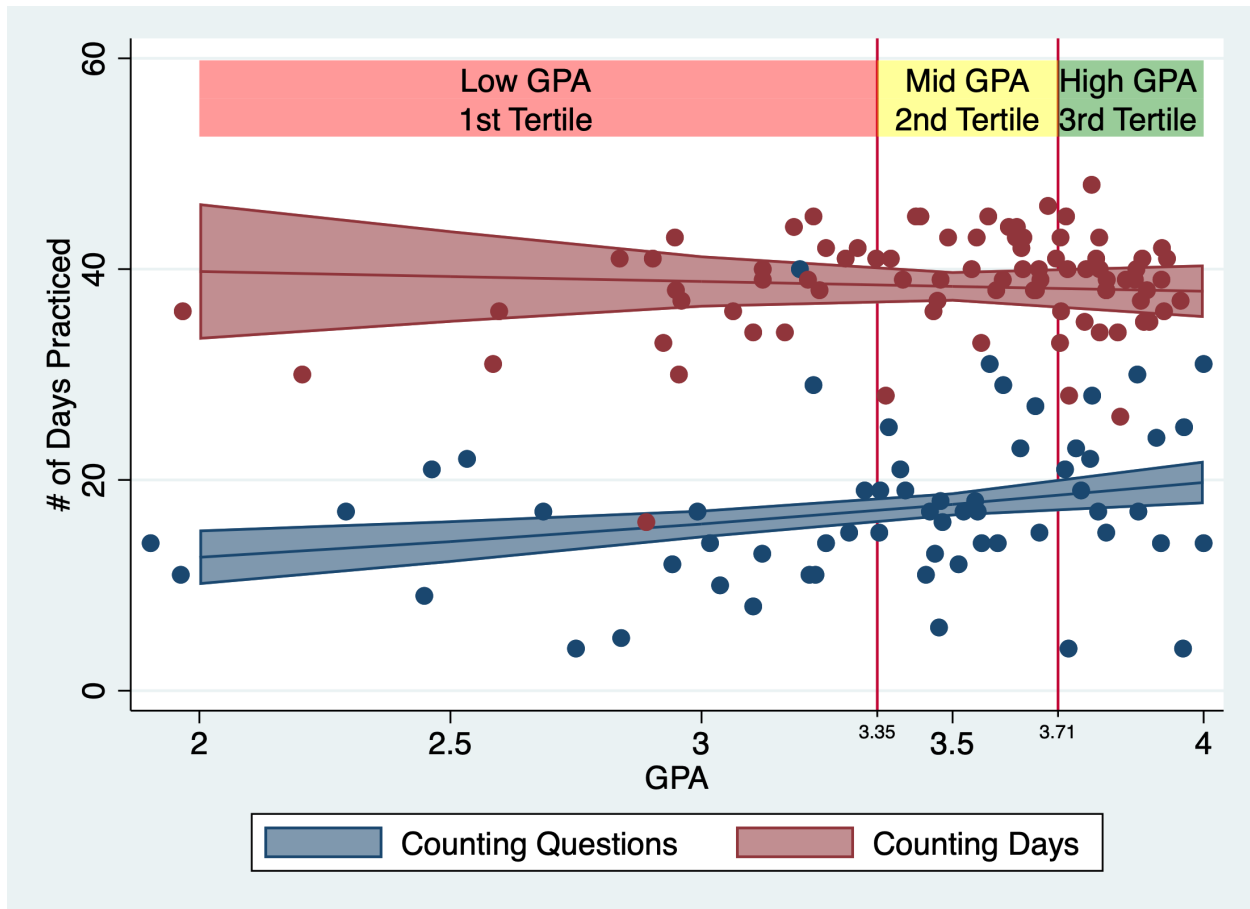


Figure 2.12: Predictive margins of counting days incentive with 95% confidence intervals. Estimated effects of GPA on number of days practiced for each of the experimental conditions in the within-class experiment.

were already employing other effective study strategies, including spaced use of other materials. In contrast, for the lowest GPA students the spacing induced by the treatment led to better exam performance.

It seems implausible that the counting days grading incentive, applied to a small portion of the course grade, will always be sufficient to nearly equalize the exam performance of low- and high-GPA students (Figure 2.9). The supplementary materials include analyses for three other semesters where all students had the counting days treatment. In all three semesters, the vast majority of students used the practice tool on more than 30 days, suggesting that the incentive was effective at inducing spacing behavior. The correlation between GPA and exam scores was negligible in one semester (Figure A.4), but not the other two (Figures A.2 and A.3).

Helping low-GPA students perform up to their potential is an important educational goal that has inspired experimentation with course activities and structures, e.g., (76). Due to the experimentally proven advantages of spacing, multiple studies have argued that instructors should exhort their

students to study more often, not just study more (159; 93). Our results suggest that it is most important to induce spaced studying among low-achieving students, to help them achieve up to their potential.

Counting days is a simple grading incentive that had a large impact in inducing spacing (Figure 2.10). It is relatively easy to implement for activities that are delivered and tracked through course management systems. We encourage the integration of the counting days approach into courses, either through grading incentives or other creative elements, as part of a campaign to induce students to adopt spaced studying strategies.

2.3 Conclusion

This chapter synthesized the findings from two studies exploring the implementation of “spaced retrieval practice” within the context of an introductory Python programming course. The first study introduced the design of a spaced, interleaved retrieval practice tool and its design features to improve students’ learning and motivation to space out their retrieval practice. The second study focused on the use of one of those design features, “counting days” as a simple yet innovative grading incentive, to encourage students to distribute their retrieval practice over multiple days, enhancing learning outcomes and final exam scores.

2.3.1 Key Findings

The first study reported the design of a tailored SuperMemo 2 algorithm and used ideas from gameful design to create a practice tool that was integrated into an e-book platform. We replaced questions with topics of questions and refined the measure of assessment in SuperMemo 2. Gameful features included unlimited attempts at answering each question with no penalty, feedback about progress toward the daily and semester-long goals, and celebration of the completion of daily goals. A high percentage (32%) of the students used the practice tool more than required and the use of the tool correlated with higher exam grades.

In the second study, the first randomized controlled trial (RCT) demonstrated that students who practiced under the counting days condition performed significantly better in exams than those in the control group. This improvement was most notable among lower-GPA students, indicating that spacing practice over more days can be particularly beneficial for students who might otherwise struggle academically. The second RCT, conducted at the instructor level, echoed these findings, showing increased usage of the practice tool under the counting days condition, although specific GPA and performance data were not available.

Moreover, the studies revealed two surprising outcomes. Firstly, a minor change in the grading

incentive led to a substantial increase in the number of practice days. Secondly, spaced practice nearly equalized exam performance among students with varying GPAs, highlighting the potential of this approach to level the academic playing field. However, for high-GPA students, the spacing incentive did not correlate with higher exam performance, possibly because these students were already employing effective study strategies, including spaced practice of other course materials besides our practice tool.

2.3.2 Implications for Future Research

The findings from these studies in Chapter 2 not only reinforce the efficacy of spaced retrieval practice in enhancing memory retention but also align with the central theme of my dissertation: optimizing learning through the innovative structuring of micro-topics within the Knowledge Graph of Micro-topics arranged in Learning Pathways (KGMLP).

The significant improvement in exam performance among students, particularly those with lower GPAs, under the counting days condition, underscores the potential of spaced retrieval to democratize learning. This aligns with the dissertation's goal of creating adaptable and personalized learning experiences through micro-topics and learning pathways. The observed leveling of academic performance across different GPA groups resonates with the KGMLP's aim to cater to diverse learning needs and paces.

Looking ahead, the plan to enhance the KGMLP such that answers on downstream topics might change the schedule for presenting prerequisite topics, and the integration of a Large Language Model (LLM) agent, promises to further this goal. The development of an advanced spaced repetition algorithm that adapts to individual student responses will not only refine the KGMLP framework but also embody the dissertation's commitment to leveraging technology for personalized, efficient, and engaging learning experiences.

As we venture into future research, the focus will be on seamlessly integrating these innovations into the KGMLP structure. This integration will ensure that the benefits of spaced retrieval practice are maximized, aligning with the overarching aim of the dissertation: to revolutionize learning by structuring micro-topics into effective learning pathways that support diverse cognitive processes in Bloom's digital taxonomy. Thus, the advancements proposed here are not just enhancements to a learning tool; they are integral steps towards realizing a more dynamic, responsive, and inclusive educational model, as envisioned in this dissertation.

CHAPTER 3

Hybrid Map: Visualized Learning Pathways Between Micro-Topic Paragraphs Improve Readability, Recognition, and Recall Compared to Novakian Concept Maps

Visual-spatial thinkers need to see to think.

Bette Fetter

In this dissertation, we delve into the nuanced interplay between Knowledge Graphs of Micro-topics arranged into Learning Pathways (KGMLP) and their implications for learning. Chapter 3 stands at the crossroads of this exploration, shedding light on two pivotal aspects: the visual presentation of learning pathways and the optimal granularity of micro-topics. We address the uncertainty surrounding the size of micro-topics within KGMLP. Through our experimental insights, we challenge the convention of overly concise micro-topics, demonstrating that a full paragraph serves as an effective size unit, particularly in the context of reading comprehension. This chapter, therefore, not only aligns with but also enriches the core theme of the dissertation, offering a more defined and evidence-based understanding of the components of KGMLP and their impact on learning outcomes. These revelations contribute to refining our approach towards creating more dynamic and efficacious educational tools and methodologies in the digital learning landscape.

Studying pre-constructed concept maps, compared to linear text, has been reported by multiple meta-analyses to stimulate meta-cognitive prompts, enhancing the learning process, knowledge retention and transfer (156; 132; 87). Concept maps provide a visual structure, facilitating meaningful learning by forming connections between concepts and ideas (136). Patterson et al. (144) explain that concept maps help distribute the cognitive load between visual and verbal channels of working memory, preventing overload.

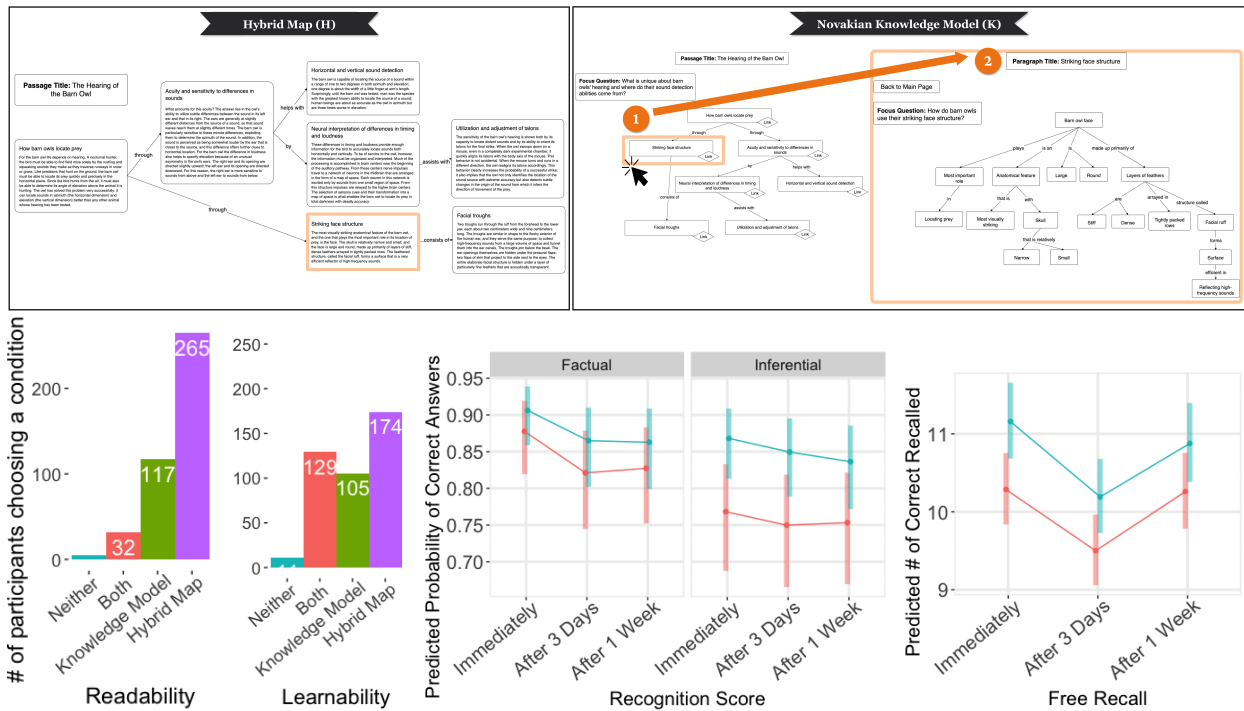


Figure 3.1: A visual summary of the experiment design and its quantitative results.

However, we posit¹ that there are still advantages to studying linear text, which remains the most common format for teaching and learning. Previous studies have often compared studying linear text and concept maps as if they are black boxes, without considering the benefits of certain features in linear text, in favor of features provided by concept maps. Moreover, the ability of concept maps to enhance learning is diminished when representing longer or more complex text (109). Krieglstein et al. (109) provide further insights into the design and complexity of concept maps and their impact on learning processes. Their study explores how the salience of the map structure and the number of nodes per sub-concept affect cognitive learning, particularly in terms of disorientation and cognitive load (109). The findings suggest that the design of concept maps, including their structural clarity, plays a crucial role in facilitating learning. This supports our proposition of a new model, which aims to optimize the presentation of complex information by integrating the clarity of linear text with the structured visual representation of concept maps.

We propose a new model, called “Hybrid Map,” which combines the benefits of linear text and concept maps. The Hybrid Map visualizes main concepts as nodes and their relations as arrows, while using linear text to explain each of these key concepts within the body of the node. This

¹This chapter is based on an under-review paper, co-authored with Tirdad Barghi, Jessica Cai, Jeffery Phonn, Benjamin Brown, Louwis Truong, Ember Shan, Winnifer Chen, Molly Kraine, Zoe Dunnum, Amelia Henriques, Rani Kang, Cynthia Lee, Yizhou Chao, Ziyi Wang, Xiaowen Yuan, Paul Resnick. The contents are only lightly edited.

approach brings together the features of linear and non-linear representation to create a Hybrid Map that is easier to follow due to its focus on main topics, resulting in fewer nodes and links.

Concept maps are defined as a set of categories, with the relationship between these categories expressed through connections with linking phrases (43, p. 129). In this study, we refer to concept maps as defined by Novak and Cañas (135), which consist of three building blocks: concepts (nodes), relations (links), and propositions. Propositions are meaningful statements formed by connecting pairs of concepts via their linking phrases (134; 135). Cañas et al. (42, 43) encourage reducing the size of nodes. Each node should include only a few words, and each map should be small enough to answer a single focus question (135; 43). Typically, a single concept map communicates content that might be shared in a single paragraph of linear text. We will call this unit of content a *paragraph*, whether it is represented as linear text or as a concept map. Each sentence is usually expressed with nouns in the nodes and verb phrases in links such that two nodes and their link typically represent a sentence. One of the many use cases of Novakian concept maps is for knowledge sharing and communication (134; 52; 88; 135; 43). However, for communicating larger bodies of content comprised of multiple paragraphs, additional structure may be helpful. To address this, Cañas et al. (43) introduced “Knowledge Models,” which consist of hyperlinked concept maps.

In this study, we conducted an online, controlled, within-subject experiment to compare Novakian Knowledge Models with their corresponding Hybrid Maps on college-level course content. Text passages were represented both as Novakian Knowledge Models and as Hybrid Maps and each subject interacted with two passages, one in each representation. After reading a passage, a participant answered multiple-choice questions and free-recall questions. Our primary analysis is quantitative, assessing differences between experiment conditions on the following outcomes:

- **Recognition:** Reading comprehension multiple-choice questions
- **Recall:** Free-recall responses
- **Readability:** Self-reported perceptions of readability
- **Learnability:** Self-reported perceptions of learnability

We measured these outcomes in three sessions, during and immediately after reading the passages, three days later for delayed tests, and seven days later for long-term tests.

To provide further insight into why people perceived one representation or the other to be better for readability and learnability, we elicited free-text explanations for their self-reported perceptions. We conducted a qualitative analysis of these explanations by thematically coding for perceived reasons for preferring one condition over the other. We followed a grounded theory ap-

proach, where we gradually identified themes as we coded the responses and step-by-step merged the codes and generated broader themes until we reached saturation.

3.1 Related Work

Burkhard (38, p. 3) defines knowledge visualization as “the use of visual representations to improve the transfer and creation of knowledge between at least two persons.” Knowledge maps, mind maps, argument maps, and concept maps are all examples of knowledge visualization tools, each with their unique characteristics and purposes (69; 125; 39; 58).

Knowledge maps serve more as an inventory or index to find information rather than as a tool to explore relationships between concepts. Mind maps, on the other hand, use nodes that all connect back to a central node that serves as the focus question. They employ a “radial hierarchy” where there is a taxonomy of concepts on each branch that extends from a central point. The guidelines provided by Buzan (39) establish that a mind map is free form and should be adapted to the preference of the creator, using images, colors, and emphasis in whatever way provides meaning to them.

Argument maps, like mind maps, display relationships between concepts. However, they serve a different purpose and have stricter design guidelines. They are organized in a top-down hierarchy with a contention at the top and strings of linked claims supporting or opposing it which terminate in a final node that provides evidence for the string of claims. While mind maps are less structured and can be used to explore many types of relationships, argument maps are specifically designed to display “logical inferences between propositions” (58).

Concept maps are similar to mind maps and argument maps. They feature a top-down hierarchical organization and are more structured than mind maps. While argument maps are designed specifically to visualize relationships between propositions and information that supports or rebuts it, concept maps can display causal and other relationships.

3.1.1 Concept Maps

Inspired by Ausubel’s assimilation theory of meaningful learning (18), Novak and Gowin (136) introduced concept maps as “graphical tools for organizing and representing knowledge” (135, p. 1). They have a “hierarchical organization, with the most general, most inclusive concepts at the top, and progressively more specific, less inclusive concepts at lower levels” (43, p. 8). Connecting pairs of concepts with their linking words form meaningful statements called “propositions” (134; 135). Novak and Cañas have provided guidelines for designing effective concept maps (135; 43; 101; 100; 42):

- Each node (concept) consists of only a few words.
- Each concept map is limited to answer only one focus question.
- Relations have linking words (short labels).
- Linking words are limited to only one to three words.
- Necessary cross-links connect sections of a concept map.
- Each concept has no more than three to four sub-concepts.
- “String maps” are discouraged.

Some of the criteria for an “excellent” concept map are more ephemeral. Cañas et al. (42) state that an excellent concept map should respond to a focus question, explain the response with clarity, be concise, be thorough, and have high clarity. Concept maps must provide knowledge that contains content and is organized in such a way that it addresses the focus question. Beyond that, it must be both concise and thorough such that it provides all relevant information and includes no irrelevant information. Finally, it must have clarity such that it can be easily interpreted and understood.

3.1.2 Applications of Concept Maps

Concept maps, compared to other knowledge visualization methods, are structured enough to be used by others. That is to say, there is uniformity in how they are produced such that readers can anticipate what to expect. This contrasts with mind maps which are free-form. Furthermore, concept maps allow flexibility in the types of relationships displayed, which differs from knowledge maps that categorize information and argument maps that track supporting or objecting claims to a specific argument. Concept Maps are widely used to improve students’ interactions with learning materials and facilitate their learning. Concept maps are used to:

- Support online video learning and reflection (164; 118)
- Improve Reading Comprehension (168)
- Improve understanding of scientific argumentations Lu et al. (121)
- Support effective navigation through learning materials (169; 170)
- Assess students’ learning (155; 62)
- Draw relations between online educational videos (119)

- Organize ideas (142)
- Augment online labs Nedungadi et al. (131)
- Enhance effective knowledge sharing (152)

3.1.3 Advantages of Studying Pre-constructed Concept Maps Over Linear Text

Studying pre-constructed concept maps, as opposed to linear text, has been shown to stimulate meta-cognitive prompts, thereby enhancing the learning process (156; 87; 132). Wong et al. (180) demonstrated that students studying static concept maps performed better than those using fill-in-the-blank concept maps. Concept maps facilitate understanding of relationships during the learning process (136). They promote meaningful learning by helping to form connections between concepts and ideas, contrasting with rote learning that involves mere memorization (156). Meaningful learning occurs when new knowledge is connected to prior knowledge (135).

Horton et al. (87) reported learning advantages of studying teacher-prepared concept maps. Patterson et al. (144) elucidate that concept maps, unlike text, help distribute the cognitive load between the visual and verbal channels of working memory, thus preventing verbal working memory overload (144).

Nesbit and Adesope (132) conducted a meta-analysis on learning with concept maps. They reviewed 67 standardized mean difference effect sizes from 55 studies involving 5,818 participants. The results showed the benefits of studying pre-constructed concept maps across a broad range of educational levels, subject areas, and settings.

Schroeder et al. (156) conducted a comprehensive meta-analysis on the effectiveness of studying and constructing concept maps. They synthesized the results of 142 independent effect sizes, involving 11,814 participants, and found that studying pre-constructed concept maps improves learning, compared to studying linear text, attending discussions or lectures, and creating or studying outlines or lists. The results were consistent across various knowledge domains, including science, technology, engineering, and math (STEM) and non-STEM subjects.

Schroeder et al. (156) observed that when studying pre-constructed concept maps by learners, the type of concept map used (interactive, animated, static, or a mix thereof) did not significantly influence differences among the groups. They highlight their efficacy, echoing assertions by Amadiou et al. (7); O'donnell et al. (137). They note that these maps prominently display essential semantic attributes, including concept interrelations, hierarchical structures, and concept centrality. Furthermore, they argue that students expend less cognitive effort in discerning these features from concept maps as opposed to textual materials.

However, Schroeder et al. (156) found significant differences in the effectiveness of studying pre-constructed concept maps across academic levels. It was significantly more effective for intermediate-level students (in grades four to eight) and secondary students (in grades nine to twelve), compared to postsecondary students.

3.1.4 Limitations and Drawbacks of Concept Maps

Limitations to reading concept maps include difficulties identifying the order of branches in the hierarchy, conveying complex concepts in a few words, and scalability.

Learners need to break down concept maps into sequences (propositions) under different topics because the exact sequence of the original, linear text cannot be easily inferred from the concept map (136). Áhlberg (6) also avers that concept maps representing a textbook need to be read in a specific order to convey the same meaning that the author intended. Similarly, Lambiotte et al. (112) reported students' difficulties in finding the right order to study the branches of a concept map.

The brevity of each node (concept) is also a problem. Áhlberg (6) found the limited number of words in each node (concept) insufficient to properly convey complex information. Dansereau (57, p. 76) argued that nodes with only a few words may “contain insufficient detail and richness for expressing complex and ambiguous relationships”.

The third category of concept map limitations concerns their scalability. Krieglstein et al. (109) examined how the structure (i.e., the salience of the spatial relationship between individual concepts) and the complexity (i.e., number of nodes per topic) of concept maps affect learning outcomes and cognitive load. They found that concept maps with a low salience of map structure increased perceptions of disorientation and extraneous cognitive load, which may hinder learning. They also suggested that the number of nodes per topic should be limited to avoid overwhelming learners with too much information. Previously, through many studies on CmapTools, Cañas et al. (43) found that when concept maps are designed for knowledge sharing and communication, as the map gets larger it becomes more complex and less readable to others. “The large, dense concept maps were useless for this purpose” (43, p. 136). They also discussed (43, p. 135, 136):

Derbentseva and Kwantes (61) reported how concept maps that were constructed at a group or committee were not always well received when presented to decision makers. We have similar experience with use of concept maps in organizations, both with maps we built and maps built by others. . . . Looking at the maps it was clear that they were a great tool for him [the author], but were too complex and dense for a reader to follow.

3.1.5 Knowledge Models

Software applications such as CmapTools impose a restriction on the canvas size for maps to prevent an overload of concepts (43). This limitation, however, does not restrict users from mapping extensive content. An alternative approach provided by these applications is the creation of “Knowledge Models.” These models allow for the interlinking of smaller concept maps, rather than incorporating an excessive number of concepts and links into a single map (41).

A Novakian Knowledge Model is structured into multiple pages, with each page represented by a distinct concept map. The amount of content in each concept map within a Knowledge Model can be analogized to a paragraph in a linear text. However, unlike the sequential order of paragraphs in linear text, nodes in each concept map within a Knowledge Model can hyperlink to other concept maps, thereby forming a network structure.

3.2 Research Questions

To address some of the previously cited limitations of Knowledge Models that ignore the benefits of linear text, we introduce Hybrid Maps that visualize the relations between paragraphs while using linear text to describe concepts within paragraphs. While maintaining the benefits of linear text, the links between paragraphs help identify and visualize the main relationships found in complex text. The main object of inquiry in this study is whether Hybrid Maps are better than, worse than, or the same as Knowledge Models for reading comprehension, both immediately while reading and later on when the reading passage must be remembered rather than consulted.

Two outcome measures are subjectively perceived readability and learnability, which cognitive scientists refer to as “judgment of learning.” If students do not like a certain knowledge representation, regardless of how beneficial it might be to their learning, they may not actually use it to get the benefits. This leads to our first two research questions:

- **RQ1** Which representation do students perceive as more **readable**, Hybrid Map or Knowledge Model?
- **RQ2** Which representation do students perceive as more **learnable**, Hybrid Map or Knowledge Model?

The cognitive science literature has shown, however, that student perception of learning is not always well-matched with actual learning (159). Thus, it is important to measure reading comprehension and learning through task outcomes as well. The tasks can include answering multiple-choice questions, which are referred to as *recognition* questions. These may be *factual* or *inferential*. The tasks can also include *free recall*, where students generate text in response to an

open-ended prompt. Proponents of Novakian Knowledge Models have argued that they should be especially helpful for inferential recognition and free recall tasks (147; 134; 156). Thus, we pose specific research questions about the difference in reader performance on these different tasks. This leads to our next three research questions.

- **RQ3** With which representation do students perform better on *inferential recognition questions*, Hybrid Map or Knowledge Model?
- **RQ4** With which representation do students perform better on *factual recognition questions*, Hybrid Map or Knowledge Model?
- **RQ5** With which representation do students perform better on *free recall*, Hybrid Map or Knowledge Model?

While improving immediate recognition and recall is good, it is not enough. One of the claimed advantages of studying concept maps, compared to linear text, is that it improves long-term learning (134; 156). Thus, we examine outcomes for the five research questions both in an initial session and in sessions three and seven days later.

3.3 Experiment Design

We conducted a within-subject experiment with $n = 419$ participants. Each subject interacted with two passages, one represented as a Novakian Knowledge Model and the other as a Hybrid Map.

3.3.1 Reading comprehension passages and multiple-choice questions

To enhance the robustness of the results, rather than having all subjects work with the same two passages, we employed *nine* passages; each subject interacted with two of them. We included eight ACT reading comprehension passages from previous real exams, all of which were released by ACT or licensed to be used in test-prep material. ACT reading texts are categorized as either “literary narrative” or “informational texts.” The latter is further clustered into subject areas including “social sciences,” “humanities,” and “natural sciences” (3). We selected two passages from each category-subject area pairing. The ninth passage was constructed from a Novakian Knowledge Model released by the inventors of the Novakian concept mapping technique at Florida Institute for Human & Machine Cognition (IHMC)². All the passages in the Hybrid Map and Knowledge Model representations are available in Appendix 2.

²We obtained the Novakian Knowledge Model from <https://cmapskm.ihmc.us/>.

The ACT reading comprehension passages used in this study are on average 803 words (ranging from 690 to 933 words) and accompanied by *ten* multiple-choice questions with *four* corresponding answer choices. Their readability levels range from *below college level* to *appropriate college level* given students' ranks in college (mean Flesh-Kincaid Grade Level ³ = 11.57 (75); mean Smog index ⁴ = 13.62 (122)). We aimed to employ a range of passages to establish performance variability that could be understood by college students, exerting a reasonable effort level (190; 11). We provided the participants with 15 minutes to read each passage and answer the corresponding multiple-choice questions. While the ACT gives 10 minutes to the test-takers for the same task, we allowed participants up to 15 minutes, so that time pressure would have less of an impact on performance (36).

To better adapt the questions to our representation conditions, we made some slight modifications. For example, because the entire passage was not presented linearly we removed line numbers from the passages; thus, we had to remove any reference to line numbers or paragraph numbers from the questions. These edits did not change the meaning of the questions. In a few cases where questions became unanswerable once line or paragraph references were removed, we eliminated those questions altogether. We manually coded the questions as either factual or inferential. The total number of all, inferential, and factual questions for each passage are listed in Table 3.1. To ensure the compatibility and uniformity of both conditions, we fixed the order of questions for each passage, regardless of how that passage was presented to a subject.

In accordance with the concepts delineated in the passage, we formulated a total of 9 questions tailored for the CmapTools passage. These questions were categorized into three distinct types: true/false ($n = 3$), factual ($n = 3$), and inferential ($n = 3$), which necessitated a comprehensive understanding of the passage for accurate responses. Our objective was to ensure that the difficulty level and structure of these questions mirrored those found in the ACT questions. The complete set of multiple-choice questions can be found in Appendix 2.

3.3.2 ACT Reading Comprehension Test

Our experiment draws on reading passages and learner tasks from the ACT. The ACT is used as a standardized test for high school students applying to college. Every four-year university in the US, and more than 200 universities outside the US, accept and value the ACT exams (4). It consists of four sections – English, Mathematics, Reading, and Science (1). In particular, the ACT reading comprehension section consists of four passages, one from each of the following subcategories, defined by ACT: 1) literary narrative, 2) social sciences, 3) humanities, and 4) natural sciences (3). The latter three are usually referred to as “informational text” by ACT. Readings in ACT are

³<https://goodcalculators.com/flesch-kincaid-calculator/>

⁴<https://www.textcompare.org/readability/smog-index/>

Passage Index	Source	Topic	Inferential Qs	Factual Qs	Total Qs
1	ACT	Natural Sciences	6	4	10
2	ACT	Natural Sciences	4	5	9
3	ACT	Prose Fiction/Literary Narrative	6	4	10
4	ACT	Prose Fiction/Literary Narrative	7	3	10
5	ACT	Social Sciences	8	1	9
6	ACT	Social Sciences	4	4	8
7	ACT	Humanities	8	2	10
8	ACT	Humanities	5	4	9
9	CmapTools		3	6	9

Table 3.1: The first three columns show the passage index, the source which we retrieved the passage from, and its topic based on the ACT categorization. The fourth, fifth, and sixth columns tabulate the number of inferential, factual, and all questions we used for the pretest and recognition test on each passage.

from passages that students frequently come across in high school and first-year college courses (3). There are three types of ACT reading comprehension questions: “key ideas and details,” “craft and structure,” and “integration of knowledge and ideas” (2).

ACT complies with the Code of Fair Testing Practices in Education. This requires selecting the reading and test materials in a way that they are fair to “all test takers regardless of age, gender, disability, race, ethnicity, national origin, religion, sexual orientation, linguistic background, or other personal characteristics” (3, p. 17). Prior studies conducted by Stiggins et al. (162) and Ashmore and Cork (17) demonstrated the validity of using the ACT reading comprehension section as an indication of students’ reading abilities.

ACT reading materials are reviewed to ensure that they are not too easy or difficult for first-year college students (3, p. 26). For these reasons, ACT reading comprehension tests have been previously used by multiple studies in psychology and education literature (24; 138; 11; 97; 120; 85; 113; 66). ACT passages were chosen because distinctive features of these standardized tests are that they have constant difficulty during the experiment, and they ensure that the difficulty level does not exceed the capabilities of the participants (i.e., college students). Another important feature of standard tests like ACT is that the chosen topics are neutral academic subjects (24). The reading section of the ACT provides meticulously selected college-level reading material that is not specific to a single subject and has proven useful as a reading assessment in previous studies. The learning of the participants was evaluated using the free-recall method. Free recall is increasingly used as the measuring instrument of choice in adult academic settings due to its more accurate

scoring methodologies. Free recall calls for the individual to write whatever they can remember about the topic matter without cues (148).

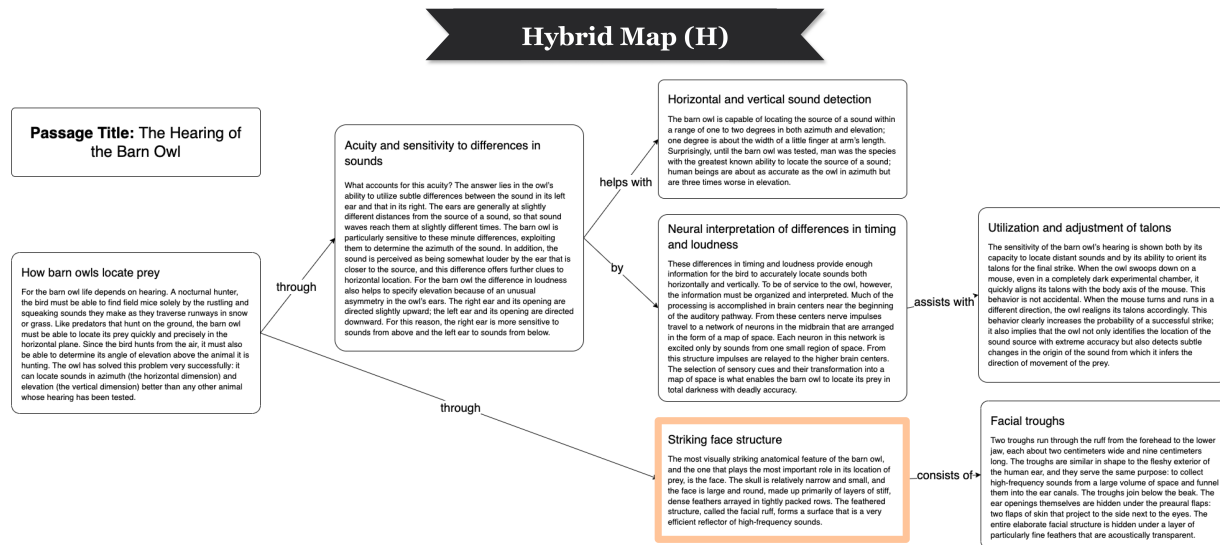


Figure 3.2: **Hybrid Map** representation. Nodes (rectangular boxes) are conceptually related via labeled arrows, in a left-to-right orientation. Each node has a title representing a concept, and a paragraph that explains it. Nodes have the same width and are aligned in columns.

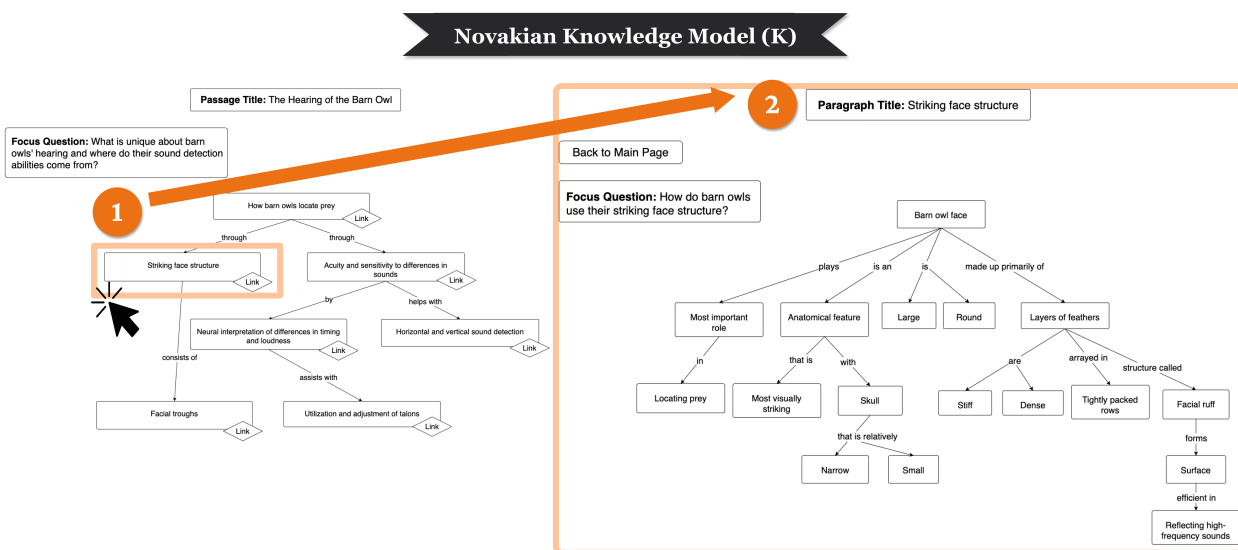


Figure 3.3: **Knowledge Model** representation. The *master-map* on the left (1) has paragraph titles in each node. Clicking on a node opens the corresponding concept map shown on the right (2) containing the information of the paragraph with that title.

3.3.3 Passage representations

We represented each passage for display under both experimental conditions in [Draw.io](#). The text as well as cosmetic features (font types, font sizes, styles, and margins) were held constant between the two conditions. Also, we provided the participants with the same affordances across the two conditions. They could pan and zoom the maps using the Draw.io preview mode. However, we disabled copying or searching in text to make sure the only way to answer the questions was by reading the content, not automated searching.

Figure 3.2 shows a sample *Hybrid Map* for one of the passages. The key features are:

- Each paragraph is represented as a node (rectangular box);
- Each node has a title, representing the essence of the paragraph;
- Same-width columns of nodes are arranged in left-to-right order on a single page.

Figure 3.3 shows a *Knowledge Model* for the same passage. We created one concept map for each paragraph of each ACT passage, carefully following the guidelines recommended by Cañas et al. (42, 43); Novak and Cañas (135) (previously discussed in subsection 3.1.1). We converted each sentence into a proposition, which typically consists of two nodes and a link between them. Each paragraph’s concept map also included a focus question at the top.

We carefully designed each concept map to meet the criteria defined by Cañas et al. (42). Each concept map in *K* condition has both a title and a focus question to state its topic and goal. Nodes in the concept map use concise labels or titles. Linking words are also concise, containing only a few words that do not cover conceptual content, but serve to link concepts into propositions. The concept maps contain a top-down hierarchical structure with broader topics on top and narrower topics lower in the map. Concept labels do not repeat in each concept map. There are cross-links between maps, relating paragraphs of text. Beyond the more explicit design criteria, the concept maps were designed to meet some of the more ephemeral design principles defined by Cañas et al. (42). Each concept map is designed to address the focus question. The concept maps were structured to be concise, thorough, and contain all information from the corresponding paragraph. Much time was spent editing the concept maps to ensure that they have clarity and that the propositions are easily interpreted. We carefully evaluated each node to determine if it could be broken into smaller ones for mapping, but they could not be.

To make the two conditions as comparable as possible, the Knowledge Model for a passage included a concept map that represents the paragraph-level concepts, something that we call a “master-map”. Each node in the master-map can be clicked to open a separate page for the concept map representing the contents of that paragraph. Paragraph nodes are visually linked and labeled with words or phrases, as in the Hybrid Map. Following the convention of Novakian Knowledge

Models, however, the nodes are arranged top-to-bottom rather than left-to-right as in the Hybrid Map.

Thus, the key features of the Knowledge Model representation are:

- A page with a master-map of paragraphs where:
 - Each paragraph is represented as a node;
 - Each node’s content is the same as the title used for the corresponding node in the Hybrid Map;
 - Each node has a link to a corresponding concept map page;
 - Nodes are arranged in top-to-bottom order.
- A separate page with a concept map for each paragraph where
 - Each node is a word or phrase;
 - A focus question sets the stage for the whole page;
 - A link back to the master-map page.

For the ninth passage, titled “Managerial Decision Making,” rather than starting from a linear text and generating the two representations, we started from the Knowledge Model representation developed by IHMC. From that, we connected the nodes and links to form propositions, as complete sentences. By connecting the propositions, each concept map was converted into a complete paragraph with a title derived from its focus question. The master-map for linking the concept maps was also designed by IHMC and we used the same map.

We meticulously designed and evaluated every concept map, corresponding to each paragraph from the ACT passages, to meet the criteria for excellent Novakian concept maps established by Kinchin et al. (101); Cañas et al. (42); Novak and Cañas (135); Cañas and Novak (40); Cañas et al. (43). Table 3.2 illustrates our evaluation of the concept maps and comparison of those designed from each ACT passage to IHMC’s “Managerial Decision Making.” We focused our evaluation on prominent criteria, including the number of follow-up nodes (children) (40; 43), number of cross-links (101; 42; 135), maximum number of repeated node labels (within each concept map) (42; 135), number of links in longest paths (101; 135), and number of strings (101; 42). Every one of the concept maps in this experiment had a top-down hierarchical structure and a focus question (42; 135).

In addition, we assessed the maps for conciseness in node and link labels and clarity in proposition formation (101; 42; 135). Linking words were notably concise, with minimal wordiness in concept labels and few incomplete sentence propositions. These included IHMC’s “Managerial

Knowledge model	# of concept maps	# of cross-links	# of nodes with more than four children	Max # of repeated node labels per concept map	# of links in the longest paths	# of strings
Managerial Decision Making	10	27	5	0	2	0
The Hearing of the Barn Owl	8	16	3	0	3	0
Conservationist and Diplomat: The Grey Areas of Panda Conservation	8	16	2	1	2	0
The Jaws that Jump	7	14	2	0	1	0
Prima Ballerina	6	12	4	1	2	0
The Buzz in Our Pockets	7	14	2	0	1	0
The Quiet Sideman	8	16	3	0	2	0
How to Watch Television	6	12	3	0	1	0
Reena	7	14	7	1	2	0

Table 3.2: *Analysis of the Concept Maps* based on excellent Novakian concept maps criteria (101; 42).

Decision Making” which included a proposition saying “Time series models → e.g. → Other” and “The Buzz in Our Pockets” which had a proposition saying “More pre-thought → although we may → cast off quickly.” Beyond these propositions, there was one awkwardly written node label in “The Quiet Sideman” that said “You have never heard before of Chu Berry.”

Relative to IHMC’s “Managerial Decision Making,” our ACT-based concept maps showcased consistent patterns in nodes with multiple children and longest path lengths. The concept maps were fewer and less complex; correspondingly there were fewer cross-links. Instances of repeated labels were few, primarily due to the complex nature of biographical writing. Both “Managerial Decision Making” and “The Quiet Sideman” featured occasionally challenging propositions. Overall, our concept maps satisfactorily represented the criteria for Novakian Concept Maps (101; 42; 135).

3.3.4 Experiment Conditions

We conducted a within-subject experiment with two conditions, “*Hybrid Map*” (*H*) and Novakian concept maps in the form of a “*Knowledge Model*” (*K*). We designed a randomization process that counter-balances for potential ordering effects, as illustrated in Figure 3.4. For each participant,

1. We randomly chose their first passage, from the *nine* passages.
2. From the remaining *eight* passages, we randomly chose their second passage.
3. We randomized whether the first passage would be presented as a Hybrid Map or a Knowledge Model. The other passage was then presented using the other representation.

3.3.5 Experiment Procedure

We conducted this experiment remotely using Google Meet⁵ video call sessions and observed participants’ interactions with the experiment website (anonymized and accessible at <https://visualexp.web.app>). Each participant completed three sessions; the second and third were three and seven days following the initial session. In each session, one of the authors had one-on-one interactions with the participant, instructing them through the experiment website, narrating the informed consent form, and answering their questions. The project PI also attended all sessions to supervise the procedure. In what follows, we explain the details of activities in each of the three sessions:

⁵<https://meet.google.com/>

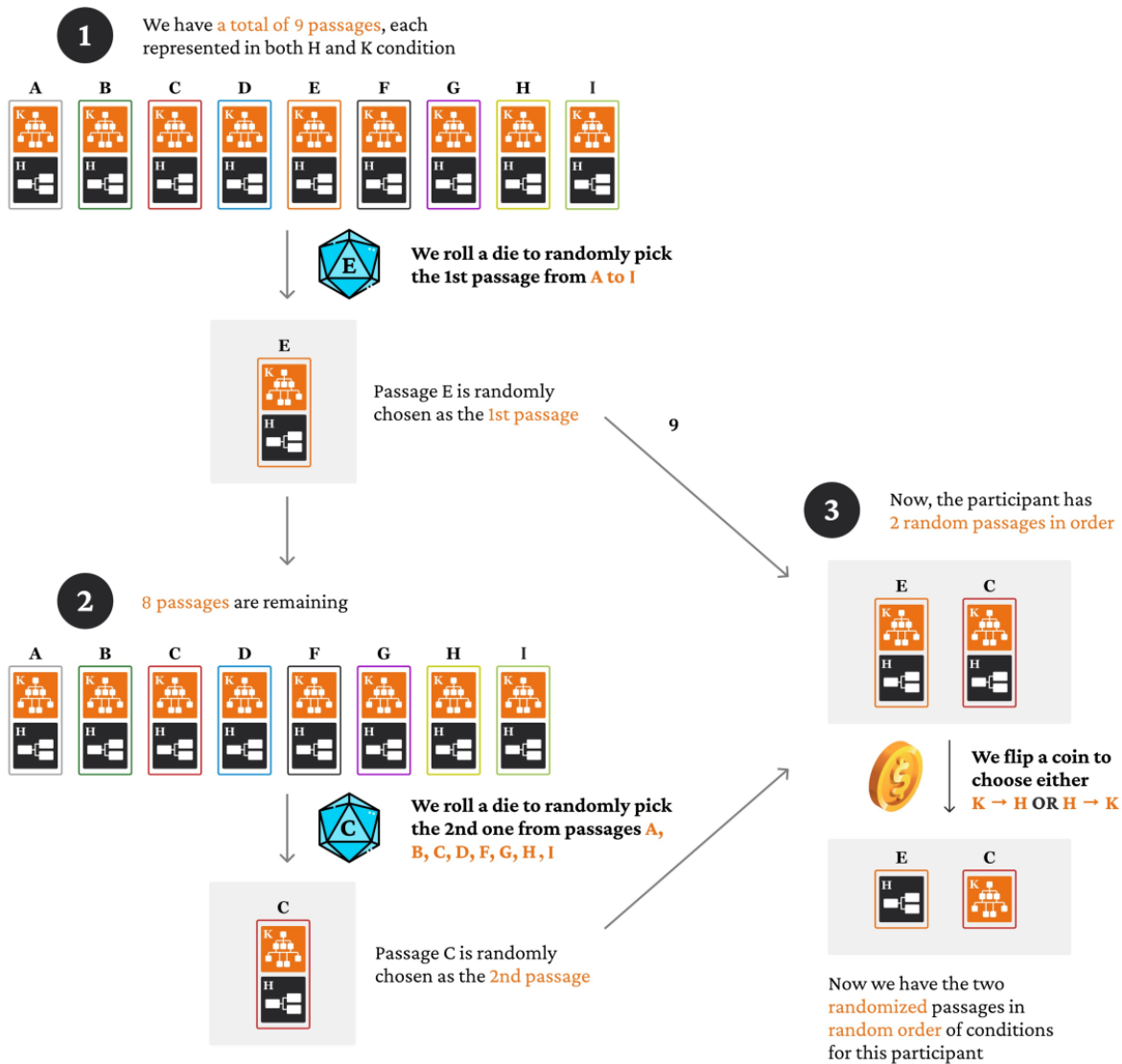


Figure 3.4: The randomization process of passages and conditions for each participant.

Session 1 The first session took on average 44 minutes and 40 seconds. The participant read and signed our study informed consent form and then went through the procedure described in the first column of Figure 3.5. Before completing the task with each representation, the subject had a chance to interact with the interface using a sample passage. This process is aimed to ensure participants are comfortable with the format and structure and to reduce the “Map Shock” effect (57). To assess their prior knowledge of the topic of the passage, the participant answered the multiple choice reading comprehension questions before being exposed to the passage (Pretest). They then answered those same questions while interacting with the passage (Recognition test). After completing all reading comprehension questions for both passages, the participant then answered two questions about their preference and reasoning for the condition they found 1) easier to read and

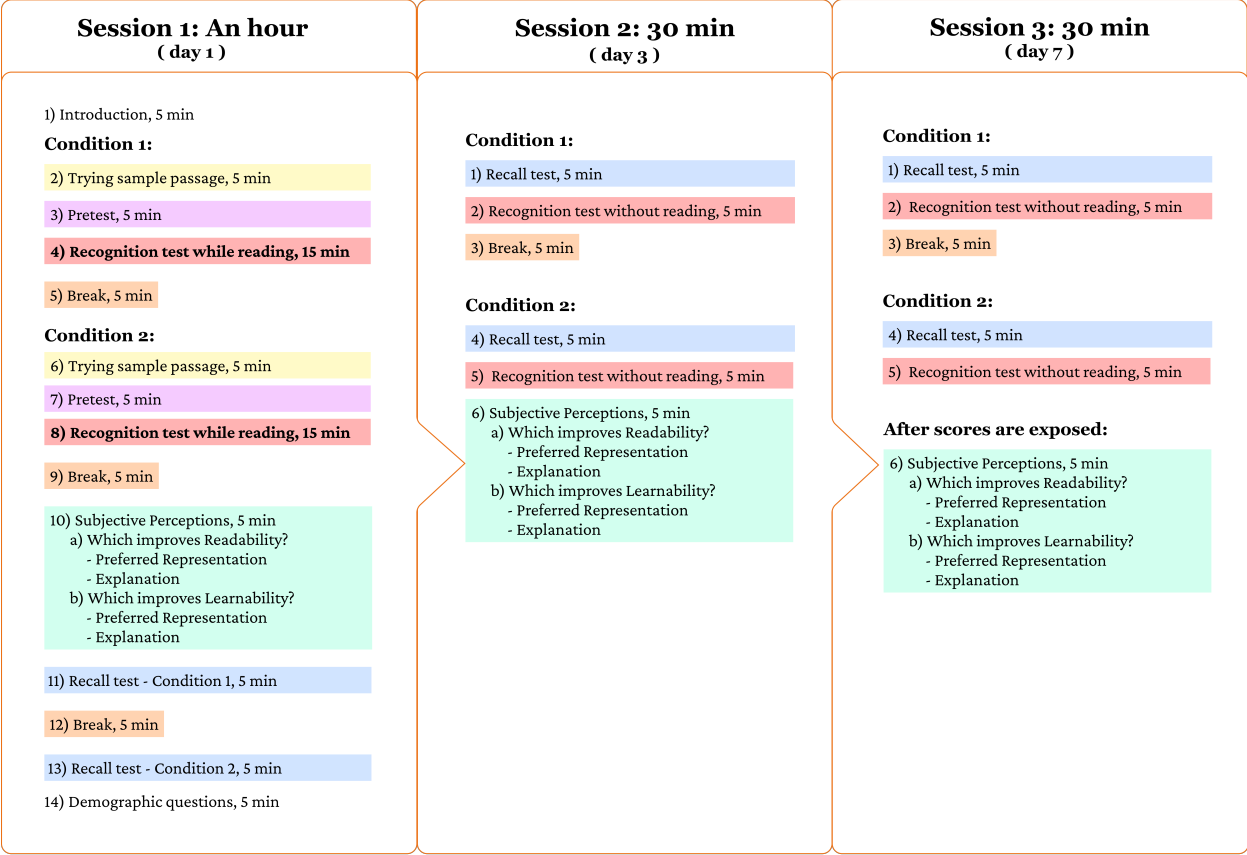


Figure 3.5: The procedure of the three sessions of the within-subject controlled experiment.

2) would rather use for their academic learning, and explained the reasons for their preferences. Then, they completed free recall tasks for each condition: they wrote whatever they could recall from the passage, without having access to it anymore. Finally, the participants were asked for their demographic information after completing the test to prevent the effects of stereotype threat (15) affecting stigmatized groups of people from performing at a different level than their baseline. The experiment website played funny cat videos from YouTube for breaks between tasks.

Session 2 (delayed tests after three days) The second session took on average 16 minutes and 5 seconds. The participant completed the same recall, and then the recognition tasks for each passage, this time without seeing the representation of the passage. Then they were asked again about their subjective perceptions of the two representations.

Session 3 (delayed tests after seven days) The third session took on average 16 minutes and 47 seconds. The subject again completed the same recall and recognition tests without viewing the passages. They then reviewed their test scores for each passage and revisited the passages using

the same representations they originally saw. Finally, they were asked again about their subjective perceptions of the two representations.

3.3.6 Power Analysis

We measured four outcomes for each participant in each of the three sessions:

- **Readability:** Binary, indicating whether the participant chose Hybrid Maps as more readable than Knowledge Models.
- **Learnability:** Binary, indicating whether the participant chose Hybrid Maps as more learnable than Knowledge Models.
- **Recognition:** Binary, indicating whether the participant answered a multiple-choice question correctly.
- **Recall:** Numeric in the range $(0, 1)$, indicating the number of key phrases (rubric items) the participant correctly recalled, divided by the total number of key phrases.

Among these, the first three require a smaller sample size to achieve 80% statistical power for 95% significance level of a minimum meaningful effect size. So, we only present the results of our power analysis for free recall.

To perform a priori power analysis to compare the effect sizes of Hybrid map (H) and Linear text (L) through our within-subject experiment, and calculate the minimum sample size required for our regression analysis, we simulated the dataset in R based on our pilot dataset. We estimated the effect sizes for the free recall test scores, based on a pilot study on 129 participants, from the same population, on our same experiment website. In our pilot study, we found, on average:

- In the Hybrid map (H), compared to the Knowledge model (L) condition, 2% (statistically insignificant) higher free recall test scores immediately after reading the two passages. So, our best estimate of the true population standardized mean difference was $\delta = 2\%$ for the free recall test scores.
- A correlation of 0.5 between the pretest and the recall scores.
- Under the Knowledge Models condition, recall scores in the second and third sessions, respectively decreased 1% and 4%. Under the Hybrid Maps condition, they decreased 0.7% and 3.4.
- When a passage was shown as the second passage for a participant, they earned on average 1% higher recall scores.

We therefore entered these estimates into our simulated models, assuming normal variations (error terms), and eventually our power analysis with the following parameters: $\alpha(\text{two-sided}) = 0.05$ and 1,000 simulations. Our power analysis code is available in the supplementary R-studio notebook.

The power analysis results in Figure 3.6 suggested that at least $N = 282$ participants are required to detect the specified effect size between the two conditions on the free recall tests to achieve a statistical power of 80% with a significance level of 95%. Our sample size of $N = 419$ was more than the minimum required according to this power analysis.

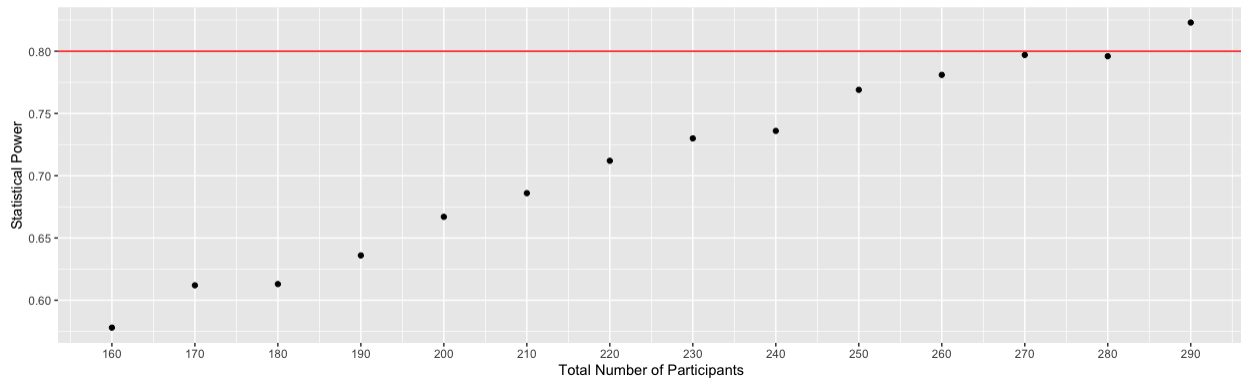


Figure 3.6: Power of simulated experiments with different numbers of participants to detect a mean difference of 2% in free recall scores.

3.3.7 Participants

Our focus is improving reading for college students in the United States. For this purpose, we aimed to invite a generalizable sample of undergraduate and graduate students from 71 schools in the United States to participate in this study. We run an internship program where many undergraduate and graduate students, from different majors and schools in the United States, collaboratively summarize scientific research papers. We defined participation in this study as a requirement in our programs' application process⁶

3.4 Quantitative Analysis Method

3.4.1 Measures

Some outcome measures are on a per-participant basis, such as their preference for which representation was more readable. Some are on a per-passage basis, such as the number of keywords

that participants recalled. And some outcome measures are on a per-question basis, whether the participant answered a multiple-choice question correctly.

The following measures are used in our regression analyses, defined later in this subsection.

Condition (per participant-passage)

The condition can be either “Hybrid Map” or “Knowledge Map.” Each participant experienced both conditions, among which 216 studied their first passage under the Knowledge Model and 203 studied their first passage under the Hybrid Map.

Readability Outcome (per participant)

Our measure of readability is based on whether the participant found “Hybrid Map,” “Knowledge map,” “both,” or “neither” of the conditions as more readable.

Learnability Outcome (per participant)

Our measure of learnability is based on whether the participant found “Hybrid Map,” “Knowledge map,” “both,” or “neither” of the conditions as more learnable.

Recognition Outcome (per participant-question)

Our measure of recognition is based on whether the participant correctly answered the corresponding multiple-choice question, which can take values of 0 or 1.

Recall Outcome (per participant-passage)

To calculate a free recall measure from participants’ textual responses, we first identified and extracted all possible rubric items from each passage that could contribute to a student’s score. For each pairing of a student’s response and a rubric item, we employed GPT-4-0613 (140) to assess whether the student’s response correctly mentioned the rubric item. The recall score was then determined by dividing the count of rubric items correctly mentioned, by the total number of rubric items present in the passage. Considering the variability in responses from Large Language Models (LLMs), each assessment was repeated multiple times—submitting the prompt until receiving either *two affirmative* or *three negative* responses from GPT-4-0613. The final decision was based on the majority of these YES/NO responses. We deemed two affirmative responses as indicative of a positive outcome, particularly as each affirmative was accompanied by relevant excerpts from the student’s response, as evidence that aligned with the rubric item. Ensuring evidence to support an affirmative response was crucial to mitigate the risk of false positives. This approach was influenced by the chain-of-thought (CoT) prompting technique, which enables stepwise reasoning in

LLMs (173). In our method, GPT-4-0613 was prompted to reason through each step before reaching a final conclusion. Additionally, by repeating the process multiple times, we generated diverse reasoning chains, each potentially leading to different conclusions. The consensus among these chains formed the basis of our final outcome. Our “user prompt” to GPT-4-0613 was as follows:



```
A student has written the following triple-quoted answer to a question:
```

```
"""
```

```
[Student's response goes here.]
```

```
"""
```

```
Respond whether in their writing the student has mentioned each of the following rubric items, listed as items of the following array (Don't add any extra rubric items, only use the ones in this array):
```

```
["Rubric Item 1", "Rubric Item 2", "Rubric Item 3", ...]
```

```
Your response should be only a JSON array of objects. Each array item should represent a rubric item, as an object with the following key-value pairs:
```

```
{
```

```
  "rubric_item": The rubric item string goes here,
```

```
  "sentences": An array of the exact sentences from the student response, which mention the rubric item. If the student has not mentioned the rubric item anywhere in their response, the value should be an empty array [],
```

```
  "mentioned": The value should be either "YES" or "NO", indicating whether the student has mentioned the rubric item anywhere in their response,
```

```
  "why_incorrect": If the student correctly mentions the rubric item and provides a valid explanation, assign an empty string to this field. Otherwise, assign a string detailing why the student's response failed to correctly mention the rubric item.,
```

```
  "correct": If the student has mentioned the rubric item and their explanation is correct, the value should be "YES", otherwise, "NO".
```

```
}
```

To validate our proposed method, we performed an extensive evaluation of GPT-4-0613 and GPT-3.5-Turbo, assessing their capability to assist in grading a dataset of free recall responses. Our approach involved randomly distributing pairs, each consisting of a rubric item and a corresponding student response, among our research team members. For each pair, four randomly selected researchers independently assessed whether the student's response correctly addressed the rubric item. Figure 3.7 depicts the interface that researchers used for this purpose. We established a consensus from these evaluations to serve as a baseline for accuracy.

Next, we quantitatively compared the grading accuracy of GPT-4-0613 and GPT-3.5-Turbo

1- Carefully read this free-recall response:

Two men invented SMS text messaging in the 1970s because they felt that there should be an easier way to communicate and that most messages could be condensed to a 160-character blurb. This allowed for faster communication. Text messaging has become an integral part of our societal culture, as seen in popular movies such as *Departure*. However, some people believe that text messaging has a negative effect on human interactions. That is, a lot of human communication is met through tonal variations -- which texting does not allow. However, texting allows us to communicate with more people than our ancestors were able to. Sure, the quality of our messages may not be as heartfelt or meaningful, but the message is still sent and received.

2- Identify whether this participant has mentioned the following key phrases from the original passage in their free-recall response, and then submit your answers:

NO	<input type="radio"/>	YES	Text messages provide a record of all our communications.
NO	<input type="radio"/>	YES	Texts live on our phones for as long as we choose to keep them there.
NO	<input type="radio"/>	YES	Text message is similar to the letter in the context of permanence.
NO	<input type="radio"/>	YES	Naysayers (critics) have said that new technologies have compromised the way we think and understand
NO	<input type="radio"/>	YES	"Real communication lives in the form - the tone, the unsteady hand on a particular word, the hasty erasures."
NO	<input type="radio"/>	YES	Text messages have cropped up in serious novels.
NO	<input type="radio"/>	YES	The time we have for real interactions has shrunk.
NO	<input checked="" type="radio"/>	YES	The first text messages were 160 characters long.

Figure 3.7: The free recall response is shown on the top to start with. Then, the researcher continues with evaluating whether each rubric item is correctly mentioned in the response by switching it to Yes. The default choice is No.

against this consensus. This comparison utilized the Quadratic Weighted Kappa (QWK) coefficient, comparing the grades assigned by each researcher with those determined by the LLMs. Our findings, illustrated in Figure 3.8, reveal that GPT-4-0613 demonstrates a grading accuracy on par with human graders, a capability not observed in GPT-3.5-Turbo. Consequently, for grading the complete dataset of free recall responses, we relied on the assessments made by GPT-4-0613.

Grouping variables

- **ParticipantID:** A categorical variable that identifies which participant this data point belongs to.
- **Session:** Whether the data point is from the “1st,” “2nd,” or “3rd” experiment session.
- **Passage:** The title of the passage corresponding to this data point.
- **Question:** A categorical variable that identifies which question this data point is about. Note that each question belongs to a single passage, so there is a hierarchical relationship between the passage and its questions.

Control variables

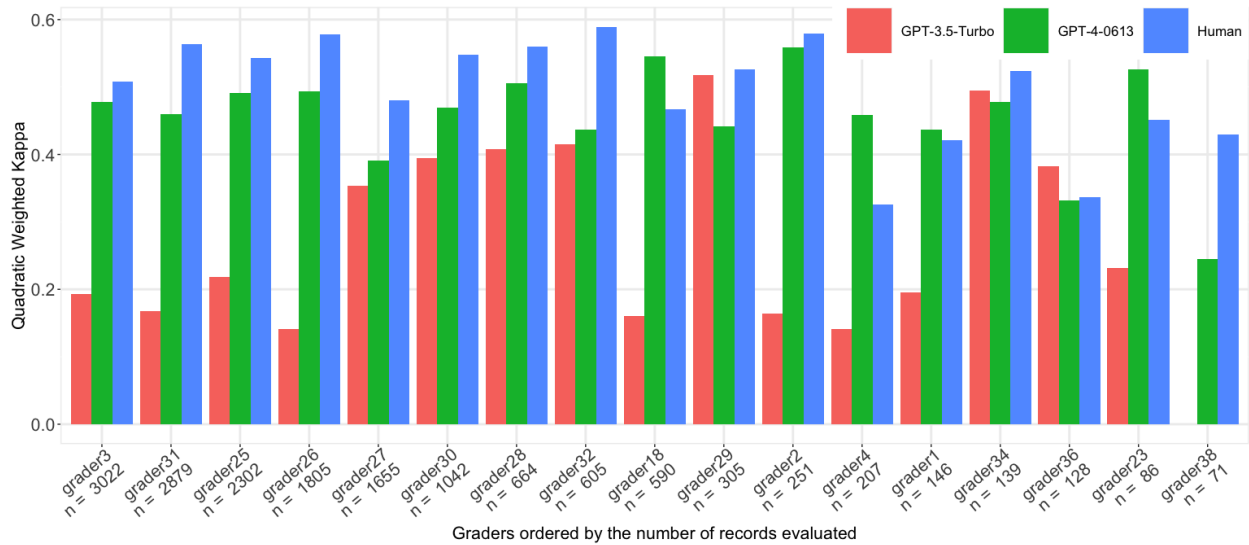


Figure 3.8: There is a group of columns for the set of records consisting of pairs of rubric items and responses, graded by the human grader identified under the group of columns. The three sub-columns indicate the corresponding QWK scores by GPT-3.5-Turbo, GPT-4-0613, and the same human grader, each compared to the consensus grade on the same records. The number of records graded is noted under each human grader identifier below the x-axis.

- **PretestScoreRatio** (per student-passage): The ratio (in range $[0, 1]$) of multiple-choice questions the participant answered correctly, before being exposed to the passage. Table 3.3 compares distributions of PretestScoreRatio across the two experimental conditions.
- **PretestRecognition** (per student-question): Whether the participant correctly answered the multiple-choice question, before being exposed to the passage (can take values of 0 or 1). Table 3.4 compares proportions of PretestRecognition across the two experimental conditions.
- **Order** (per student-question): Whether the data point corresponds to the first or second passage that the participant studied.
- **QuestionType**: Whether the type of the question is “inferential” or “factual.”

3.4.2 RQ1 and RQ2 Analysis Method

Upon concluding each of the three experimental sessions, participants were asked to identify the conditions they found more **readable** and *learnable* from four options: “Hybrid Map,” “Knowledge Model,” “Both,” or “Neither.” They were then asked to justify their selection in free-form text. A causal analysis was conducted only for participants who selected either “Hybrid Map” or

Table 3.3: Distribution of PretestScoreRatio across the experimental conditions

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 75	Max
Condition: Knowledge Model							
PretestScoreRatio	1,216	0.364	0.179	0	0.222	0.5	0.9
Condition: Hybrid Map							
PretestScoreRatio	1,216	0.351	0.18	0	0.222	0.444	1

Table 3.4: Distribution of PretestRecognition across the experimental conditions

Variable	N	Percent
Condition: Knowledge Model		
PretestRecognition	9,610	
... 0	7,258	63.7%
... 1	4,131	36.3%
Condition: Hybrid Map		
PretestRecognition	9,572	
... 0	7,389	64.9%
... 1	3,995	35.1%

“Knowledge Model,” to determine if there was significant evidence to suggest a preference for one condition in terms of **readability** and/or *learnability*. This involved a two-sided hypothesis test with the following specifications:

- **Null hypothesis** (H_0): the probability of participants selecting either condition as more readable/learnable is equal ($p = \frac{1}{2}$).
- **Alternative hypothesis** (H_1): the probability of participants favoring one condition over the other is different ($p \neq \frac{1}{2}$).

The “exact binomial test” implemented in *R* language as “binom.test” was used to test these hypotheses on the data collected from each session. The two-sided test rejects H_0 if the observed value deviates significantly from the expected value $p = \frac{1}{2}$ under H_0 . For an observed value $X \text{ Binom}(n, p)$, the $P - \text{value} = P(X \leq x) + P(X \geq n - x)$, where n represents the number of independent observations.

3.4.3 RQ3, RQ4, and RQ5 Regression Models

In our within-subject experiment context:

- Each participant took the test in three sessions.
- There were two types of questions: Inferential and Factual.
- We randomized the order of the two conditions for each participant.
- Participants may have had varying levels of prior knowledge on each topic.

As a result, the variables, *Session*, *QuestionType*, *Order*, *PretestScoreRatio*, and *PretestRecognition* may confound the effects of the treatment on the corresponding outcome measurements, and we need to control for their effects in our regression models. Also, our within-subject design involves repeated measurements of the outcome per *Participant*, *Question*, and *Passage*, which means the observations are not independent. So, we cannot use simple *t-test*, *ANOVA*, or similar methods that assume *i.i.d.* observations; instead, we use mixed-effect models, where we adjust for the random intercept of these grouping variables. On the other hand, the demographic variables cannot possibly affect the randomization, because each participant goes through both experimental conditions. Hence, we do not control for the effects of the demographic variables.

To study the research questions *RQ3*, *RQ4*, and *RQ5*, we conduct regression analyses in *R* using the following functions.

- “glmer” function from “lme4” package (22)

- “emmeans,” “pairs,” and “emmip” functions from “emmeans” package (114)

To answer **RQ3** and **RQ4** we measure the average difference in probabilities that participants correctly answer the ACT reading comprehension questions that are “factual” and “inferential” in the Hybrid Map compared to the Knowledge Model representation. In the regression model, the dependent variable is “Recognition,” i.e., the correctness of the participant’s answer to each inferential or factual recognition question (0 or 1). So, we analyze it using “Logit” regression. Note that because each question belongs to a specific passage, we adjust for the crossed random intercept of Participants and the hierarchical random intercept of the Passage and Question variables.

```
Recognition_m <- glmer(
  Recognition ~ Condition * Session * PassageType
  + QuestionType + Order + PretestRecognition
  + (1 | ParticipantID) + (1 | Passage/Question),
  family=binomial(link='logit'))
```

For a robustness check, we investigate whether the effects of the two experimental representations differ across topics. In particular, we wanted to check whether the effects were primarily driven by results on just one of the ACT reading comprehension categories or by the one passage taken from the CmapTools website.

```
Recognition_m_passageType <- glmer(
  Recognition ~ Condition * PassageType + PretestRecognition
  + Order + (1 | ParticipantID) + (1 | Passage/Question),
  family=binomial(link='logit'),
  data = dataPerQuestion)
```

To answer **RQ5** we measure the average difference in score that participants earned on the free recall test in the Hybrid Map, compared to the Knowledge Model representation. Our regression model considers the recall scores as the dependent variable. Note that we defined the recall score as the ratio of the number of rubric items that the participant correctly mentioned in their response, divided by the total number of rubric items in the passage. Due to the large number of observations, based on the central limit theorem (111), we can assume that standard errors would have a normal distribution and analyze the results using the “lmer” function from “lme4” package (22):

```
Recall_m <- glmer(
  Recall ~ Condition * Session * Order * PretestScoreRatio
  + (1 | ParticipantID) + (1 | Passage),
  family="poisson", data=data)
```

Notes In the results section, we will report the marginal means of the predicted effects for each of the regression models, averaging over the levels of the categorical variables. The complete tables of summary statistics and regression results are available in Appendix 1. We use Tukey correction for multiple hypothesis testing of all the reported p-values. Also, the Variance inflation factor (*VIF*) values calculated for all the coefficients (excluding those that interact) in all the regression models are less than 2.00, indicating no evidence for multicollinearity.

3.5 Qualitative Analysis Method

At the conclusion of each session, participants answered two open-ended questions where they explained their perceptions of the two knowledge representations based on readability and helpfulness for their future academic learning. For qualitative analysis of these free-text responses, we employed Grounded theory and conducted thematic analysis. Grounded theory is an iterative method of analyzing and categorizing data that moves from the generation of broad concepts toward specific themes stated as meaningful expressions or codes (178; 48). Codes are labels or tags used to assign significance to certain units (127).

To code each response, we divided the text into individual sentences. Researchers could go through the code book and match them with each sentence if applicable. Each code had a switch indicating either *H* or *K* condition, this allowed researchers to indicate if the code was describing either *H* or *K* favorably. Each qualitative response was coded by three researchers. If there was a consensus between at least two researchers in each group, that code was confirmed. Otherwise, the code was excluded from the analysis.

All the codes were phrased in terms of the positive aspects of the knowledge visualization models. For instance, if a response were to say one condition was unorganized, the other condition would be coded as organized. We did not apply codes to explanations that did not compare the two conditions. The process of coding responses continued until saturation; i.e., when no new codes were added to the codebook (153).

3.6 Quantitative Results

3.6.1 RQ1 Results

As illustrated in Figure 3.9, immediately after reading the two passages, 265 participants chose Hybrid Maps and 117 chose Knowledge Models as easier to read. Thus, 69.37% of those who expressed a readability preference chose Hybrid Maps (95%*CI* = [0.623, 0.724]). We reject the

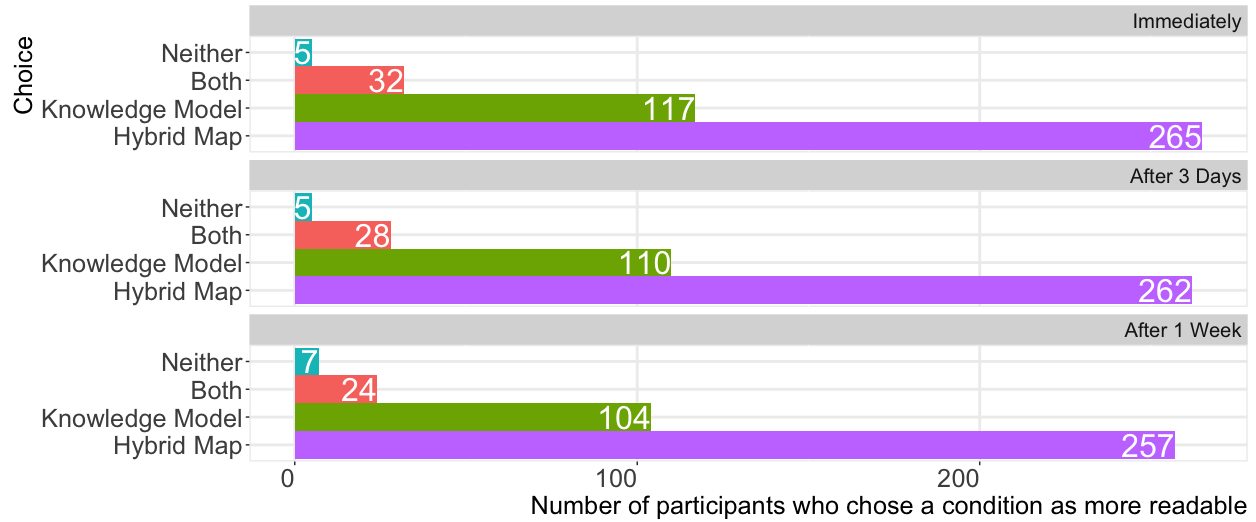


Figure 3.9: Subjective perceptions of readability.

null hypothesis of an even split in preferences ($p < 1e - 13$). Results were similar three and seven days later.

3.6.2 RQ2 Results

As illustrated in Figure 3.10, immediately after reading the two passages, 174 participants chose Hybrid Maps and 105 chose Knowledge Models as more helpful for their academic learning. Thus, 62.37% of those who expressed a learnability preference chose Hybrid Maps ($95\%CI = [0.535, 0.661]$). We reject the null hypothesis of an even split in preferences ($p < 1e - 4$). The results were similar three and seven days later. Interestingly, seeing their test score results after one week, which often showed that participants performed better with Hybrid Maps, did not seem to have a large effect on their subjective perception of which representation was better for their academic learning.

3.6.3 RQ3 and RQ4 Results

The mixed-effects regression model for RQ3 and RQ4 is visualized in Figure 3.11, illustrating the predicted probabilities of correctly answering recognition questions. This comparison spans across sessions, question types, passage order, and their interactions.

A pairwise comparison of the results indicates a significant difference in performance between the Hybrid Map and Knowledge Model conditions. Participants who read the passages under the Hybrid Map condition answered the questions correctly significantly more often than those who read the passages under the Knowledge Model condition. This was observed in the immediate test

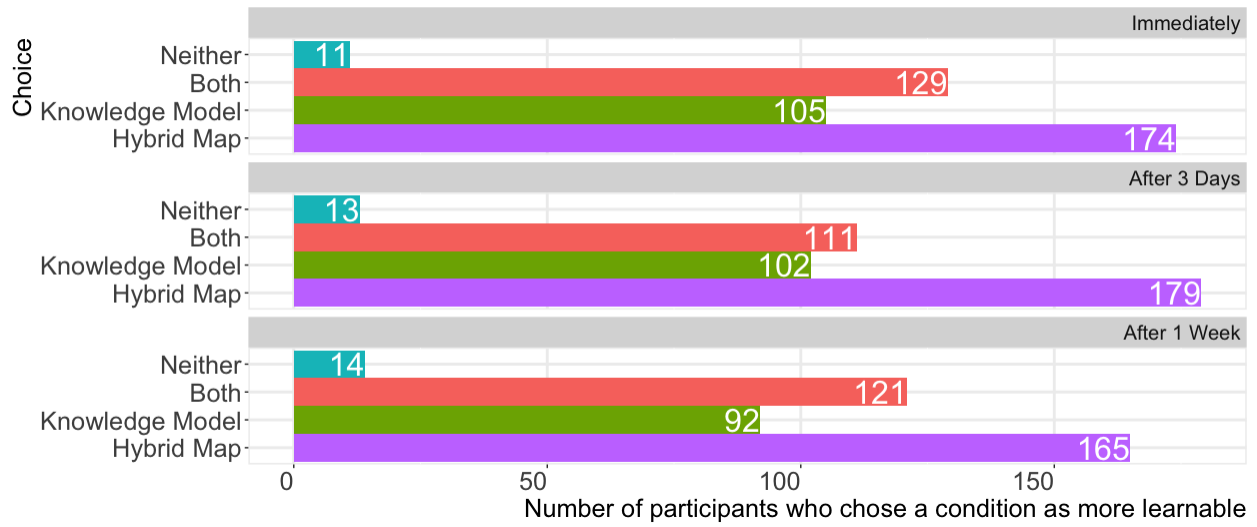


Figure 3.10: Subjective perception of which representation was more helpful for academic learning.

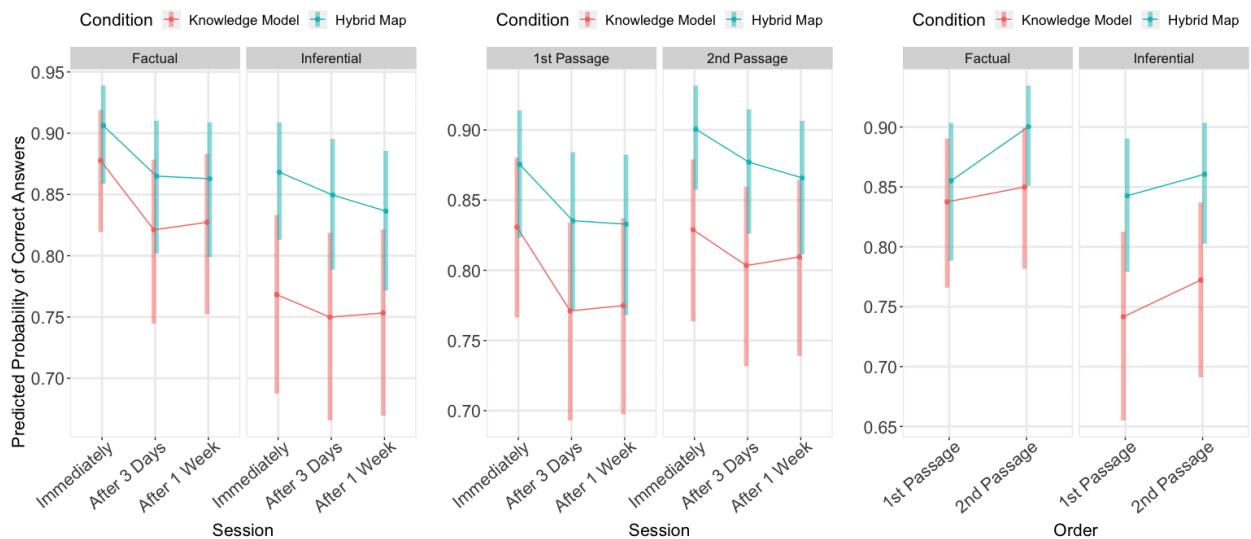


Figure 3.11: Predicted probabilities of correctly answering recognition questions.

(*odds.ratio* = 1.64, $p < .0001$), three days later (*odds.ratio* = 1.62, $p < .0001$), and one week later (*odds.ratio* = 1.48, $p < .0001$).

When comparing across question types, the Hybrid Map condition again outperformed the Knowledge Model condition, with *odds.ratio* = 1.35, $p < .0001$ for inferential questions and *odds.ratio* = 1.84, $p < .0001$ for factual questions.

We also investigated the potential influence of the “Map Shock” effect (57), hypothesizing that participants might perform better if they studied the Knowledge Model as their second passage. However, no such effect was observed. The Hybrid Map condition still resulted in significantly more correct answers than the Knowledge Model condition, regardless of whether participants received Hybrid maps (*odds.ratio* = 1.46, $p < .001$) or Knowledge Models (*odds.ratio* = 1.70, $p < .0001$) as their first passage.

3.6.4 A comparison across passage types

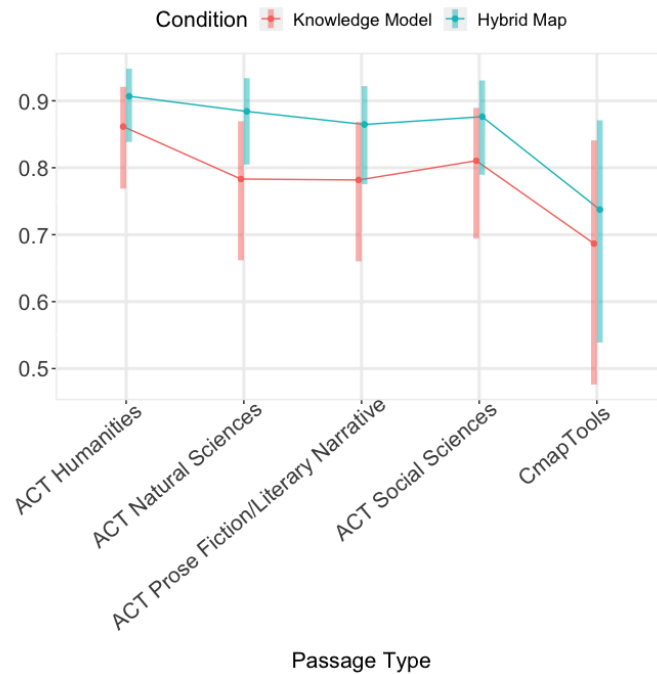


Figure 3.12: Predicted probabilities of correctly answering the recognition questions divided by the passage type.

For robustness check, we investigate whether the effects of the two representations differ across topics, including: literary narrative, social sciences, humanities, natural sciences, and the passage we extracted from CMapTools. Figure 3.12 shows the predicted probabilities of correctly answering the recognition question divided by the passage type. The favorable result for Hybrid Maps is

largely consistent across topics, not driven by just one kind of passage. However, this subgroup analysis, especially for the CmapTools group, is underpowered and the results may not be reliable.

3.6.5 RQ5 Results

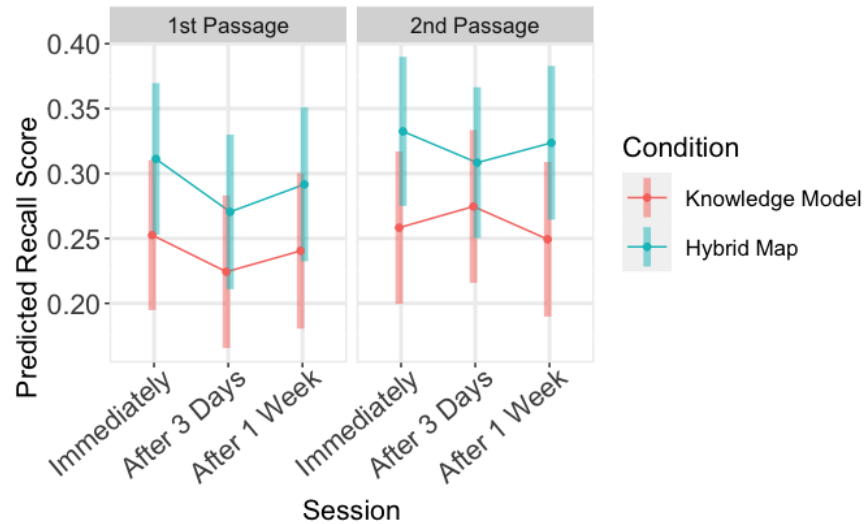


Figure 3.13: Predicted recall scores based on the mixed-effects regression model for RQ5.

Figure 3.13 show the predicted numbers of key phrases correctly recalled divided by the total number of key phrases, based on the mixed-effects regression model for RQ5. A pairwise comparison of the results reveals that participants recalled significantly more words when using the Hybrid Map than a Knowledge Model: $ratio = 1.08, p < .0001$ in the immediate test, $ratio = 1.07, p < .01$ three days later, and $ratio = 1.06, p < .05$ one week later.

3.7 Qualitative Results

In analyzing participants' reasons for preferring one knowledge representation over the other for readability and learnability, through iterative thematic analysis, we identified 26 codes. We then grouped these into five larger themes. The themes and component codes are listed below.

- **Macro Presentation and Outline**
 - **One page:** Text is represented within a single page
 - **Multiple pages:** The information is spread across multiple pages
 - **Horizontal orientation:** The information is better represented horizontally

- **Top-down orientation:** The information is better represented vertically
 - **Easier navigation/maneuvering:** Interface allows for dragging and clicking through condition with ease
 - **Better hierarchy:** It is easier to follow the information from basic to advanced
 - **Better structure/organization:** Clear layout of information, breakdown of information structure, clearer and coherent representation of text.
- **Micro Presentation and Readability**
 - **Presented in groups:** Information grouped similarly to paragraphs
 - **Choppy sentences:** Information flows better in paragraphs rather than discrete phrases
 - **Wordiness:** Reading less wordy paragraphs are more favorable
 - **Small nodes:** Information is better presented in smaller pieces
 - **Conciseness:** Participant specifically mentioned concise or referred to smaller pieces of text
 - **Identifiability:** The key information was easier to identify.
 - **Less time to read:** Information is faster to read through
 - **Quick skimming:** Efficient scanning to locate ideas and read text
 - **Complete sentences:** Complete sentences are better than short propositions
 - **Felt more natural:** Visualization felt close to what participants are accustomed to
 - **More details:** The representation provides more details/nuances for each concept within each node.
 - **Following the story:** It is easier to follow the story and chronological order of content
 - **Perceived Learning**
 - **Easier memorization/recall:** Easier to retain or recall information
 - **Easier to answer questions:** The representation is more helpful to find answers to the multiple choice questions
 - **Genre of Passage**
 - **Appropriate for informational:** The format is more appropriate for informational types of passages

- **Appropriate for literary:** The format is more appropriate for literary narrative types of passages
- **Concept Relations**
 - **Nodes relations:** There are clear, explicit, links between related paragraphs/nodes
 - **Fewer arrows:** Fewer linking relations make the representation easier to comprehend
 - **Distracting:** The knowledge representation is distracting

In the following subsections, we describe each of the five themes. For each, we quote comments from participants that illustrate the theme.

3.7.1 Macro representation and outline

Many participants preferred maps on a single page rather than spread across multiple pages. S283 favored Hybrid Maps: *“[It] was much easier to read because it was on one page, and much easier to follow the flow of information from one section to the next”*. S283 also added: *[Knowledge Model] was harder to follow because it was much more spread out, and it required clicking between multiple pages.”* S285 agreed: *“[It] required me to click across multiple links to get all the information I needed. I felt [it] required more effort to understand the text.”* On the other hand, S85 favored multiple pages: *“I could just find the corresponding topic and click on it to get more information.”*

Though not frequently discussed, a few participants stated their preference for the horizontal orientation of Hybrid Maps or the vertical orientation of Knowledge Models. S36 wrote: *“It is also more comfortable to read in a horizontal...format than up to down.”* S42 agreed: *“The second passage was also easy to follow especially because it reads left to right which is natural for English speakers.”* S56, however, disagreed by saying: *“Passage 2 was vertically presented, which made it easier for me to look and read.”*

Students also noted that the format of either the Hybrid Map or the Knowledge Model impacted their ability to navigate through the passage. S148 favored the Hybrid Map because they could navigate it more easily: *“[It] helped because the map at times was easier to follow therefore I got less confused.”* S71 agreed: *“Definitely less confusing or intimidating to read through.”* S80 also agreed: *“The use of a single broad category to define all of the relevant details of the section made it easier to navigate”* S24 preferred Knowledge Models: *“[It] contained information in chunks, which allowed me to locate information without too much navigation.”* S39 also agreed: *“It was much clearer to navigate and follow because of the general outline with links to more outlines.”*

Participants stated preferences for how either Hybrid Maps or Knowledge Models displayed the hierarchical relationships of concepts. S12 preferred Hybrid Maps: *“It was also easier to*

read in my head, since I wasn't constantly stopping, trying to figure out where to read next." S174 favored Knowledge Models: *"[It] was easier to navigate and can see the connections between every concept and what stems from what, with the root/main concept at the top."*

Design Recommendation

- Use only a single page.
- Incorporate fewer hyperlinked nodes.
- Use left-to-right hierarchy for the map representation for left-to-right languages (e.g., English).

3.7.2 Micro-representation and Readability

Some students preferred grouping similar sentences in Hybrid Maps instead of reading discrete propositions. S334: *"Much less fragmented and grouping of ideas was more meaningful - it was easy to digest information before making a leap from one node to another."* S35: *"I felt like it was easier to read whole sentences rather than assess the fragments of a concept piece by piece. The flow of going paragraph by paragraph also made it easier to cluster concepts together."* S323 added: *"[Hybrid Map] was easier because the information was more lined up and concise. There were less blocks to look through and the information was more "together" for a lack of a better term. Searching through [Knowledge Model] felt like I was doing a scavenger hunt."*

On the other hand, some students found Hybrid Maps to have too much text and preferred the smaller nodes of Knowledge Models. S126 found the smaller nodes easier to read: *"It's simply easier to read the short bits of information."* S48: *"Passage 1 was almost too text heavy with long paragraphs that could have been separated a bit more to help the reader mentally categorize all of the information a bit more."* S111 *"[Knowledge Model] was easier for me to comprehend because it was more spread out and showed the connections between ideas."*

The conciseness of Knowledge Models was viewed differently by different participants. S163 found that the Hybrid Maps' concise nodes were helpful *"As much as smaller, more concise pieces of information can be helpful, the amount of information taken in from the [Knowledge Model] was too minimal. [Hybrid Map] had a good balance of keeping it concise, but also being complete thoughts."* S134 found that the Knowledge Models' concise nodes were helpful: *"[It] was the easiest to work through visually and condensed information into small but meaningful enough chunks so that ideas flowed naturally in the chart."*

Different participants reported that it was easier to identify key information in the two conditions. S131 found that it was easier to spot key information in the Hybrid Map: *"[It] is more*

structured and organized, thus it is easier to follow and locate key information. The format of [Knowledge Model] is more like a concept map and takes longer time for me to process and locate information.” S137 found that it was easier to spot key information in the Knowledge Model: *“[It] had key points and split up the information. Didn’t have to search through a long passage for key words.”* S13 agreed: *“It was quicker and easier to understand the information because it was only the key points with arrows pointing to other phrases of relatable and connecting information”*

Participants also found that the representation was a factor in how quickly they could read a passage. S7 found that the format of the Hybrid Map allowed them to read more quickly: *“[It is] easier to understand and conceptualize because my eyes can skim one area of data faster and more accurate than many lines of sparse, forked data. Skimming a passage is easier when it is in one area because I don’t get distracted by other sections.”* However, S222 found that it was the Knowledge Model that allowed them to read the passage faster: *“The broken up sections were easier to get through and remember where certain information was in a section. I liked that it was not one giant paragraph and I felt I could get through it faster.”*

Some participants found that Hybrid Maps allowed them to quickly skim content in the passages. S18: *“All of the information was in one spot rather than having to navigate around sentences. Also it was easier to skim”*

On the other hand, some participants found that Knowledge Model allowed them to quickly skim content in the passages. S244: *“[The] structure provided enough info to skim through at a quicker rate in comparison to the structure of [Hybrid Map].”* S257 agreed: *“[It] was easier to read because it was put in a simple format. It allowed me to easily skim the passage due to the flowchart method.”* Some student reported that they preferred Hybrid Maps because the information flowed better as sentences rather than discrete choppy phrases. S38 found that Knowledge Model’s use of node-link propositions instead of sentences was problematic: *“I was very distracted by the structure and had to spare much energy to simply make sense of the sentences.”* S354 similarly stated: *“[Knowledge Model] broke it down into notes too much, so it was more difficult to “read” it in a smooth way.”* S135 added: *“[Knowledge Model] was too choppy and broken up, with very little information in each box and a seemingly unnecessary amount of transitions. [Hybrid Map] was more clear, with larger bodies of text in each section which only transitioned to another box of text when it felt important to do so.”* S203 also disliked Knowledge Models: *“Passage 2 [Knowledge Model] on the other hand felt a bit harder for me to understand the author’s message to the reader as I was going through multiple boxes and seeing if there were any key words that I should take out of it. Each box only contained a single word and so it makes it difficult for me to maintain focus on what the passage was talking about as I am constantly looking at one box to another to get all the details of what this whole slide was talking about. There is a lot of visual clutter that prevented me to focus as I am constantly thinking maybe I am looking at the wrong*

path of boxes laid out to me to answer the questions.”

Some participants preferred Hybrid Maps because the representation just felt more familiar. S283 favored Hybrid Maps *“[It] was also easier to follow because of the way that it was written as a series of sentences and paragraphs, which meant it felt more like something that I was used to reading on an everyday basis. [Knowledge Model] was in a format that was very unfamiliar to me.”* S97 also agreed: *“I am more comfortable engaging in the format of “regular” structured passages (like that of [Hybrid Map]).”* S23 added: *“I am more used to reading words than flowcharts since I have been reading passages for my entire life. Flowcharts are less common for me.”* Few students preferred to read in complete sentences rather than reading tiny nodes and links. S354 favored Hybrid Maps: *“This was much easier to read because it did not interrupt my “flow” of reading in my head.”*

As a conclusion to this section, one of the participants gave an interesting comparison of the two representations. S345 wrote: *“The strengths of the [Hybrid Map] style were the adequate level of context and detail and the helpful use of visual flow, while the weaknesses of the [Knowledge Model] are directly opposite of this in that there was a lack of context and detail while also having an overwhelming level of visual flow”*

Design Recommendations

- Create a separate node for each main concept.
- Use headings and other signaling elements to highlight the main information of each node.
- Use complete sentences, instead of choppy sentences; provide more content in each node, and try to avoid prolixity.

3.7.3 Perceived Learning

Some students discussed their perceived ability to learn the material in their qualitative responses. These statements generally discussed either their ability to recall information from the passages or their ability to identify the answers to multiple-choice questions.

Participants had mixed responses on whether Hybrid Map or Knowledge Model improved their recall of information. S9 perceived the Hybrid Map to facilitate better recall because of the detail it offered *“...having large bits of information with clear and concise sub-headings that led to only one or two other directly-related pieces of information felt more constructive whilst maintaining a clear flow that made it easy to follow and retain.”* S59 agreed: *“I was able to retain more of the content and the extra information forced me to make sense of what I was reading.”* On the other hand, S17 perceived that reading the Knowledge Model helped their recall: *“Since the information*

is short and concise in a note-taking format, it was easier to retain information. My brain could recall certain things based on visualizing where it was in the chart". S43 added: "I retained the information better and could remember it visually the way it was displayed."

Some participants perceived the Knowledge Model to be more beneficial for finding the answers to multiple-choice questions while reading the passage. S211 perceived that they were better able to answer multiple-choice questions with the Hybrid Map: *"It was easier to comprehend, I can see it all in one page rather than constantly changing pages. The titles on each section also made it easier to remember where to find answers".* S96 added: *"The topics in [the Knowledge Model] is difficult for me to understand, but it is easier to read and find answers through the flowchart."* S27 also agreed: *"It was easier to navigate with pinpoints and simplistic wording. I was able to find answers more quickly."*

From the feedback and observations of researchers in experiment sessions, it can be suggested that participants approached each condition differently. When using Hybrid Maps, participants typically read the passage, began answering questions, and periodically went back to the passage to search for answers to difficult questions. With a Knowledge Model, a participant might start out attempting to read the Knowledge Model like a traditional text, but before going through the passage in its entirety, they would start reading questions. After they started reading questions, they would search for answers by reading node labels and following links. S351 mentioned: *"[Knowledge Model] give me the clues to find answer quickly But it's hard for me to recall what the passage says overall."* S359 elaborated more: *"The format of [Knowledge Model] was harder to make sense. It was easy in terms of answering questions, but I didn't really understand them. When I was recalling, only key words showed up. I only paid attention to the information that's necessary for the questions. I remember there were 8 graphs, and I didn't think of reading them thoroughly just because I wasn't going anywhere reading them."*

Design Recommendation

- More signalling effects like headers and visual links between content can be used to help identify key information.
- Paragraphs should be as short as possible to facilitate the quick identification of important information.
- Information condensed to one page makes the information easier to find and navigate.
- Facilitate visual cues in the map design to improve information retention.

3.7.4 Genre of Passage

Some participants found Hybrid Maps more beneficial for literary narratives. Similarly, a number of participants speculated that Knowledge Models would be beneficial for informational texts. Many students agreed that Knowledge Models were not well tailored to presenting literary or narrative writing. S247 favored Hybrid Maps for narrative passages: *“For stories, I find a linear prose-like reading experience to work better as it is visually simpler in prose format...”* S85 agreed as well: *“[It] would be better for History, English, and Social Sciences when more detail is needed in order to gain a complete picture of the topic.”* S345 disliked Knowledge Models in this manner: *“[It provided] far too few details and context. This was especially salient in the literature example where we are no longer able to grasp the perspective of the narrator and the contexts necessary to answer the passage questions.”* Some participants also found that Knowledge Models could be beneficial for informational texts. S247 described: *“For scientific knowledge that’s linear, cause-and-effect, and more compartmentalized, a flowchart seems to be a natural visualization of such a thing.”* S178 added: *“[It] would be good for things with a lot of content like maybe physics, math, chemistry, etc.”*

Additionally, some participants conveyed that Hybrid Maps helped follow the narrative passages because they included more details and sentences. S10 wrote: *“[Hybrid Map] did a better job of conveying the full details of the story and providing the user a full understanding of what the passage was about.”*

Design Recommendation

- Use complete sentences and clear pathway for story/literary narrative passages with more details.
- Retain the rhetoric and composition of a passage in nodes about literary or narrative literature.
- Try to use more condensed short nodes for informational passages.

3.7.5 Concept relations

There was no consensus on which type of passage better displayed the relationships between concepts. Some students found that they could comprehend relationships well with the Knowledge Model, while others preferred Hybrid Maps. S73 found Hybrid Maps to have a better display of relations: *“I believe it’s more easy for me to have a major topic for a paragraph and I can check the logic relationship of the sentences in the paragraph by my own. Having too much relationship*

description makes kind of confused” S374 preferred the fewer arrows in the Hybrid Map: “... *there were less arrows connecting the information so it was easier to follow.*” S6 in contrast, preferred Knowledge Models: “*It was easier to make connections and easily see the cause and effect aspect of the text or sentence.*” Those who preferred Hybrid Maps often found the Knowledge Models to be confusing because it included too many nodes and links. Many participants reported being distracted by the number of nodes and links in Knowledge Models. S345 mentioned: “*[Knowledge Model] contained too little context/writing while having an overbearing amount of visual flow and separation.*” S71 similarly noted: “*[It] had too many different arrows and text boxes. My brain turned to jelly immediately and it was really difficult to focus on my task. [Hybrid Map] had more in each text box, but it allowed me to slow down and actually read what was inside of it instead of bouncing around frantically.*” S36 agreed: “*There were too many arrows and backtracking which made it unpleasant to view and gain any sort of comprehension from.*” S44 added: “*It is just like going through a maze. You may find the correct path immediately, or you will have to run into several dead ends first.*”

Design Recommendation

- Try to reduce the number of linkages on the page by reducing the number of tiny nodes.
- Try to make pathways and relationships between concepts easier to follow by merging smaller nodes and, therefore, reducing the number of nodes and links.

3.8 Discussion

3.8.1 Summary of the results and design implications

We compared reading through Novakian Knowledge Models with our new design called Hybrid Maps. Through a within-subject experiment, we compared reading comprehension and learning across the two knowledge representations on $n = 381$ college students in the United States. We found robust and consistent results that reading through Hybrid Maps resulted in significantly higher scores of inferential and factual recognition, and free recall; and improved perceived learning and readability, immediately, three days, and one week after reading two random passages. We also employed the Grounded theory approach and through thematic analysis of the open-ended feedback, identified features in both Hybrid Maps and Knowledge Models that make them more helpful for different use cases. We identified 26 codes and further grouped them into five larger themes. Based on the extracted codes, we suggest ten design recommendations for improving reading and learning through knowledge visualizations:

- Use only a single page and fewer or no hyperlinked nodes
- Use left-to-right hierarchy for the map representation for left-to-right languages (e.g., English).
- Create a separate node for each main concept.
- Use headings and other signaling elements to highlight the main information of each node.
- Use complete sentences, instead of choppy sentences; provide more content in each node, and try to avoid prolixity.
- Paragraphs should be as short as possible to facilitate the quick identification of important information.
- Facilitate visual cues in the map design to improve information retention.
- Retain the rhetoric and composition of a passage in nodes about literary or narrative literature.
- Try to use more condensed short nodes for informational passages.
- Try to reduce the number of linkages on the page by reducing the number of tiny nodes.

The intricacy of textual material forming knowledge graphs warrants attention. Schroeder et al. (156) proposed that concept maps' spatial continuity might facilitate younger students' comprehension by explicitly mapping concept relationships, thus obviating the need to extract and structure information from descriptive texts. Contrary to their assertion that concept maps are less effective for advanced learners due to their developed learning and reading skills, our results suggest otherwise. We attribute the disparity not to learner maturity but to the complexity inherent in advanced learning materials. Feedback from our study indicates that complex texts at advanced levels encompass elements that defy representation in Novakian concept maps. Simplification into small nodes inevitably strips away sophisticated linguistic structures and nuances, proving effective at simpler academic levels but faltering with increasing textual complexity. A recurrent critique of Novakian Concept maps was their fragmented, difficult-to-follow nature, lacking the cohesive flow characteristic of traditional text.

Challenges of intricate texts in concept mapping are exemplified in our observations. One interesting observation is based on the Hybrid map version of "Managerial Decision Making." Unlike the other concept maps which were made from existing linear text passages, the linear text used in this Hybrid map was made from a pre-made concept map by IHMC. The majority of the participants struggled with and complained about this Hybrid map as the sentences felt choppy,

mechanical, and boring to read. Here are a few sentences from the Hybrid condition. These sentences on inferential statistics sound like a list in linear format: “Inferential statistics are based on the notion of probability. Probability measures the likelihood of random variables. Random variables can follow the normal distribution, the binomial distribution, and other distributions.” It lacks the authorial style to tie the content together into a cohesive explanation. Further, translating complex text to concept maps often dilutes its essence. A case in point is “The Quiet Sideman,” where one of the sentences reads “If sunlight could pass through music, ‘A Ghost of a Chance’ would funnel it out in the broadest spectrum of colors.” In the concept map this became “‘Ghost of a Chance’ - would funnel out → the broadest spectrum of colors - if → Sunlight could pass through music.” Broken down into small nodes and links, a vividly metaphorical sentence loses its poetic resonance when reduced to concept map propositions, rendering it confusing and lackluster.

In conclusion, our study underscores the limitations of Novakian concept maps in encapsulating the complexity and stylistic nuances of advanced-level texts. While effective for simpler academic content, these maps struggle to convey the depth and coherence found in sophisticated literature. This disconnect not only impacts comprehensibility but also diminishes the engaging qualities of the original text. Future research should focus on developing more nuanced mapping techniques that can preserve and accurately represent the richness of advanced textual material, thereby enhancing the learning experience for higher-level students.

3.8.2 Potential limitations to external validity

It is noteworthy to mention that for our pre-test, we asked participants the same ACT questions before their exposure to the passage. This may result in “generation effect” (as discussed in “desirable difficulties” literature (157)) and improve their learning of the passage. However, we argue that this design has been the same for all the participants in different conditions, and we do not envision any confounding effect due to this design. Participants never received feedback about their answers during their first session, and they were not informed about their test scores until the end of the third session, one week later.

We are not concluding Hybrid Maps and Knowledge Models are mutually exclusive or should be used instead of other activities. We tested the mettle of Hybrid Maps by comparing them to studying with Novakian Knowledge Models, instead of other types of knowledge visualization, because the latter has been extensively studied and advocated for years.

There may be misgivings that the five-minute period that participants had to try a sample passage under each experimental condition before studying the main passages, was not enough, and we did not extensively train participants on reading through Knowledge Models. However, many studies, including those by the inventors of Novakian Knowledge Models, emphasize that using

concept maps requires minimal training (94). “The technique is relatively intuitive and requires only a basic understanding of relationships and class inclusion principles”(13, p. 533). It seems plausible, however, that students who are used to drawing concept maps of their own for studying their college courses might have higher comprehension when reading Knowledge Models than the participants in our study.

In our study, participants’ long-term recall was tested after seven days. But it was also reasonable to examine longer retention intervals. However, there is no objective criterion for determining the “correct” interval for this purpose, while there is no reason to expect that the pattern of results would reverse at longer intervals (94).

We tried hard to select passages and participants in such a way that the results of this study can be generalizable to college-level students when studying their first-year courses. For this purpose, we chose random passages from real ACT reading comprehension exams that are fairly accepted by colleges and universities in the United States and other English-speaking countries as appropriate proxies for the assessment of reading comprehension in college-level courses. Also, we defined participation in this study as a requirement in our internship program application process to get a large diversity of undergraduate and graduate participants from a large spectrum of majors and programs, and from 43 schools in the United States. Defining the points they earned in our experiments as a criterion in the internship application process may have motivated the participants too much to perform their best in the experiment. This may raise some concerns about the external validity of the results to a larger population of college students who are not necessarily that motivated. However, we believe course grades and degrees, which are considered the main motives for students to study at schools, may be stronger than the type of motivation we provided to our participants, and we see no reason to expect that lower or higher motivation levels would reverse the impact of the two representation conditions on reading comprehension. We highly encourage future studies comparing Knowledge Models and Hybrid Maps on students with varying levels of motivation.

In addition, the primary language of most of the participants in our study is English. Our results are not generalizable to college students in other countries or those who study in other languages. We suggest replications of this experiment on more diverse samples of participants with a broader spectrum of ages and educational backgrounds.

Finally, we conducted this study as an online experiment and all the study materials are in digital form. The results may not be generalizable to studying knowledge visualizations in hard copy. It might be beneficial to replicate this experiment in person on paper-based materials to investigate the generalizability of our results.

3.8.3 Future work

There is a much larger body of literature that discusses the benefits of concept mapping (drawing concept maps), which was not the focus of this study. As a next step, we are interested in conducting similar experiments to compare note-taking using Novakian Knowledge models and Hybrid Maps.

While several web-based, mobile, and desktop applications are specially designed for Novakian Concept Mapping, we believe it is necessary to develop tools especially for Hybrid Mapping so that instructors can provide their students with more readable and learnable material through this method of knowledge representation.

3.9 Conclusion

In this study, we introduced Hybrid Maps, in which relationships between paragraphs are visualized from left to right, and each node as a paragraph is represented as linear text. We compared it with Novakian Knowledge Models, which are pure non-linear, top-down structures and all the information is divided into granular nodes that are spatially linked. Through a within-subject experiment, we compared 419 participants' inferential and factual recognition, and free recall; and perceived readability and learnability; during and after reading two out of eight, randomly chosen ACT passages, in either of Hybrid Map (*H*) or Novakian Knowledge Model (*K*) formats. Our results indicate that the majority of participants reported the Hybrid Maps as more readable and learnable than Knowledge Models. Also, their inferential and factual recognition, and free recall test scores, immediately, three days, and one week after studying the passages also showed significant improvements when they studied the passages in Hybrid Maps, compared to Knowledge Models. Our thematic analysis of the participants' written explanations of their preference revealed that reading through Hybrid Map is perceived as more helpful than its equivalent concept maps due to its structure and organization, easy-to-navigate format, presentation of information in paragraphs (chunks), and efficient use of complete sentences, rather than choppy phrases.

As we draw conclusions from this chapter, it becomes evident how the findings intricately intertwine with the overarching themes of the dissertation, particularly regarding the structuring and presentation of micro-topics within Knowledge Graphs of Micro-topics arranged into Learning Pathways (KGMLP). Our findings address the uncertainty surrounding the ideal size of micro-topics in KGMLP. Contrary to the prevailing notion of needing highly granular content, our research reveals that micro-topics do not necessarily have to be smaller than a full paragraph for effective reading comprehension. This realization offers a new perspective on the 'micro' aspect of KGMLP, suggesting a more flexible approach to defining the scope of micro-topics, which is

crucial for their optimal utilization in educational settings. Thus, this chapter not only contributes to the foundational understanding of KGMLP but also paves the way for the subsequent chapter, where these concepts are further explored and applied in various learning scenarios. The integration of these insights into the larger KGMLP framework is instrumental in advancing our approach towards more effective and adaptive learning strategies in the evolving landscape of educational technologies.

CHAPTER 4

1Cademy: Social Note-Taking in a Knowledge Graph of Micro-topics with their Learning Pathways (KGMLP)

If you want truly to understand something,
try to change it.

Kurt Lewin

Collaborative note-taking has emerged as a pivotal learning activity in online education, enhancing knowledge retention and germane load (understanding) (54; 53; 126). However, research has also highlighted a potential downside: the increase in extraneous cognitive load, which can impede the learning process (53). To address this challenge, our work¹ harnesses the power of “micro-topics” and “learning pathways.” These concepts aim to enhance the readability of collaborative notes, thus retaining the benefits of collaborative note-taking while minimizing its drawbacks.

We define “micro-topics” as concise and indivisible yet comprehensive knowledge units, fundamental to the structure of online learning platforms. These units enable self-paced, personalized learning by breaking complex subjects into manageable, coherent segments. The effectiveness of micro-topics is maximized when integrated into “learning pathways”—the sequential connections of these micro-topics that create a logical, educational journey. Such pathways act as cognitive stepping stones, guiding learners through the material in a structured manner. For instance, a clear understanding of right triangles and the concept of a hypotenuse is pivotal before delving into the complexities of the Pythagorean theorem (160). This approach to structuring content aims to optimize the learning experience by making complex subjects more approachable and understandable.

We introduce the concept of a Knowledge Graph of Micro-topics arranged into Learning Pathways (KGMLP), a directed acyclic graph where each node symbolizes a micro-topic (e.g., a para-

¹This section is based on an under-review paper, co-authored with Paul Resnick. The contents are only lightly edited.

graph of text, an image, a video, etc.) that conveys one primary idea or concept, and each link indicates a learning pathway from a source to a destination node. Links between nodes guide learners along a structured pathway, situating subsequent nodes within the learner’s Zone of Proximal Development (174) to learn. A KGMLP can provide a structured, semantic representation of the dependencies and connections among different micro-topics. A well-structured KGMLP can enable various applications, such as adaptive learning pathways, intelligent tutoring systems, curriculum design, and knowledge assessment.

The collaborative creation of a KGMLP, encompassing micro-topic extraction and learning pathways development, can enhance student learning outcomes. In their meta-analysis of 142 studies, Schroeder et al. (156) found advantages of extracting concepts and linking for designing learning pathways—manifested as concept maps—over traditional learning strategies such as linear note-taking, participating in lectures, or studying texts and concept maps in isolation. The results were consistent across both STEM (science, technology, engineering, and math) and non-STEM fields of knowledge. They especially found a significantly larger positive effect of collaborative concept mapping on students’ learning, compared to individual mapping efforts.

We introduce “1Cademy,” a platform designed to foster social learning through collaborative note-taking in the form of a large KGMLP when many learners collaborate asynchronously over many months. Distinct from note-taking platforms like Google Docs (181), which typically produce isolated documents created by individuals or small groups, 1Cademy centralizes a single gigantic KGMLP shared among all the contributors, where individuals curate and modify only small sub-graphs of the shared KGMLP. This approach mirrors the collaborative dynamics found in crowdsourcing platforms such as Wikipedia (176) and StackExchange (71), necessitating a cohesive and integrated knowledge graph characterized by uniquely identifiable nodes. The core philosophy of 1Cademy is to provide students with a sense of making permanent contributions that benefit a broader community, distinguishing it from platforms catering to short-term or individualistic note-taking needs.

Our main contributions are:

- An articulation of challenges that must be overcome to ensure the effectiveness of collaborative micro-topic learning pathways generation on a time scale of months, content scope of a textbook or course, and group size of dozens to thousands. These challenges include:
 - Motivating students to read and improve others’ work
 - Reaching a consensus on micro-topics and learning pathways
- We propose the following sociotechnical features to address these challenges:
 - A proposal mechanism for changes to a node or its links

- A requirement that new node proposals also include at least one learning pathway
- A vote-dependent acceptance threshold for proposals
- Community-specific contribution scores

Our first field trial outcomes come from a collaborative mapping exercise involving 29 students in an experimental course, wherein the participants were able to establish a shared KGMLP encompassing 934 nodes, interconnected to a high degree. We drew inferences about 1Cademy's feasibility as a tool supporting scalable, asynchronous collaboration on a coherent KGMLP.

In addition, the 1Cademy platform has supported a large-scale collaborative effort for the past *four* years, involving 1,754 students from 208 institutions, who formed 16 research communities and developed an expansive KGMLP comprising 50,947 nodes and their links through 271,836 proposals.

This study begins with a review of prior literature. Section 4.2 summarizes the challenges that must be overcome to ensure the effectiveness of collaborative micro-topic and learning pathways generation. Section 4.3 describes the design of 1Cademy, with a focus on features intended to overcome the challenges. Section 4.4 reports a field trial in one semester of a course that used 1Cademy. Section 4.5 describes field trials with larger student-led research communities not associated with courses. Analysis of usage data and interviews with the participants confirms that the challenges were largely overcome.

4.1 Related Work

This section reviews the literature on collaborative note-taking, micro-topics, learning pathways, and how generating and using them impact learning.

4.1.1 Impact of Collaborative Note-Taking in Online Learning

Collaborative note-taking has been identified as a significant enhancer of learning outcomes in online education contexts. Various studies have explored its impact on students' knowledge retention and conceptual understanding, particularly in STEM and flipped classroom settings.

In a substantial study involving 273 STEM university students divided into 61 groups over a ten-week period, Costley et al. (54) explored the effects of online collaborative note-taking on student performance. The findings revealed a notable enhancement in both long-term and short-term information retention. Additionally, these collaborative efforts were observed to foster creative conceptual understanding, thus highlighting the pedagogical benefits of this approach in STEM education.

The role of collaborative note-taking was further investigated in the setting of a flipped learning environment at a Korean university (126). Focused on a scientific writing course, this study demonstrated that student groups engaging in collaborative online note-taking achieved significantly higher scores in online quizzes and individual writing assignments. This evidence underscores the effectiveness of collaborative note-taking in boosting academic performance in flipped classroom contexts.

While these studies collectively validate the effectiveness of collaborative note-taking in enhancing online education, they also reveal an associated challenge. Costley and Fanguy (53) reported an increase in cognitive load among students engaged in collaborative note-taking. Participants experienced heightened levels of both germane cognitive load, which is beneficial, and extraneous cognitive load, which can be detrimental. This indicates that while collaborative note-taking can improve understanding of course content, it might also introduce elements of increased cognitive complexity, resulting in a nuanced cognitive experience.

This challenge motivated us to leverage “micro-topics” and “learning pathways” in our research to improve the readability of others’ notes and reduce the extraneous cognitive load while maintaining the advantages of collaborative note-taking. By enhancing the readability and coherence of shared notes, we seek to preserve the advantages of collaborative note-taking while reducing its potential cognitive burden.

4.1.2 Micro-Topic Learning

Recent studies indicate students’ preference for concise micro-topics over traditional, lengthy text-based learning (14; 51; 67). Micro-topic refers to concise, digestible pieces of information, such as flashcards and short videos, which are widely used in online learning platforms (59). Platforms like Khan Academy and Duolingo use micro-topics to deliver educational content (99; 167). Micro-topics provide several advantages over longer pieces, including boosting academic self-efficacy, capturing students’ attention, reducing cognitive load, and facilitating personalized learning (37; 34; 96). However, fragmented micro-topics are not enough and students need learning pathways to follow.

4.1.3 Learning Pathways of Micro-Topics

Learning pathways are the dependencies among concepts or skills that determine the order of learning. Learning pathways are essential for effective learning, as they help learners build a solid foundation of prior knowledge before moving on to more advanced topics (35). Learning pathways also help instructors design appropriate curricula and assessments for learners (63; 116).

Several methods have been proposed to identify and represent Learning pathways in learning domains. Some methods rely on expert knowledge or existing curricula to manually define the pathways (166). Other methods use data-driven approaches to automatically infer the prerequisite relations from various sources of evidence, such as learner performance data, text analysis (117), or graph analysis (79). However, these methods may have limitations in terms of scalability, accuracy, or generalizability.

4.1.4 Learning Objects and Knowledge Components

Research on learning objects is crucial for understanding the structure and delivery of micro-topics in education. Learning objects, defined as digital materials with instructional value, enhance the flexibility and effectiveness of teaching and learning methods (86). Their concept is rooted in a granularity scale in education, where components form lessons, lessons create modules, modules compose courses, and courses build programs. A similar notion is defined in knowledge component modeling, which views a student's knowledge as a collection of interconnected knowledge components. Each knowledge component represents a learned cognitive unit or structure that is deduced from how a student performs on tasks that are related to each other (104). McGreal (124) discusses the significance of learning objects as modular content units in online education, emphasizing the benefits of creating versatile and interoperable learning objects suitable for varied learning environments. This approach aligns with a granular educational structure, where smaller knowledge objects, akin to micro-topics, form the building blocks of more complex educational units. Downes (65) supports this view, likening efficient course design to a cobbler using pre-existing materials rather than starting from the ground up. In this paper, 'learning pathways' refer to sequences of these micro-topics, demonstrating their utility in structuring learning experiences in less granular contexts.

4.1.5 Collaborative Generation of Learning Pathways of Micro-Topics

Schroeder et al. (156) executed an extensive meta-analysis, examining 42 years of concept map research, encompassing 142 distinct effect sizes from 11,814 participants. This study underscored the efficacy of concept map construction, revealing its superiority over other educational methods like linear note-taking, class discussions, lectures, or studying various textual materials, lists, outlines. Particularly, students actively involved in creating concept maps showed notable improvement in learning outcomes compared to those reviewing pre-constructed concept maps (156). These results were evident across different educational levels and disciplines, including both STEM and non-STEM subjects, corroborating findings from earlier meta-analyses (87; 132).

Novak and Cañas (135) have highlighted the enhancement of meaningful learning through collaborative concept mapping, building upon Ausubel’s differentiation between rote and meaningful learning. Rote learning is characterized by mere memorization without integrating new information into existing knowledge (134). Conversely, meaningful learning involves the integration and creation of new knowledge within established cognitive frameworks, a process often termed as knowledge elaboration (92). This type of learning employs tactics like self-explanation (50) and elaborative interrogation (68) to forge connections between new and existing knowledge.

Schroeder et al. (156) highlight the necessity for elaborative cognitive processing in concept map creation, akin to text construction. This process demands active engagement in self-reflection, questioning, and summarization by the learner. Essential is not only the understanding of key conceptual ideas but also their interrelations and effective visual-spatial representation. The spatial arrangement of links and nodes, representing the connections and relationships among these concepts, presumably involves intensive elaborative processing (156). Similarly, Karpicke and Blunt (95, p. 772) describe concept mapping as “an elaborative study method: It requires students to enrich the material they are studying and encode meaningful relationships among concepts within an organized knowledge structure.”

Although effective in both solo and group settings, Schroeder et al. (156) found particularly intriguing results when comparing collaborative versus individual concept mapping. A blend of collaborative mapping with individual effort yielded significantly greater learning effects than solitary mapping. This indicates that collaborative process of extracting micro-topics and generating learning pathways in the form of concept maps notably surpasses collaborative linear note-taking in enhancing learning. Nevertheless, we will explore the challenges in engaging students in such an effective collaboration in the subsequent section.

4.2 Challenges in Collaborative Generation and Improvement of KGMLPs

We have categorized these challenges into the following three:

4.2.1 Motivating Students to Read and Improve Others’ Work

The goal is to motivate students to engage with others’ work. They may be too busy, lazy, or confident; or they may find others’ contributions too boring, complex, or irrelevant (103). In the presence of the competing option of going solo, creating a personal area of the KGMLP, students should be encouraged to engage with each other’s work; otherwise, the group work may not be fruitful.

The participants may not be willing to edit or improve the contributions of others. For example, they may be too polite, respectful, or afraid; or they may find the contributions too good, bad, or controversial (103). In many settings, editing work is invisible and not rewarded. Editing others' work can also be socially awkward. Hansen and Resnick (82) found that people in a technical support email list were quite willing to answer questions and even willing to write summary pages in a companion wiki, but were reluctant to edit the content of others' work. Restrictions on editing can demotivate improvements entirely. For instance, new editors on Wikipedia, whose contributions are reverted, tend to leave the platform more frequently, and those who remain often reduce their rate of contribution (80).

4.2.2 Reaching a Consensus on Micro-topics and Learning Pathways

Collaborators may have difficulties coming to an agreement on how to construct parts of a knowledge graph, which can inhibit progress on the other parts (74). Unlike the independent entries on platforms like Wikipedia or StackExchange, in a KGMLP, where interconnected links are crucial, consensus is more challenging to achieve. Disagreements may arise over the relevance, accuracy, or necessity of a link, often fueled by contributors' diverse expertise and background knowledge, leading to inconsistencies in terminology, definitions, or assumptions. This variance can cause confusion, particularly in widely used or interdependent entries, as changes by one participant may inadvertently disrupt the work of others.

Various crowdsourcing platforms have implemented strategies to mitigate similar challenges. Wikipedia, for instance, employs both human editors and automated bots to reverse non-beneficial edits (177), and high-traffic pages are often locked, permitting only authorized editors to make changes (177). StackExchange grants editing rights exclusively to proven, high-quality contributors (141). While effective for platforms like Wikipedia and StackExchange, these approaches may not fully address the unique requirements of a KGMLP in an educational setting. Granting instructors administrative rights to refine content and pathways, and remove erroneous information, is critical. However, the high volume of contributions in large courses poses a challenge, as instructors may struggle to promptly review all content. This delay in oversight might lead to a temporary persistence of misleading or incorrect information on the KGMLP, potentially impacting student learning adversely.

4.3 1Cademy System Design

This section introduces 1Cademy, a system designed for asynchronous collaboration. The system facilitates the generation, evaluation, and improvement of a large KGMLP. The primary aim is to

mitigate the challenges discussed in the previous section on a time scale of months, content scope of a textbook or course, and group size of dozens to thousands. The unique design features of this study are as follows:

- A proposal mechanism for changes to a node or its links
- A requirement that new node proposals also include at least one learning pathway
- A vote-dependent acceptance threshold for proposals
- Community-specific contribution scores

The following features, although implemented in 1Cademy, are not discussed in this section as they are commonly used in other online communities:

- Community guidelines
- Peer review system (voting and commenting)
- Reputation system (including leaderboards, badges, nudges, and assigning special privileges)
- User training and tutorials
- Content moderation tools
- Search functionalities
- Semantic analysis tools
- Tagging and categorization
- Preventing duplicates

4.3.1 Characteristics of the KGMLP

In our research, our primary objective is to improve collaborative micro-topic extraction and learning pathways generation on a Knowledge Graph of Micro-topic based Learning Pathways (KGMLP), presenting several definitive characteristics. The KGMLP is composed of various nodes, with each node symbolizing a unique piece of knowledge. Importantly, each node is standalone, signifying its capacity to convey meaning without any necessary reference to other nodes or outside resources. Further, these nodes are indivisible in their nature, indicating that any attempt to dissect them further could lead to a loss of inherent meaning.

We utilize terms, such as “parent” and “child,” to describe the source and destination of each link respectively. The KGMLP follows a structure where if node A happens to be a child of node B, then node B is considered a parent of node A. This structuring framework contributes to the unidirectional character of learning pathways, which shows that a node, after becoming a parent of another, cannot inversely become its child.

The characteristics of the KGMLP prohibit any cyclical node relationships, meaning that if node A is a parent of node B, and node B is a parent of node C, then node C can never be a parent of node A. Each link between any two nodes outlines a learning pathway, denoting that learning a parent node prior to learning its child nodes is desirable. Furthermore, each node in this graph can have varying relationships, one or multiple parents, and zero, one, or multiple children, creating a diverse network. For instance, only one node exists with zero parents and is hence termed the “root,” while numerous nodes with zero children, termed “leaves,” can be found within this thematic graph.

Node types Each node is of one of these types (for example, see Figure 4.1):

- *Concept*: defines a granular unit of knowledge.
- *Relation*: explains the relationships between two or more linked *Concept* nodes without defining any of them.
- *Question*: contains an auto-gradable question with constructive feedback.
- *Reference*: indicates a citation to a resource outside of the KGMLP. Nodes of other types cite *Reference* nodes.
- *Idea*: represents an idea posted by an individual without citing any *Reference* nodes.

Social tagging Tags can be applied to nodes. Rather than allowing arbitrary text strings as tags, concept nodes are used as tags. Thus, the same mechanisms that encourage the development of consensus about titles and descriptions for concepts also encourage the adoption of a limited, well-understood tagging vocabulary.

The rest of this section elaborates on the four design features that form the contributions of this study.

4.3.2 A Proposal Mechanism for Changes to a Node or Its Links

To preserve the coherence of the KGMLP, consensus on micro-topics and learning pathways must be achieved. Unwarranted, accidental, or spam changes could disrupt the consensus. Therefore, in

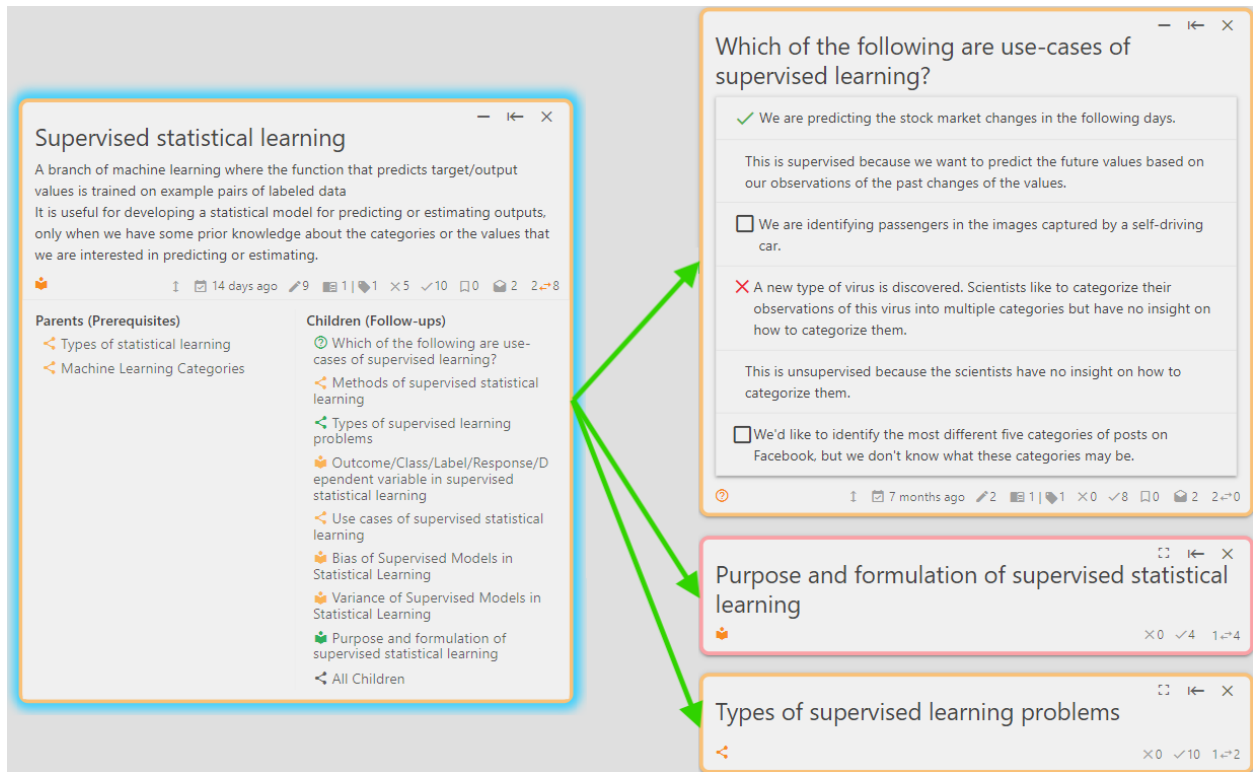


Figure 4.1: 1Cademy knowledge graph user interface.

- For the node **Supervised statistical learning**, its shadow indicates that it is selected, and its orange border means it has not been updated since the user marked it as studied. The numbers in the node footer from left to right indicate that the node was last updated two years ago; received 5 downvotes and 12 upvotes; cited one reference and tagged another node; and linked to two parents and 16 children. Green arrows indicate this node is a parent of “Types of supervised learning problems,” “Purpose of supervised statistical learning,” and “Which of the following are use-cases of supervised learning?” nodes.
- The node “Types of supervised learning problems” relates “Classification Problems” and “Regression Problems” that are defined in its child nodes. It is collapsed and has not been updated since the user marked it as studied.
- The node “Purpose of supervised statistical learning” is expanded, and updated or not studied yet.
- The node “Which of the following are use-cases of supervised learning?” is a multiple-choice question with four choices. Clicking each reveals whether the choice is correct or wrong and expands its corresponding feedback below it.
- Clicking — at the top of a node collapses it to only display its title; expands it to display the title, content, and footer; **X** hides it; and **←** hides all its descendants from the user’s notebook (view of the KGMLP).
- We use Dagre.js (56) for the implementation of the four directed, acyclic graph layout algorithms (78; 91; 21; 32; 154) to reorganize the map and put nodes in optimal locations in same-width columns.

1Cademy, all modifications to the KGMLP commence as proposals. Whether a user is proposing a new node or an improvement to an existing one, they are required to select an existing node to make the proposal on.

To propose a new node, a user should go through the following procedure:

1. Search and navigate through the KGMLP to find the relevant cluster of nodes;
2. Identify an appropriate parent (direct prerequisite) node;
3. Propose the node as a child under the parent node;
4. Specify the title, content, and reasoning for the proposal. The reasoning encourages users to reflect on the proposal's purpose and allows other users to understand why the proposal was made to evaluate its helpfulness.

The system imposes a constraint that there is always a single, canonical “current version” of each node, including its contents and its links. We have implemented a simplified version control system. Each proposal offers a new final state of the node, including title, content, links, and cited references and tags, not a revision to some element of the node. Proposals that have not been selected as the current version remain accessible for exploration as alternative viewpoints.

Note that there is no automated support for merging two proposals. For example, if one person proposes a change to the contents and another person proposes a change to the links only one of these proposals can be accepted. One of the authors, or someone else, could make a new proposal that manually merges the two changes.

The advantage of this over a full-featured revision control system is its simplicity. It is very easy for people to understand because each proposal, if accepted, specifies a complete state of the node. There is no possibility of merge conflicts and thus no need to consider how the proposal would interact with any other pending proposals. This simplicity comes at the cost of requiring a person to notice when there are good ideas in multiple pending proposals and create a combined proposal. Because each node is relatively small, typically with just a single paragraph, a single image, or a short video, the benefits of simplicity outweigh the costs. In a site like Wikipedia, with very large pages as nodes, a proposal mechanism like ours might need a more complex version control system.

4.3.3 A Requirement that New Node Proposals Also Include At Least One Learning Pathway

When proposing any new node, users are required to identify at least one existing node as a parent of the new one. This requirement is devised to accomplish a set of objectives. First, it serves as

a motivation for the users, encouraging them to read and study the peer-generated content thoroughly, in order to correctly identify the best learning pathway. Secondly, it acts as a deterrent to duplicate entries. When the process involves linking new nodes, duplicates surface easily and will be therefore discouraged or removed by the community. Thirdly, it stimulates meaningful learning. Learners are incited to ponder about the conceptual relations between their previously acquired knowledge and the new nodes that they wish to add. Lastly, it informs about learning pathways. It provides information to the community about various helpful ways to learn new concepts. When any user faces difficulty in comprehending a node, they can study parent nodes to understand the learning pathways and keep tracing the steps backward till there are no unknown micro-topics left. Once the antecedents are clear, they can progress through the child nodes step by step, thus achieving their learning goals.

4.3.4 A Vote-Dependent Acceptance Threshold for Proposals

All proposals go through a peer review process before getting implemented into the KGMLP. The process starts with voting on how helpful already implemented nodes are for one's learning. If a node is found to be helpful by many users, 1Cademy makes it more difficult to modify, compared to nodes that users do not find very helpful to their learning.

To moderate the acceptance of proposals, a node is moved from an open state where anyone can modify it, to a progressively tighter lockdown as users upvote it. For a proposal to be accepted, it needs to receive at least half as many net votes (upvotes minus downvotes) as the version it proposes to replace. This helps ensure that helpful nodes would not receive spurious edits.

Each proposer automatically upvotes every proposal they submit. Thus, if a proposal is made on a node with two or fewer net votes, the proposal is approved and implemented into the KGMLP immediately. In cases where nodes have more votes, the proposal needs at least half to get approved (e.g., seven net votes on a proposal for a node that already has thirteen net votes). Compared to hierarchical administration in online communities, such as StackExchange or Wikipedia, which is shown to negatively affect the members' motivation to contribute (81), quality assessment and improvement on 1Cademy happen through democratic community acceptance. All users have the same privileges since decision-making is based on direct votes.

4.3.5 Community-Specific Contribution Scores

Each node has two types of proposals:

- *Approved proposals* are already implemented in the KGMLP because they have received net votes greater than or equal to half of the net votes on the original node.

- *Pending proposals* stay on the waiting list of the corresponding node until they receive enough upvotes to get approved.

Having granular and standalone proposals, if a proposal gets an upvote or downvote, the proposer would earn or lose reputation points, accordingly. Due to the small size, each node receives a limited number of proposals, which are ranked based on their net votes. Each upvote/downvote on a node increases the upvotes/downvotes on every *approved proposal* on the node, proportionate to their current net votes. This way, if the community has assigned a higher net vote to an approved proposal, it indicates that this proposal has had a higher impact on the evolution of the node. So, when the node gets an upvote/downvote, this proposal gets a higher share of that upvote/downvote, and its proposer gains/loses their reputation points accordingly. Hence, votes on nodes affect the contribution scores of the contributors in a fair manner, such that each contributor gains/loses points proportionate to their contributions.

This mechanism allows the development of a contribution score for each user on each node that they have contributed to, which equals the total number of upvotes minus downvotes received on their pending and accepted proposals on that node. As opposed to online communities such as StackOverflow or Quora, where each user has a global reputation, in 1Cademy each user has a node-specific reputation. A user's contribution score in a community (represented by a tag) is defined as the net summation of their reputation on all nodes under that tag. Because each tag represents a subcommunity on 1Cademy, users get hierarchically defined reputation points that dynamically change in communities, and sub-communities, all the way down to granular nodes.

4.4 Course Usage Study

We conducted a longitudinal study with 29 (16 male, 13 female; ages 19 – 26) students in an experimental course over ten weeks of the Winter 2020 semester at a large public research university in the United States. Based on observations and students' feedback throughout the semester, we iteratively made modifications to the design of the system. In section 4.3 we reported the system's final design that remained stable for the last month of the study. After the end of the semester, we collected students' reflections and thematically analyzed them. In addition, we used structural equation modeling to causally infer the effects of collaboration on students' perceived learning on 1Cademy.

The students used 1Cademy to study two textbooks, “An Introduction to Statistical Learning with Applications in R” (90) and “The Book of Why” (145). I served as the instructor in the course. The participants included both undergraduate and graduate students from two departments of Computer Science and Information Science.

After the semester, we asked students to fill out a questionnaire on Qualtrics to reflect on their experience using 1Cademy throughout the semester. We distributed the online questionnaire a few days after releasing course grades; answering the questions was not required, and students did not earn any points or other incentives for responding. We also collected and analyzed students' usage data throughout the semester.

In the following sections, we first illustrate an example of students' actual asynchronous collaboration, to show the system in action. Then we present our analysis of students' usage data and end-of-semester reflections. Throughout the following sections, we have used pseudonyms for students: S1, S2, ..., S29.

4.4.1 Case Study: the Collaborative Evolution of a Node

In this subsection, we walk through the asynchronous evolution of a node. The node began incomplete (upper part of Figure 4.2), but through proposals by other students, more connections and examples were added, and the quality and comprehensiveness improved (lower part of Figure 4.2).

1. On March 15th, S12 proposed the initial node and titled it "Eliminating Confounders," as a child node of "Defining confounders." It listed methods of deconfounding that students learned from "The Book of Why." These two methods were "RCT," and "back-door criterion."
2. Immediately afterwards, S12 proposed "Randomized Controlled Trial (RCT)," as a child node under "Eliminating Confounders." The former node was previously created by S6.
3. Later that day (March 15th), S12 proposed a child node for "Eliminating Confounders," titled, "Back-Door Criterion." The node briefly explains what a back-door criterion is and why it is used for the purpose of deconfounding.
4. On April 2nd, S10 proposed an improvement to the content of the node "Eliminating Confounders," and added "front-door criterion" as another deconfounding method. However, S10 did not propose any node for defining "front-door criterion" because this concept is introduced in later chapters of "The Book of Why."
5. On April 4th, S8 proposed a new child node defining "Front-Door Criterion" under the node "Eliminating Confounders." The content of the node explained the concept and contained an additional diagram. S8 (after learning the front-door criterion) was able to collaborate with S12 and connect S12's explanation of a different concept (eliminating confounding) to provide the rest of the class with another way of learning and visualizing it.

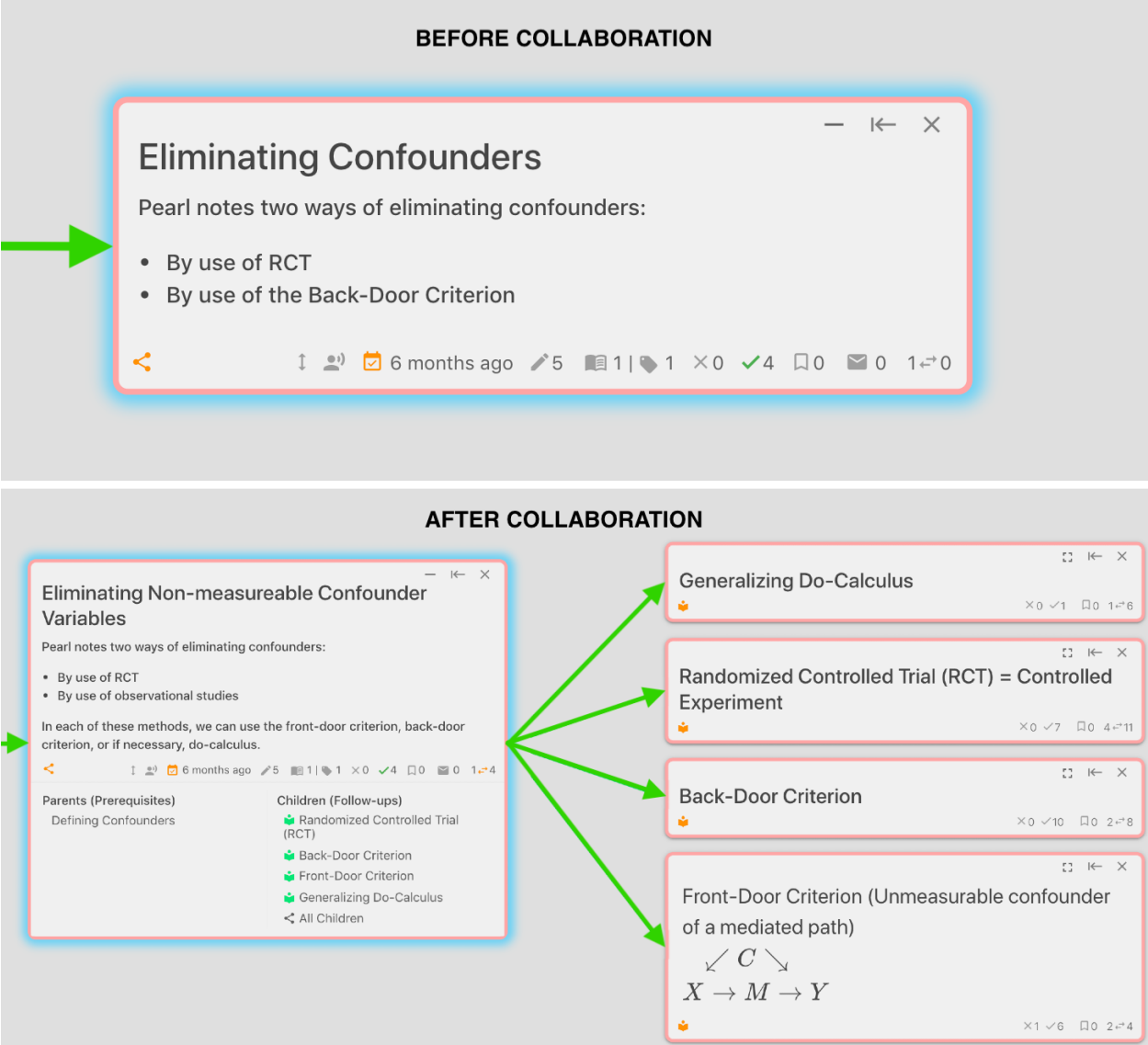


Figure 4.2: Evolution of a Node. The students interacted with this UI during the study, which is an older version of the UI in Figure 4.1.

6. On April 5th, the class had a meeting that prompted a conversation about the content of this node, allowing students to discuss the concepts presented on 1Cademy.
7. After the class, S11 created a new child node to define “Generalizing Do-Calculus,” as another child node under “Eliminating Confounders.” The node introduced three strategies when using do-calculus to deconfound.
8. On April 12th, about a week after the class meeting, S11 proposed many changes to this node. They stated in their proposal reasoning: “This update reflects the conversation from the 4/5 discussion. We update the title to discuss eliminating non-measurable confounders and simplify the strategies into two: RCT and observational studies.” The changes are as follows:
 - Changed the title from “Eliminating Confounders,” to “Eliminating Non-measurable Confounder Variables.”
 - Changed the list to only include “RCT,” and “observational studies.”
 - “Front-door criterion,” “Back-door criterion,” and “Do-calculus” were added as methods to deconfound the analysis of both observational studies and randomized control trials.

Drawing from the class discussion, S11 reorganized, connected, and clarified difficult concepts by improving the node and link structure on the map. Afterward, these interconnected nodes received a significant number of upvotes from other students indicating their helpfulness for learning.

After S12’s initial proposal was accepted, the node was iteratively improved. At first, the node contained no child links, but by the end, the node contained links to child nodes with further explanation of the content. For example, after S12 linked the node to the one created by S6, students could now visualize the connections and learn the linked node. The discussion on April 5th showed that conversations could translate into improvements on the map. As a result, S11’s improvements helped to make S12’s node clearer by making distinctions between concepts. By the final iteration of the node, five different students (S6, S8, S10, S11, and S12) had collaborated to build a node with the proper learning pathways that could help students learn the concepts. As students continued to read and learn from “The Book of Why,” they returned to nodes previously added to the map, proposed content edits, and added new links.

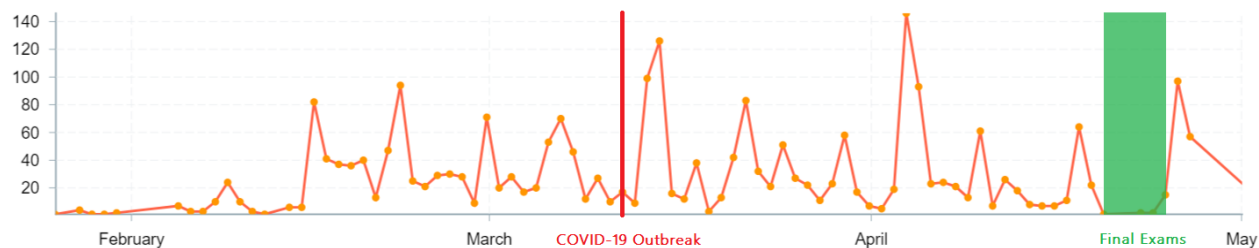


Figure 4.3: The number of proposals posted on each day over the study period (01/26/2020 - 04/30/2020). Classes transitioned to the online setting because of the COVID-19 outbreak on March 11th. The university’s final exam period is marked in green.

4.4.2 Trends of Activity

To evaluate the success of asynchronous collaboration on 1Cademy, we begin with trends of activities throughout the semester, then conduct a causal analysis of what led nodes to get more students’ upvotes indicating their helpfulness, and finish with a qualitative analysis of student reflections.

Students created a total of 934 nodes. They submitted 2, 131 proposals, including 721 proposals for edits to nodes and 1, 410 proposals for revisions to links. Figure 4.3 illustrates the trends in the cumulative number of proposals posted each day throughout the study. Students sustained their contributions throughout the entire semester. Because this course had no exams and students earned points progressively throughout the semester, contributions were minimal during the final exam period.

4.4.3 Causal Inference

The main objective of our causal analysis is to assess whether more asynchronous collaboration causes a node to be voted as more helpful by the students. We take the students’ collectively reported helpfulness, as a proxy for measuring their satisfaction of learnability of the micro-topic and its learning pathways. If the nodes that evolved through more collaboration are reported as more/less helpful, we can conclude that more collaboration has positively/negatively impacted their learning satisfaction. For this purpose, we analyze the causal effects of the number of collaborators on a node’s helpfulness to students’ learning.

In our analysis, we aimed to measure the average causal effect (ACE) (145) of the number of unique collaborators (*UniqueCollaborators*) on the net vote count (*NetVotes*). We built a causal diagram, including relevant variables and their effects determined through reasoning and theory. We then estimated the effect size for each causal relation represented by the arrows in the diagram, using structural equation modeling. In doing so, we were able to deconfound (control) the proper variables and isolate the causal effects.

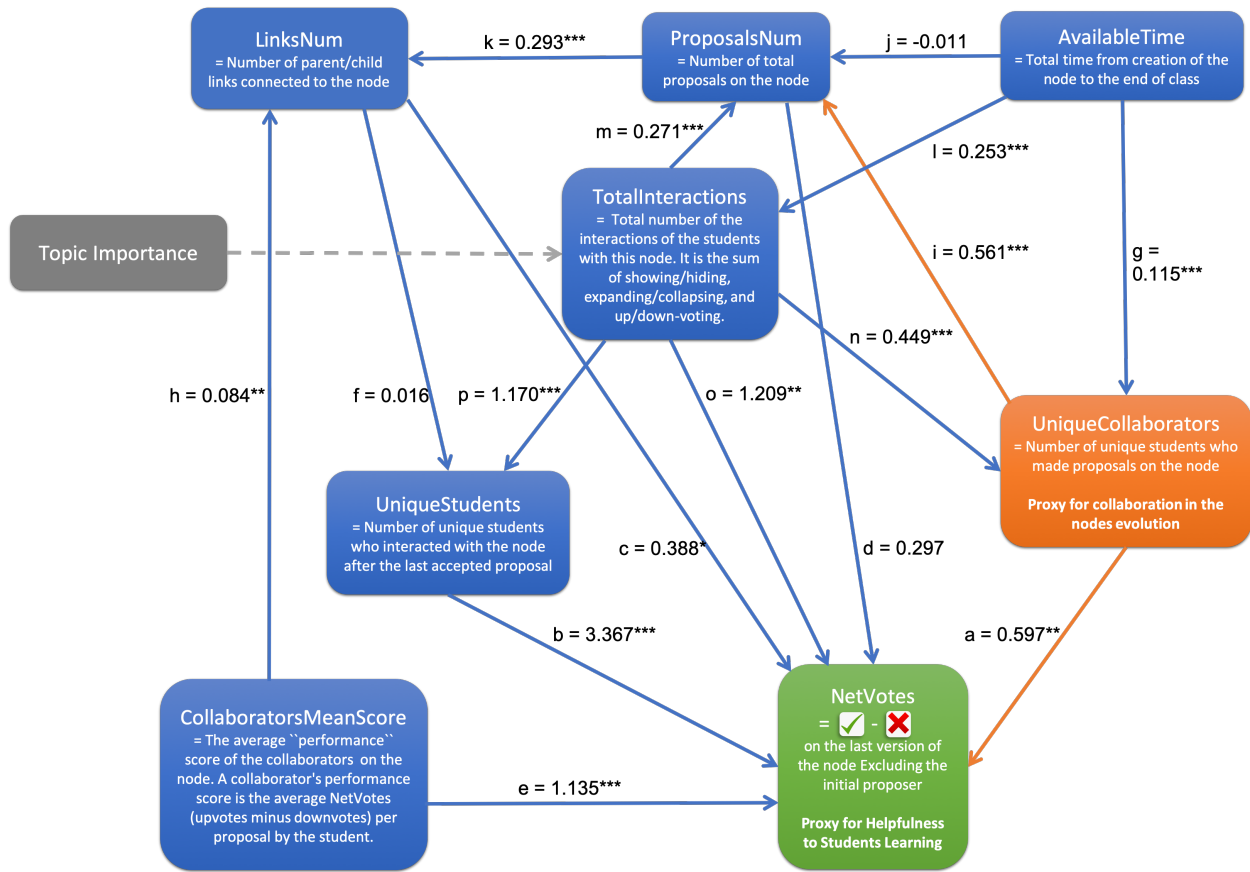


Figure 4.4: Causal diagram of the effects of students' two types of collaboration on the helpfulness of nodes. The orange arrows illustrate the main effects. The direction of each arrow indicates the causal direction of the corresponding effect. The numbers represent path coefficients estimated through Structural Equation Modeling (SEM), and the stars depict the statistical significance of the test. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

4.4.3.1 Variables involved in the analysis

Each data point (the unit of study) represents a unique node on 1Cademy. Figure 4.4 shows the final path diagram, including estimates of direct causal effects between pairs of variables.

- **UniqueCollaborators:** Number of distinct students who made at least one proposal on the node. It serves as a proxy for collaboration on the node.
- **LinksNum:** The number of parent and child links connected to the node.
- **ProposalsNum:** The number of proposals made on the node, regardless of who made them.
- **NetVotes:** Upvotes minus downvotes on the node. Votes cast by students who did not interact with the node again after its final modification were omitted. *The vote cast by the creator of the node is also omitted.* This indicates how helpful nodes were reported by students and serves as a proxy for learning satisfaction of the micro-topics and their learning pathways; our main outcome variable of interest.
- **TotalInteractions:** Number of times students interacted with this node.
- **UniqueStudents:** Number of unique students interacting at least once with the node, after its final modification (students who could potentially contribute to the NetVote score.)
- **AvailableTime:** The elapsed time from the creation of the node to the end of the class.
- **CollaboratorsMeanScore:** The average “performance“ score of the collaborators on the node. A collaborator’s performance score is the average net votes of the proposals by the student on the node.
- **Topic Importance:** A latent (unmeasurable) variable that represents the importance of a topic in the course curriculum.

4.4.3.2 Path analysis using Structural Equation Modeling (SEM)

We estimated the path coefficients in the causal diagram using the *sem* command in *lavaan* package in R (150). It estimates simultaneous regression models and controls for the specified confounders. Running the model generated the path coefficients displayed in Figure 4.4. (The detailed statistics are available in the appendix.) The unit of analysis is a node on 1Cademy, (i.e., each data point represents a node). To interpret the results, we computed the total effect of each independent variable on *NetVotes*. The total effect is the sum of the coefficients on the direct link and any mediated paths. When holding other covariates on their average and categorical variables proportionately to their levels, our causal model estimated that **for each additional unique collaborator**

the *NetVotes* would increase on average by .837 ($p - value = 5.18e - 06$) votes. This is the total effect of $a + i * d + i * k * c + i * k * f * b$.

- The direct effect is $a = .597$ ($p - value = 6.76e - 03$).
- The mediated effect by *ProposalNum* is $i * d = .167$ ($p - value = .193$).
- The mediated effect by the path *UniqueCollaborators* → *ProposalsNum* → *LinksNum* → *NetVotes* is $i * k * c = .064$ ($p - value = .0465$).
- The mediated effect by the path *UniqueCollaborators* → *ProposalsNum* → *LinksNum* → *UniqueStudents* → *NetVotes* is $i * k * f * b = 0.009$ ($p - value = .492$).

This analysis rejects the null hypothesis of the inefficacy of asynchronous collaboration on 1Cademy. We interpret these results as:

- Having more collaborators on a node helped not only the collaborators, but also those who did not participate in the creation or improvement of the node but interacted with it.
- Students found nodes with more parent/child links connected to them, more helpful, which sheds light on the benefit of the linking constraint.

Hence, more collaboration caused higher satisfaction of learning.

4.4.4 Student Reflections

We analyze students' reflections administered, at the end of the semester, a few days after the distribution of the course grades. *Nineteen* students filled out the online questionnaire. We included the students' responses to questions that were particularly relevant to the system objectives. Although due to a small number of observations ($n = 19$) the numbers reported in the following survey results do not statistically validate any hypothesis, we report them for scrutiny.

The survey questions are as follows:

1. "Imagine you want to review one of the concepts that you learned, to what extent would you prefer to review it on our collaborative maps in comparison to conventional course textbooks/lecture notes? Please explain."
2. "How did you decide whether to upvote/downvote on a node?"

4.4.4.1 Reviewing collaborative KGMLP versus conventional textbooks/lecture notes

Of the *nineteen* responses, *ten* students reported preferring the KGMLP, *five* felt neutral and *four* preferred conventional methods.

Students cited various reasons for their preference. S6 felt the graph promoted self-assessment more than conventional methods, “I strongly prefer collaborative maps. The platform allowed me to confirm my understandings (whether my understanding is accurate, sufficient, etc.) and made me self-evaluate better about my understanding and knowledge...” S6 attributed this to the collaborative aspect of the map, “...This was especially true when I read nodes created by others, which contents were different from my understandings of the topics.” In contrast, S13 felt the differences in understanding of collaborators negatively affected their experience, “collaborative maps suffer from the issue of inconsistent effort and learning style of authors...”

Students such as S16 felt others’ contributions actually made nodes more understandable “...students may write it in a way that even non-technical people may understand...” They may be referring to the difficulty in understanding jargon used by machine learning professionals. Reading representations of others’ understanding may reduce the jargon to include only terms understandable to someone at a similar experience level. S5 reported a similar sentiment, “The collaborative map is a way of brainstorm and we could know other people’s thoughts.” In a sense, the KGMLP served as an ongoing, iterative brainstorming environment to represent the collective knowledge learned throughout the semester. If one person knows a topic deeply, they are incentivized to share their understanding with the rest of the community through new additions or revisions.

Others felt that the granularity of nodes helped their understanding by mediating overload and improving organization; S17 reported, “One thing I really love about the map is that everything is concise. I [get] a very simple explanation, which is hard to find for machine learning topics, and can go deeper if I choose to” and S18, “I think it was easier to understand how information flows this way. There was less information on each node than you would find in a book, for example...”

4.4.4.2 Votes indicate helpfulness for one’s learning

We chose to analyze responses to this question to provide supporting evidence for the use of netvotes as an indication of helpfulness, and consequently a proxy for students’ learning satisfaction, in our causal analysis.

Sixteen out of the *eighteen* respondents said that they voted based on whether the node helped their understanding of a concept, *one* reported they did not vote enough and *one* said they voted because they wanted to reward their classmates for contributing helpful proposals.

S5 responded almost identically to how they were told to vote, “When I think the node is helpful to learn and really clear to describe something, I will upvote it.”, S11 responded similarly,

“If I learned something” and S7 said “If I found the node helpful and concise, I would upvote it...”

Some students created processes to determine the helpfulness of a node when voting. S14 explained their four steps, “1.) did it have a proper citation 2.) was it correct (I would sometimes look it up if it seemed suspicious) 3.) was the content relevant to the parent nodes 4.) was there not too much or too little information (if so, edit it before voting)”. S20 defined two steps, “1. Is it easy to understand? (Than the textbook) 2. Is the information correct?”

Some students responded that they downvoted nodes that were copied from the textbook. S16 said “[I] see whether the node is clear and helpful for our learning. If it’s something just copy-paste from textbook then it’s down[voted]...” Others downvoted when there was incorrect or missing information, like S6, “... I downvoted some later in the semester only when I noticed the patterns of behaviors that were not helpful to others -(e.g.) repeatedly ignoring references to be added, etc...” and S18, “... I tended not to down-vote on nodes unless I thought that the concept was wrong.”

4.5 Research Communities Study

The 1Cademy platform has supported a large collaborative effort since its inception *four* years ago, in addition to its class deployments. This effort has involved 1,754 students and researchers from 208 institutions, culminating in an expansive KGMLP comprising 50,947 nodes and their links through 271,836 proposals.

Currently, 1Cademy hosts *sixteen* student-led research communities, each organized around a different discipline. Figure 4.5 visualizes the network of relations between nodes in these color-coded communities.

4.5.1 Interview Protocol and Participants

To further understand the effectiveness of our design features in improving the students’ learning satisfaction and enhancing collaborative micro-topic extraction and learning pathway generation, we conducted semi-structured interviews with *ten* members of these research communities who were selected from among the most active contributors on 1Cademy a month prior to the interview. Our aim was to capture a wide range of experiences and perspectives, so we stratified our sample to include diversity in terms of:

- Duration of engagement with the platform
- Area of expertise or main contribution areas within the KGMLP, which correlates with their field of study

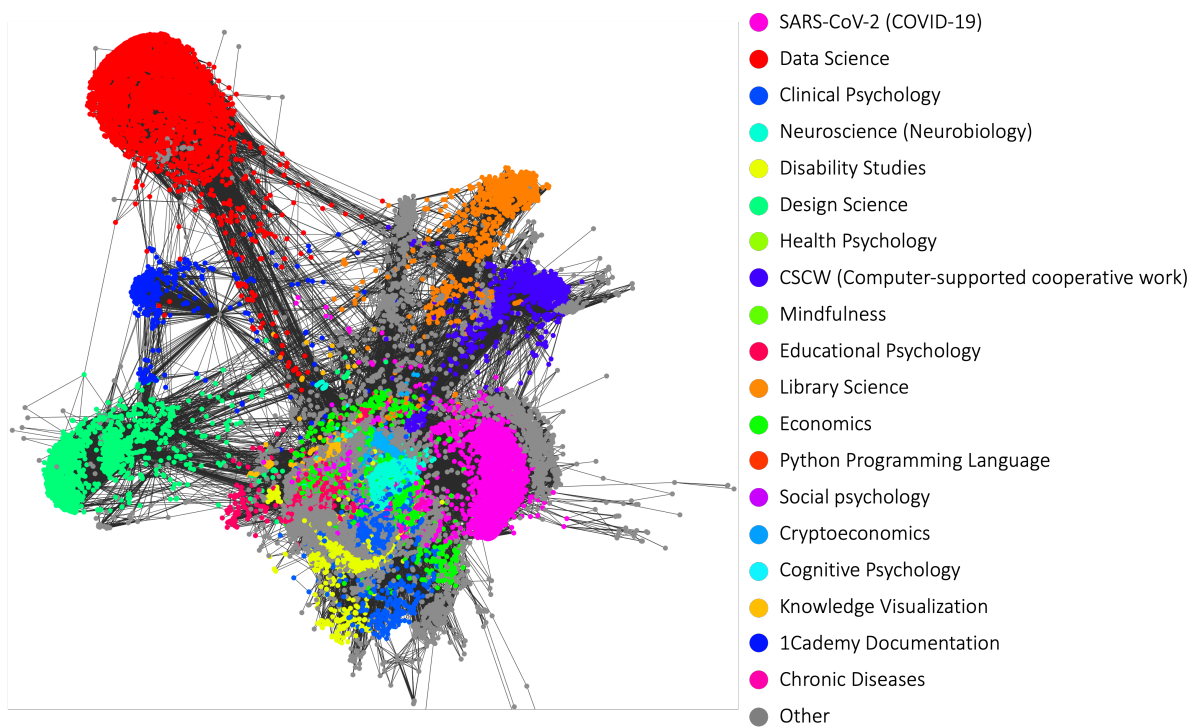


Figure 4.5: Network of connections between nodes on 1Cademy through parent/child/tag/relation links. Nodes tagged in each community are color-coded.

- Affiliated institutions in the U.S.
- Academic level or degree

The main objective of these interviews was to study to what extent the design features of 1Cademy improve the collaborative micro-topic extraction and learning pathway generation, and perceived helpful for the community members learning. The interviews were designed to gather insights into the participants' experiences, perceptions, and suggestions regarding the collaborative construction, evaluation, and improvement of the KGMLP.

4.5.2 Interview Format

We utilized a semi-structured interview format. This approach allowed us to use a predefined set of questions to ensure consistency across interviews, while also providing the flexibility to explore interesting themes that arose organically during the session.

All interviews were conducted virtually and were video-recorded with consent from the participants². During each interview session, the participant shared their computer screen with the interviewer and answered questions about their experience with the system. Each interview lasted approximately 30 minutes, and we used Dovetail (64) for transcribing and subsequent analysis.

4.5.3 Interview Questions

The interview questions were semi-structured, allowing for flexibility in the conversation while ensuring that key topics were covered. As we learned more from the interviewees, we continuously updated our questions to better understand the collaboration dynamics and reflect them in our analysis. We asked questions to understand the participants' experiences and perceptions of collaborating with other community members in the construction and improvement of the KGMLP. We also asked questions to gather the participants' suggestions for improving the collaborative construction and improvement of the KGMLP. The questions included:

- How did you find the experience of collaborating with other community members in the construction of the knowledge graph?
- Can you describe any challenges you faced in reaching a consensus on learning pathways with other members?
- How did the design features of 1Cademy help in maintaining common ground among the community members?

²This study is approved under the IRB (Institutional Review Board) HUM00192467 and HUM00196425.

- Can you share any instances where you were motivated to read or improve others' work? What factors contributed to this motivation?
- What features or mechanisms would you suggest to improve the process of reaching a consensus on links?
- How do you think the platform can better facilitate the maintenance of the common ground among the community members?
- What features or mechanisms would you suggest to motivate community members to read and improve others' work?

These questions were designed to provide insights into how the contributors can collaborate effectively in a KGMLP-building context. Understanding the perceptions and experiences of the contributors will enhance future design decisions and help shape the ongoing collaborative dynamics on 1Cademy.

4.5.4 Research Communities Study Results

We adopted an iterative coding methodology inspired by grounded theory (139), which helped structure our interpretations into distinct categories. The transcription, iterative coding, and ensuing analysis of our interviews were conducted using Dovetail (64). In this segment, we present the key themes that surfaced during our analysis. As we acknowledge the potential for unreliability in small-number statistics, interviewing only *ten* participants, we deliberately refrain from stating any numerical data, concentrating instead purely on the elaboration of the themes. Furthermore, we examine the various applications for which users utilized 1Cademy.

Throughout this section, the interviewees are represented by codenames to ensure anonymity, and these identifiers remain consistent across all categories. For instance, I1 refers to the same interviewee throughout the various subsections.

4.5.4.1 Motivating Participants to Read and Improve Others' Work

The motivation to read and improve others' work emerged as a significant theme in our analysis of the interview transcripts. The interviewees shared their experiences and perceptions of how they were motivated to engage with the work of other community members and the factors that contributed to this motivation.

Several interviewees mentioned the role of the leaderboard and contribution scores in motivating them to read and improve others' work. For instance, I1 stated, "*one of the main factors that motivates me to improve upon others' work is the 24-hour points leaderboard. I usually try to stay*

on top, but it's very difficult to maintain my status. It's a great way to keep track of your own contributions and to see how others are contributing to the community. It's also a great motivator to improve your own work and to contribute more to the community." Similarly, I4 mentioned, "the reputation scores gave me a sense of achievement and motivated me to contribute more." These statements suggest that the leaderboard and contribution scores provided a sense of competition and achievement, which motivated the interviewees to engage more with the work of others.

The interviewees also highlighted the importance of the quality of others' work in motivating them to read and improve it. For example, I4 shared, "I remember reading a really well-written node on neurofeedback research. It was so comprehensive and well-structured that it motivated me to improve my own nodes." Similarly, I7 stated, "I remember once when I was studying the concept of the Matthew Effect, I came across a node created by another member. The note was well-written and provided a clear explanation of the concept. I was motivated to read it and even suggested a few improvements." These statements suggest that the quality of others' work can serve as a source of inspiration and learning, which can motivate community members to engage with it.

The interviewees also mentioned the role of the proposal system in motivating them to read and improve others' work. For instance, I2 stated, "the platform's design, like the proposals that are independent of one another and a certain number of votes are required to accept and implement proposals, encouraged me to engage with others' work." In contrast, I3 mentioned, "ICademy attempts to remedy this with the proposal and leaderboard system, but I'm not sure how effective it is in terms of promoting engagement." These statements suggest that the proposal system provided a structured and transparent mechanism for community members to engage with and improve the work of others, but there were mixed opinions about how well it promoted engagement with others' work.

The interviewees also suggested potential improvements to the platform to further motivate community members to read and improve others' work. For example, I2 suggested, "we could make the proposal review process a more integral part of the community, which would encourage more engagement in reviewing others' proposals." Similarly, I6 suggested, "maybe there could be some sort of reward system for reviewing and improving others' work. Like, maybe you could earn points or badges for reviewing a certain number of nodes, or for making significant improvements to a node." These suggestions indicate that additional features or mechanisms, such as a more integrated proposal review process or a reward system for reviewing and improving others' work, could further motivate community members to engage with the work of others.

In summary, our analysis suggests that the motivation to read and improve others' work is influenced by several factors, including the leaderboard and contribution scores, the quality of others' work, the proposal system, and potential improvements to the platform. These findings provide valuable insights into how to design and implement collaborative platforms to motivate

community members to engage with and improve the work of others.

4.5.4.2 Reaching a consensus on micro-topics and Learning Pathways

The participants highlighted the importance of ensuring a shared understanding among the community members, especially given their diverse levels of expertise and background knowledge. They also pointed out the role of 1Cademy's design features in facilitating this process. The challenge of reaching a consensus on links emerged as a prominent theme in our analysis of the interview transcripts as well. The participants expressed that disagreements were inevitable given the diverse perspectives and knowledge of the contributors.

The linking constraint was frequently mentioned as a key feature that helped maintain the common ground. As I1 noted, *“the requirement to identify learning pathways is really useful for this. It ensures that all the nodes are connected in a logical way, which helps to maintain a common understanding among all the community members.”* This sentiment was echoed by I4, who found that *“the linking feature was really helpful in keeping things organized. It made sure that we were all on the same page and that the knowledge graph remained coherent.”* These comments suggest that the linking constraint not only helped organize the knowledge graph but also fostered a shared understanding among the community members.

The vote-dependent acceptance threshold was another feature that participants found helpful in reaching a consensus on a canonical description of each micro-topic. I3 mentioned that *“the proposal system was useful because it allowed us to discuss and vote on changes before they were made. That way, we could make sure that everyone was on board with the changes.”* Similarly, I6 found that *“the proposal method is also really useful. It allows us to suggest changes or additions, and then others can vote on whether they agree. It's a good way of ensuring that the content is accurate and relevant.”* These comments highlight the role of the vote-dependent acceptance threshold in facilitating consensus-building and ensuring effective collaboration.

Participants also emphasized the importance of engaging with others' work in reaching a consensus on a canonical description of each micro-topic. I5 echoed this sentiment, noting that *“the feature that allows us to propose edits was very helpful. It allowed us to give each other feedback and understand where we might have gone wrong.”* These comments underscore the importance of active engagement and feedback in fostering a shared understanding among the community members.

The participants reported that disagreements often arose over the relevance, correctness, and necessity of the links. As I2 noted, *“Naturally, there were disagreements. For instance, sometimes we couldn't agree on whether a link was relevant or necessary. And sometimes, we had different perspectives on topics. But I think that's part of the process, you know? It's through these discussions and debates that we learn and grow.”* This sentiment was echoed by I5, who stated, “...

there were times when other members and I had different views on how to construct parts of the knowledge graph. For example, we sometimes disagreed on whether a link was relevant, correct, or necessary. We also used different criteria or standards to justify our choices, which made it difficult to reach a consensus.” These quotes highlight the complexity of the decision-making process in constructing the KGMLP, where contributors need to negotiate their differing views and standards.

The participants also reported that the process of reaching a consensus could be time-consuming and challenging. For instance, I3 shared, *“There were times when we had different ideas about how certain concepts should be linked. For instance, in the ADHD and Autism community, there was a debate about whether we should link certain symptoms directly to the disorders or whether we should link them through intermediate concepts like cognitive processes or brain structures. It took us a while to reach a consensus on that.”* Similarly, I10 mentioned, *“... there were a few instances where I disagreed with the links proposed by others. For example, I remember a case where a member linked their node on 'violent crime' to my node on 'homicide'. I felt that the link was not necessary as 'homicide' is a type of 'violent crime' but the other member insisted that the link was important for understanding the concept of 'homicide'. It took us a while to reach a consensus.”* These experiences underscore the need for effective mechanisms to facilitate the consensus-building process.

Despite these challenges, the participants appreciated the democratic nature of the decision-making process facilitated by the voting system. As I11 pointed out, *“I think one of the main challenges was just getting everyone on the same page. With so many people contributing, it's inevitable that there will be some disagreements. But I think the platform does a good job of facilitating discussion and helping us reach a consensus. Voting is particularly helpful in this regard.”* This sentiment was echoed by I6, who stated, *“... I think the voting system helps a lot with this. It's like a democratic way of deciding what makes the most sense.”* These quotes suggest that the voting system can serve as an effective tool for resolving disagreements and reaching a consensus.

Despite the positive experiences, some participants also pointed out areas for improvement. For instance, I2 suggested that *“we could do a better job of communicating between communities, especially when it comes to topics like the DSM concepts. Maybe we could have regular meetings between members of different communities to ensure that we're all on the same page.”* Some participants also suggested that more opportunities for in-depth discussions could further facilitate the consensus-building process. As I9 suggested, *“I think voting works well, but maybe there could be more opportunities for discussion before a link is finalized. Like a forum or chat feature where we could debate and justify our choices.”* Similarly, I10 proposed, *“I think a feature that allows members to have live discussions and debates on proposed links would be helpful.”* These

suggestions indicate that while the voting system is valuable, additional features for facilitating discussions could further enhance the process of reaching a consensus on links.

In summary, our analysis also suggests that 1Cademy’s design features, particularly the linking constraint and vote-dependent acceptance threshold, played a crucial role in reaching a consensus on a canonical description of each micro-topic among the community members. However, there is also a need for more explicit communication and guidance mechanisms to further enhance this process. Reaching a consensus on links emerged as a significant challenge in the collaborative construction of the KGMLP. The participants reported that disagreements were common due to the diverse perspectives and knowledge of the contributors. However, they also acknowledged the importance of reaching a consensus on the quality of the KGMLP for their learning. The voting system was appreciated as an effective tool for facilitating the decision-making process, but the participants also suggested that more opportunities for in-depth discussions could further enhance the consensus-building process.

4.5.4.3 Applications of 1Cademy

Participants reported using 1Cademy for a variety of purposes, including collaboratively reviewing scholarly literature, developing original research questions, and organizing ideas for writing a research paper. They also explained how they use 1Cademy to study their course content, prepare for exams, engage in discussions with classmates, present in journal clubs, and search for information during technical interview sessions. Some users also reported that they prefer to navigate through their personalized knowledge map to learn rather than searching online, explaining that it is easier to navigate through learning pathways that are already structured for their understanding.

Through this large collaboration, multiple groups of students were formed in the machine learning and educational psychology communities who published the following research papers:

- **Machine learning community papers:**
 - Interactive Natural Language Processing (22 authors) (171)
 - 1Cademy@ Causal News Corpus 2022: Leveraging Self-Training in Causality Classification of Socio-Political Event Data (5 authors)(133)
 - 1Cademy@ Causal News Corpus 2022: Enhance Causal Span Detection via Beam-Search-based Position Selector (5 authors) (49)
 - 1Cademy at Semeval-2022 Task 1: Investigating the Effectiveness of Multilingual, Multitask, and Language-Agnostic Tricks for the Reverse Dictionary Task (3 authors) (172)
- **Educational psychology community papers:**

- Reducing Procrastination Without Sacrificing Students’ Autonomy Through Optional Weekly Presentations of Student-Generated Content (3 authors) (189)
- Retrieval-based Teaching Incentivizes Spacing and Improves Grades in Computer Science Education (3 authors) (187)
- Another Victim of COVID-19: Computer Science Education (5 authors) (188)
- Incentivized Spacing and Gender in Computer Science Education (10 authors) (186)

4.6 Discussion

The results of our study suggest that the design elements of 1Cademy effectively support asynchronous collaboration in student-led learning research communities. These design elements include a proposal mechanism for changes to a node or its links, a requirement that new node proposals also include at least one prerequisite link, a vote-dependent acceptance threshold for proposals, and community-specific contribution scores. These mechanisms were found to be instrumental in maintaining the collaborative note-taking activity on the KGMLP.

In the experimental course deployment (section 4.4), the causal analysis provided evidence that more asynchronous collaboration on a node led to it being perceived as more helpful to students’ learning. We take the votes on each node as an indication of the quality of the micro-topic and its learning pathways. Furthermore, the student reflections revealed a general preference for the KGMLP over conventional learning methods, with students citing the benefits of self-assessment, understanding others’ perspectives, and the concise and organized nature of the KGMLP.

In the research communities study (section 4.5), the system sustained voluntary participation from thousands of users over a period of years. We can not claim that the design features were necessary or optimal for meeting the challenges. There is still room for improvement. However, the sustained voluntary usage and student reflections indicate that the design as a whole was effective at supporting collaborative note-taking.

However, our study is not without limitations. The sample sizes of both studies were relatively small. Therefore, the findings may not be generalizable to other contexts or populations. In terms of future work, we plan to conduct further studies with larger and more diverse samples to validate and extend our findings. We also aim to explore the potential of 1Cademy in other educational settings, such as high schools or professional training programs. Moreover, we plan to investigate the impact of 1Cademy on individual learning outcomes, such as knowledge retention and transfer, critical thinking skills, and motivation for learning.

Another avenue for future research is to examine the social dynamics within the 1Cademy communities. Understanding how users interact with each other and how these interactions influence

the evolution of the KGMLP could provide valuable insights into the social aspects of collaborative learning.

Finally, we plan to continue refining the design of 1Cademy based on user feedback and research findings. For instance, we could introduce features to support synchronous collaboration or to facilitate more effective navigation of the KGMLP.

4.7 Conclusion

We introduced 1Cademy, an innovative platform designed to foster asynchronous collaboration in both course-based and student-led research environments. The unique features of 1Cademy, such as its proposal mechanism for node changes and links, the requirement for new node proposals to include at least one learning pathway, a voting system for proposal acceptance, and tailored community contribution scores, are specifically engineered to address the twin challenges of constructing a Knowledge Graph of Micro-topic arranged into Learning Pathways (KGMLP). These challenges revolve around motivating students to read and improve others' work, and reaching a consensus on micro-topics and learning pathways in settings where numerous learners are involved over several months.

Our comprehensive longitudinal study, involving 29 students over a semester, has empirically validated the effectiveness of asynchronous collaboration on 1Cademy. The causal analysis revealed a notable benefit: more collaborators on a node not only aided those directly involved in its creation or enhancement but also enriched the learning experience for those who engaged with the node subsequently. Students reported that the platform's collaborative nature facilitated self-assessment and enhanced their understanding of the content.

Through our field trials, we established the practicality and scalability of our approach. Users successfully developed a vast, interconnected KGMLP, evidencing the platform's capacity to support large-scale, collaborative efforts over an extended period (four years in our case). The results from our research community study offered profound insights into student challenges and motivations, highlighting the effectiveness of the democratic decision-making process enabled by the voting system. The leaderboard and contribution scores emerged as key motivators for students to engage with and enhance others' work. Nonetheless, feedback suggests that incorporating more opportunities for in-depth discussions could further enhance the consensus-building aspect of the platform.

To sum up, 1Cademy presents a viable and innovative method to engage students in the co-creation and refinement of micro-topics and learning pathways. It empowers students to collaboratively and asynchronously develop, assess, and refine micro-topics and their associated learning pathways. Looking forward, we aim to refine 1Cademy based on student feedback and to explore

wider applications of this methodology in diverse educational and instructional contexts.

CHAPTER 5

Conclusion

This dissertation demonstrates the significant potential of the Knowledge Graph of Micro-topics arranged into Learning Pathways (KGMLP) in three learning activities: spaced retrieval, reading, and collaborative note-taking, to effectively elevate four (out of six) cognitive processes in Bloom’s digital taxonomy: remembering, understanding, analyzing, and evaluating. Combining a pre-designed KGMLP with a spaced retrieval practice tool that motivates daily practice through the Counting Days incentive has proven beneficial for knowledge retention, particularly for students with lower academic achievements, highlighting the inclusive nature of this method. Furthermore, the empirical evidence from our controlled experiment and thematic analysis underscores the superiority of KGMLPs over traditional Novakian concept maps in improving reading for deeper understanding and retention of knowledge. The development and implementation of 1Cademy as a platform for collaborative note-taking signifies an innovation in social learning, successfully addressing the complexities of student interaction in knowledge construction and pathway creation. The design features of 1Cademy, particularly its linking constraint, proposal mechanism, and community-specific contribution scores, have been shown to facilitate effective and meaningful collaboration among learners. This dissertation not only contributes to the field of educational technology by presenting an innovative approach to learning but also sets a new direction for future research in understanding and optimizing digital learning environments.

5.1 Summary of Findings

Curriculum Design and Pedagogy: In the initial chapters, this dissertation underscored the significance of micro-topics as essential units of knowledge that facilitate deeper cognitive engagement. By dissecting complex subjects into smaller, digestible components, learners were able to engage more thoroughly with the content, leading to enhanced understanding and retention.

The Effectiveness of Counting Days at Inducing Spacing: Further, the research delved into the efficacy of spaced retrieval practices when integrated with structured learning pathways. Em-

irical evidence gathered suggested that consistent, spaced interactions with micro-topics significantly improve long-term learning retention. The “counting days” incentive mechanism was a simple, but very effective motivator for spaced retrieval, specially for low-achieving students.

Hybrid Maps and Knowledge Visualization: A cornerstone of this dissertation was the development and validation of a Knowledge Graph of Micro-topics arranged into Learning Pathways (KGMLP), an innovative approach to knowledge representation. These maps synergize the benefits of linear and non-linear knowledge structures, offering learners a more comprehensive and interconnected understanding of topics.

1Cademy: A Platform for Collaborative note-taking: The introduction of 1Cademy, a collaborative note-taking platform based on KGMLP, marked a practical application of the theoretical concepts explored. This platform demonstrated the feasibility and effectiveness of using micro-topics to facilitate the creation, navigation, and sharing of learning pathways.

5.2 Implications for Educational Practice

5.2.1 Curriculum Design and Pedagogy

This dissertation has highlighted the importance of adopting a curriculum design that embraces micro-topics, allowing for more efficient and effective student learning. The use of micro-topics facilitates the breaking down of complex subjects into smaller, manageable units, making learning more accessible and engaging. To maximize the potential of these micro-topics, it is essential to plan the curriculum around a Knowledge Graph of Micro-topic based Learning Pathways (KGMLP). This approach ensures that the curriculum becomes a robust tool for student learning, offering a structured yet flexible path through which students can navigate complex subjects.

Additionally, the curriculum should be designed to promote spacing in learning. Spaced retrieval practices, as evidenced in the dissertation, have been shown to significantly improve long-term retention, particularly for students who initially struggle with the material. By incorporating these practices into the curriculum, educators can enhance the efficiency and effectiveness of learning.

Integrating KGMLP participation into the curriculum and grading system can further motivate its use. By recognizing and rewarding engagement with KGMLPs, educators can encourage students to actively participate in the creation, navigation, and sharing of micro-topic summaries and learning pathways.

5.2.2 Instructional Strategies and Technology Integration

The research presented in this dissertation underscores the need for providing tools and materials that facilitate participation in developing and learning from KGMLPs. Such tools can help in visualizing and navigating the interconnectedness of micro-topics, thereby enhancing the overall learning experience. Covering the concept of learning pathways is crucial for better enabling the use of KGMLPs. Instructional strategies should include discussions and activities that help students understand how individual micro-topics connect within the larger framework of a subject. This understanding is vital for students to effectively engage with and benefit from KGMLPs.

Integrating course learning content with KGMLPs offers another avenue for enhancing learning experiences. For instance, textbooks and other learning materials can be viewed within the context of a KGMLP, allowing students to see how different concepts are interrelated. This integration can provide a more holistic view of the subject matter and facilitate deeper understanding and retention of the material.

In conclusion, this dissertation's findings advocate for a transformative approach to curriculum design and instructional strategies, emphasizing the integration of micro-topics and learning pathways with modern educational practices and technologies. This approach promises to not only enrich the learning experience but also prepare students more effectively for the complexities of modern knowledge landscapes.

5.3 Limitations

Scope of Generalizability: One of the primary limitations identified in this dissertation is the scope of generalizability of the findings. The research conducted was specific to computer science courses (chapter 2), ACT reading comprehension passages (chapter 3), and independent study courses and voluntary student research communities (chapter 4). As such, the results and conclusions drawn may not be universally applicable to all educational settings, academic levels, or demographic groups. Future research should aim to replicate these studies in a broader range of contexts, including diverse cultural, socio-economic, and educational backgrounds, to determine the wider applicability and effectiveness of these strategies.

Long-term Impacts and Interdisciplinary Applications: Another significant limitation is the lack of insight into the long-term impacts of the educational interventions studied. The research predominantly focused on immediate or short-term learning outcomes, leaving the long-term retention and application of knowledge unexplored. Additionally, the dissertation primarily concentrated on specific subject areas, limiting its insights into the interdisciplinary applicability of micro-topics and KGMLPs. Future research should extend to explore how these educational strate-

gies impact knowledge retention and transfer over longer periods and how they can be adapted and applied across various disciplines.

Methodological Considerations: The research methods employed in this dissertation, while robust in their current form, have limitations in terms of the depth and breadth of data collection and analysis. For instance, the reliance on quantitative data might overlook the nuanced individual experiences and perceptions of learners. Qualitative approaches, including detailed case studies and interviews, could provide richer insights into the subjective experiences of students and educators with micro-topics and KGMLPs.

Technological Barriers and Accessibility: The implementation of advanced educational technologies like 1Cademy, while promising, presents its own set of limitations. Technological barriers, such as lack of access to reliable internet and digital devices, can hinder the widespread adoption of these platforms, particularly in under-resourced areas. Moreover, the design and interface of such platforms may not be universally intuitive or accessible, potentially excluding users with varying levels of tech-savviness or those with disabilities.

Resource Constraints and Institutional Adaptability: Resource constraints in educational institutions can also limit the adoption and integration of the proposed strategies. The development and maintenance of KGMLPs and platforms like 1Cademy require financial, technological, and human resources, which may not be readily available in all educational contexts. Additionally, the adaptability of educational institutions to integrate these new approaches into their existing systems and curricula can vary, potentially hindering the widespread implementation of these innovations.

Ethical and Privacy Considerations: Finally, the integration of educational technologies like 1Cademy, which facilitate the collection and analysis of student data, raises significant ethical and privacy concerns. It is imperative to maintain the confidentiality and security of student information and ensure its ethical utilization for educational advancement. The complexity of these issues is magnified in collaborative platforms, where knowledge is shared and created collectively by numerous participants. For instance, in such expansive collaborative settings, students' interests in specific topics could potentially become transparent to a broader audience. To address this, I implemented measures such as anonymizing votes and proposals. However, it's important to acknowledge that the presence of community-specific contribution leaderboards might still inadvertently disclose students' preferences, albeit to a lesser extent.

In summary, while this dissertation has made significant contributions to the field of educational technology, these limitations highlight the need for continued research and thoughtful implementation of the strategies discussed. Addressing these limitations will be crucial in advancing the field and ensuring the equitable, effective, and sustainable use of educational technologies and strategies in diverse learning environments.

5.4 Future Research Directions

This dissertation lays the groundwork for numerous future research endeavors, particularly focusing on the intersection of AI technology, collaborative learning, and adaptive educational systems. The following areas represent key directions for future research:

Advanced AI Techniques in Educational Settings: Future research aims to advance the integration of sophisticated AI methodologies within educational platforms like 1Cademy. This endeavor will focus on harnessing the capabilities of natural language processing and machine learning algorithms to forge more personalized, adaptive learning experiences. A key area of exploration will be the effectiveness of AI in meticulously curating and generating micro-topics and learning pathways. These will be tailored to accommodate a variety of learning styles and needs. My existing research has concentrated on the development of a Large Language Model (LLM) agent. This agent is designed to serve two purposes: 1) facilitate and encourage contributions by community members, 2) simulate a user role within 1Cademy, engaging in activities such as contributing new and improvement proposals, evaluating proposals from others, and offering constructive feedback on community contributions. Significant strides have been made in employing LLMs for extracting micro-topics from extensive texts. However, the creation of high-quality, effective learning pathways demands further, in-depth research and exploration.

Improving the Spaced, Interleaved Retrieval Practice Tool: To enhance the student learning experience, we are developing another LLM agent to automatically generate a diverse array of high-quality, auto-gradable questions for each micro-topic, aiming to alleviate the monotony of repeated questions and increase student engagement in spaced retrieval practice. Concurrently, a more sophisticated spaced repetition algorithm is in the works. This algorithm will be designed to integrate students' previous responses with the KGMLP, effectively guiding students through their learning journey. By adapting to students' performance, this approach will ensure that correct answers lead to more advanced topics while incorrect responses trigger a review of prerequisite concepts, thus optimizing the learning experience by catering to individual needs and progress.

Cross-Cultural and International Collaborations: Another avenue for future research involves examining the impact of cross-cultural and international collaborations facilitated by platforms like 1Cademy. This research will seek to understand how such collaborations can enhance the learning experience and foster a more inclusive educational environment, catering to a wide range of cultural and educational backgrounds.

Longitudinal Impact Studies: Longitudinal studies will be crucial in assessing the long-term effectiveness of AI-enhanced collaborative learning platforms. These studies will focus on measuring the impact of such platforms on learning outcomes, skill acquisition, and real-world application over extended periods.

Scalability and Accessibility in Diverse Educational Contexts: Future investigations will also look into the scalability and accessibility of platforms like 1Cademy in various educational contexts, especially in under-resourced areas. This includes assessing the challenges and opportunities in integrating advanced educational technologies in diverse settings and finding solutions to bridge the digital divide.

Integration with Established Educational Systems: A crucial avenue for future research involves examining the integration of innovative platforms, such as 1Cademy, into current educational frameworks and curricula. This investigation will focus on aligning 1Cademy's features with recognized educational standards and investigating how it can augment traditional teaching methods. The inclusion of daily spaced retrieval practice tools is feasible in courses equipped with an extensive, autogradable question bank, which can be efficiently created using advanced Language Learning Models (LLMs). While developing Hybrid Knowledge Graphs and Machine Learning Pathways (KGMLPs) for course content may initially be time-intensive for instructors, incorporating 1Cademy as a collaborative note-taking tool can streamline this process, facilitating the creation, evaluation, and refinement of KGMLPs. My experience teaching seven independent study courses at the University of Michigan School of Information, where 1Cademy was the primary learning technology, yielded positive student feedback and valuable insights from the micro-topics and learning pathways developed by the students.

Continuous Improvement and User Feedback: Lastly, future research will focus on developing continuous improvement mechanisms within educational platforms. This will involve creating robust feedback systems that allow for the constant evolution of the platform based on user experiences and emerging educational needs and trends. For example, we are investigating mechanisms to infer design improvements based on the analytics of the user interaction logs on 1Cademy for different educational use cases. These insights may help instructors, curriculum designers, and the system developers to provide more engaging and effective learning experiences for students.

Each of these research areas not only extends the work presented in this dissertation but also opens new horizons in the field of educational technology, promising to enrich our understanding of the interplay between technology, collaboration, and learning.

5.5 Concluding Remarks

This dissertation has illuminated the potential of micro-topics and learning pathways in revolutionizing the educational landscape. It has provided a foundation for future explorations in educational technology, highlighting how KGMLPs can significantly enhance cognitive processes and learning experiences. The journey undertaken in this research, while comprehensive, opens new avenues for innovation and exploration in the pursuit of advancing educational practices.

APPENDIX A

Chapter 2 Appendix - Counting Days: A Spacing Incentive that Unlocks Low-GPA Students' Potential

A.0.1 Data availability

We are not comfortable publishing the raw datasets, even without individual student identifiers, because of the risk of reidentification. There were 203 students; with several demographic characteristics and prior GPA, we think that someone who had other sources of information such as the class roster might be able to identify some individuals, revealing sensitive personal information such as their final exam score, prior GPA, and diligence in completing course activities. We would be comfortable sharing the raw datasets with only reviewers for the purposes of checking our analyses.

A.0.2 Code availability

In addition to the supplementary material document, we have attached our *Stata do* file; and *R-studio* notebook files, in both *.Rmd* and *.html* formats.

A.0.3 Participant Funnel

Table A.1 shows the participant funnel and exclusions in the within-class experiment. A total of 199 participants were randomized to one of the two conditions.

Post-randomization, 40 students had no prior GPA because they were in their first semester (21 from the counting days condition and 19 from counting questions). Since our focus is the correlation between the prior GPA and final exam score, we excluded these 40 students in the second row. Note that after excluding those students, a few freshmen remained. We treat them as sophomores because they had taken courses in a previous semester and had prior GPA.

Two students, both under the counting questions condition, dropped the course or did not take the final exam. Since our primary outcome measure was final exam score, these students are

	Total	Counting Days	Counting Questions
All participants who ever used the practice tool (# who were randomized)	199	110	89
All students with prior GPA	159	89	70
Completed course final exam	157	89	68
Took course for grade	143	83	60

Table A.1: Participant funnel in the within-class experiment. The columns list the total, those under counting days, and those under counting questions conditions.

excluded from the analysis.

Finally, we excluded 14 students (*six* from the counting days condition and *eight* from counting questions) who did not take the course for a letter grade (e.g., pass/fail, audit, etc.) because such students might not be affected by the grading incentive in the same way as other students.

In the between-instructor experiment, we were not granted access to students' GPA or final exam scores, which eliminated the need to exclude any data points. Consequently, our analysis included all 27 instructors and their 657 students in the counting questions condition, as well as the 44 instructors and their 996 students in the counting days condition.

These two experiments are approved by the University of Michigan Institutional Review Board (IRB) under HUM00141422 and HUM00144387. Students were informed about the nature of the research. They did not have a choice about being randomized to treatment or control but had the option, at any time, to request that their data not be used in the research; no one exercised this option.

A.0.4 Summary Descriptive Statistics & Randomization Balance Check

Table A.2 presents the summary statistics of the numeric variables for the within-class experiment, with each variable displayed in three rows. The bottom row represents all students, the middle row represents only those under counting days, and the top row represents only those under counting questions. In the right-most column, the results of a group F-test (with $anova(lm())$) comparing the corresponding variable across the two conditions are reported. The randomization process ensured no significant difference in prior GPA between the two conditions. However, we observed a significant impact of the experimental condition on practice days and exam scores.

Table A.3 shows the summary statistics of the categorical variables for the within-class experiment. The columns list the total, those in the counting days, and those in the counting questions

	Group	Min	Median	Max	Mean	SD	Test
Final Exam Score (in %)	Counting Questions	49.1	83.267	100	81.729	11.589	F= 3.954 *
	Counting Days	35.6	87.333	100	85.331	9.995	
	All Students	35.6	85.667	100	83.819	10.801	
Practice Days	Counting Questions	4	17	40	17.300	7.400	F= 417.631 ***
	Counting Days	16	39	48	38.506	5.008	
	All Students	4	34	48	29.608	12.146	
1.0 Practiced Questions	Counting Questions	170	401	444	392.483	46.334	F= 5.664 **
	Counting Days	190	412	662	414.976	61.680	
	All Students	170	402	662	405.538	56.683	
Prior GPA	Counting Questions	1.903	3.469	4.000	3.358	0.487	F= 2.742
	Counting Days	1.967	3.626	3.954	3.482	0.404	
	All Students	1.903	3.548	4.000	3.430	0.443	

Table A.2: Summary statistics of the numeric variables in the within-class experiment. Significance levels are specified with stars (*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$).

	Total	Counting Days	Counting Questions	χ^2 Test
Female	90 62.9%	54 65.1%	36 60.0%	0.382
Male	53 37.1%	29 34.9%	24 40.0%	0.382
White	87 60.8%	50 60.2%	37 61.7%	4.774
Asian	33 23.1%	21 25.3%	12 20.0%	4.774
1.6 Neither White or Asian	23 16.1%	12 14.5%	11 18.3%	4.774
Sophomore	90 62.9%	51 61.4%	39 65.0%	0.340
Junior	27 18.9%	17 20.5%	10 16.7%	0.340
Senior	26 18.2%	15 18.1%	11 18.3%	0.340
Non-Native English	36 25.2%	17 20.5%	19 31.7%	2.313

Table A.3: Summary statistics of the categorical variables in the within-class experiment.

conditions. The last (right-most) column reports the results of a group χ^2 test to check for balance of the corresponding variable across the two conditions. None of the tests are statistically significant ($p > 0.05$), indicating no evidence to reject the randomization balance of the specified variables across the experimental groups.

For the between-instructor experiment, tables A.4 and A.5 present data on the number of students who completed the course with each instructor across the experimental conditions. Under the Counting Days condition, class sizes ranged from a minimum of 5 students to a maximum of 79 students, while under the Counting Questions condition, class sizes varied from a minimum of 5 students to a maximum of 89 students. The total numbers of students under the Counting Questions and Counting Days conditions were 657 and 996, respectively.

Instructor ID	Condition	Students
24	Counting Days	43
591	Counting Days	13
3517	Counting Days	52
7764	Counting Questions	16
18152	Counting Days	36
20117	Counting Questions	58
21579	Counting Questions	5
22229	Counting Days	11
27995	Counting Questions	63
32821	Counting Days	20
37373	Counting Days	13
38527	Counting Questions	11
42574	Counting Days	11
48924	Counting Days	6
50283	Counting Days	17
52287	Counting Days	27
54148	Counting Days	25
56273	Counting Questions	9
56354	Counting Days	9
56770	Counting Days	14
57839	Counting Days	24
58532	Counting Days	16
58891	Counting Questions	13
59358	Counting Days	69
60783	Counting Questions	13
60810	Counting Questions	8
60827	Counting Days	18
65136	Counting Questions	7
66268	Counting Days	12
66841	Counting Questions	6
67969	Counting Days	18
72864	Counting Questions	6
74785	Counting Questions	89
76483	Counting Days	24
77801	Counting Days	79
79066	Counting Days	5
96850	Counting Questions	47
97650	Counting Questions	10
98344	Counting Days	8

Table A.4: The experimental condition each instructor belongs to and the number of students they taught under that condition in the within-class experiment.

Instructor ID	Condition	Students
100543	Counting Days	17
103556	Counting Days	31
105846	Counting Days	15
106733	Counting Days	7
107143	Counting Days	21
112188	Counting Days	10
112807	Counting Questions	6
114229	Counting Questions	33
114415	Counting Questions	18
116709	Counting Questions	15
117405	Counting Days	11
117649	Counting Questions	11
117785	Counting Days	19
118236	Counting Questions	25
119599	Counting Questions	15
121669	Counting Days	81
145037	Counting Days	21
145525	Counting Questions	31
148844	Counting Days	19
152078	Counting Days	14
157565	Counting Days	10
157640	Counting Days	9
162023	Counting Days	12
196231	Counting Questions	66
198938	Counting Questions	18
199682	Counting Days	84
202142	Counting Days	14
208270	Counting Questions	9
227477	Counting Questions	49
272384	Counting Days	8
272638	Counting Days	8
277019	Counting Days	15

Table A.5: Continued - The experimental condition each instructor belongs to and the number of students they taught under that condition in the within-class experiment.

A.0.5 Hypothesis Testing Results

	Two-sample t-test with equal vari- ances	Two-sample Wilcoxon rank-sum (Mann–Whitney) test
1.6 Final Exam Score	1.988*	1.968*
Practiced Days	20.436***	9.767***
Practiced Questions	2.380**	2.745**

Table A.6: T-test and Two-sample Wilcoxon rank-sum (Mann–Whitney) test results for the within-class experiment.

These tests examine whether the final exam scores, and the number of days and total questions practiced for the counting days group are significantly higher than those for the counting questions group. Significance levels are specified with stars (*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$).

We begin our analysis with basic bivariate statistical tests for the within-class experiment. To determine if the final exam scores for the counting days group are significantly higher than those for the counting questions group, we conduct one-sided t-tests and Wilcoxon signed-rank tests. We also compare the number of days and total questions practiced by both groups. The results of these tests for the within-class experiment are presented in Table A.6. The tests consistently indicate that the counting days incentive mechanism results in a statistically significant increase in final exam scores, number of days practiced, and total questions answered, compared to the counting questions mechanism.

	Two-sample t-test with equal vari- ances	Two-sample Wilcoxon rank-sum (Mann–Whitney) test
1.6 Practice Days	5.648***	3.747***
Practiced Questions	1.585	0.652

Table A.7: T-test and Two-sample Wilcoxon rank-sum (Mann–Whitney) test results for the between-instructor experiment. These tests examine whether the number of days and the number of questions practiced for the counting days group are significantly higher than those for the counting questions group. Significance levels are specified with stars (*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$).

The test results for the between-instructor experiment are provided in Table A.7. Once again, all tests demonstrate that the counting days incentive mechanism yields a statistically significant en-

hancement in the number of days practiced and the number of questions practiced when compared to the counting questions mechanism.

A.0.6 Regression Results

Table A.8 presents the regression results for the within-class experiment, with and without controlling for demographics and academic variables. Comparing the results, we observe no substantial difference in the estimates of interest. To estimate the difference in linear correlation between GPA and exam score for a range of GPAs from 2.893 (tenth percentile) to 3.548 (mean), we used the “`emtrends`” command from the “`emmeans`” package in R. Without controlling for demographics and academic variables, under the counting questions condition, the estimated trend is 0.109 ($p < .001$). Under the counting days condition, the estimated trend is nearly zero, -0.009 ($p = 0.704$). The contrast of -0.118 between the two trends is statistically significant ($p < .01$). Similarly, when controlling for those variables, under the counting questions condition, the estimated trend is 0.108 ($p < .0001$). Under the counting days condition, the estimated trend is nearly zero, 0.0194 ($p = 0.369$). The contrast of -0.0882 between the two trends is statistically significant ($p < .01$).

	Final Exam Score		Days Practiced		Questions Practiced	
	Beta W/O Ctrls (1)	Beta With Ctrls (2)	N. Bin. W/O Ctrls (3)	N. Bin. With Ctrls (4)	N. Bin. W/O Ctrls (5)	N. Bin. With Ctrls (6)
Counting Days (vs. Questions)	2.625*** (0.791)	2.215** (0.811)	1.360*** (0.316)	1.638*** (0.305)	0.139 (0.186)	0.216 (0.186)
GPA	0.657*** (0.157)	0.784*** (0.155)	0.248*** (0.074)	0.223** (0.072)	0.097** (0.037)	0.093* (0.037)
Counting Days#GPA	-0.726** (0.230)	-0.605* (0.235)	-0.168 (0.091)	-0.247** (0.088)	-0.027 (0.054)	-0.049 (0.054)
Female (vs. Male)		-0.139 (0.121)		0.133*** (0.040)		0.018 (0.027)
Asian (vs. White)		0.099 (0.142)		-0.091* (0.044)		-0.041 (0.030)
1.21 NonWhiteOrAsian (vs. White)		-0.026 (0.145)		-0.066 (0.048)		-0.035 (0.032)
Junior (vs. Sophomore)		0.312* (0.146)		-0.059 (0.045)		-0.062* (0.031)
Senior (vs. Sophomore)		0.387** (0.149)		-0.036 (0.046)		0.004 (0.031)
NonNativeEnglish (vs. NativeEnglish)		0.344* (0.135)		0.011 (0.041)		-0.004 (0.028)
[Intercept]	-0.713 (0.524)	-1.280* (0.522)	2.011*** (0.254)	2.056*** (0.245)	5.645*** (0.127)	5.675*** (0.126)
[Parameter]	Scale: 2.608*** (0.117)	Scale: 2.788*** (0.118)	Alpha: 0.010*** (0.007)	Alpha: 0.004*** (0.006)	Alpha: 0.017*** (0.002)	Alpha: 0.016*** (0.002)
Log Likelihood	144.049	156.444	-480.101	-470.348	-779.858	-775.635
# of Obs.	143	143	143	143	143	143
χ^2	17.414 ***	42.203 ***	180.996 ***	200.502 ***	14.662 **	23.109 **

Table A.8: Regression results of the within-class experiment. Dependent variables are specified in column headers. Each column displays the coefficients (as log odds ratios), standard errors (in parentheses), and significance levels (** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$)

The six regression models for the within-class experiment have the following specifications in STATA:

```
(1) betareg final_0_1 i.counting_days c.gpa c.gpa#i.counting_days
```

```
(2) betareg final_0_1 i.counting_days c.gpa ///  
c.gpa#i.counting_days 1.female 1.junior 1.senior 1.asian ///  
1.nonwhiteorAsian 1.nonnativeenglish
```

```
(3) nbreg practice_days i.counting_days c.gpa ///  
c.gpa#i.counting_days
```

```
(4) nbreg practice_days i.counting_days c.gpa ///  
c.gpa#i.counting_days 1.female 1.junior 1.senior 1.asian ///  
1.nonwhiteorAsian 1.nonnativeenglish
```

```
(5) nbreg practice_count i.counting_days c.gpa ///  
c.gpa#i.counting_days
```

```
(6) nbreg practice_count i.counting_days c.gpa ///  
c.gpa#i.counting_days 1.female 1.junior 1.senior 1.asian ///  
1.nonwhiteorAsian 1.nonnativeenglish
```

Note that we used the “vif” command in R to calculate the Variance Inflation Factor (VIF) as a measure of multicollinearity among the multiple regression variables. With the exception of the treatment variable, GPA, and their interactions, all controlled variables have VIF lower than 2.0, indicating no evidence of multicollinearity.

A.0.7 GSEM Results

Table A.9 shows the results of our Generalized Structural Equation Model (GSEM) estimation for the within-class experiment, with four dependent variables: final exam score, days practiced, questions practiced, and GPA. We used a Beta regression to estimate the final exam score after transforming it to the range (0, 1). We used Negative Binomial regressions to estimate the number of days and questions practiced. We used an OLS to estimate the GPA. We performed this analysis only in STATA using the following command:

```
gsem (c.practice_days c.practice_count c.gpa ///
      c.gpa#c.practice_days c.gpa#c.practice_count ///
      1.female 1.junior 1.senior 1.asian 1.nonwhiteorAsian ///
      1.nonnativeenglish -> final_0_1, family(beta) link(logit)) ///

      (i.counting_days c.gpa i.counting_days#c.gpa 1.female 1.junior ///
      1.senior 1.asian 1.nonwhiteorAsian 1.nonnativeenglish -> ///
      practice_days, nbreg) ///

      (c.practice_days c.gpa 1.female 1.junior 1.senior 1.asian ///
      1.nonwhiteorAsian 1.nonnativeenglish -> practice_count, nbreg) ///

      (1.female 1.junior 1.senior 1.asian 1.nonwhiteorAsian ///
      1.nonnativeenglish -> gpa, )
```

	Final Exam Score	Days Practiced	Questions Practiced	GPA
Counting Days (vs. Questions)		a: 1.638*** (0.305)		
Counting Days#GPA		b: -0.247** (0.088)		
Days Practiced	b: 0.088* (0.039)		i: 0.058* (0.027)	
Days Practiced#GPA	e: -0.024* (0.011)			
Questions Practiced	h: -0.004 (0.007)			
Questions Practiced#GPA	g: 0.001 (0.002)			
GPA	j: 0.844 (0.797)	c: 0.223** (0.072)	f: -0.001 (0.025)	
1.21 Female (vs. Male)	-0.149 (0.124)	0.133*** (0.040)	-0.059* (0.029)	-0.072 (0.095)
Asian (vs. White)	0.122 (0.141)	-0.091* (0.044)	-0.023 (0.030)	-0.031 (0.084)
NonWhiteOrAsian (vs. White)	-0.026 (0.146)	-0.066 (0.048)	0.001 (0.026)	3.271*** (0.075)
Junior (vs. Sophomore)	0.313* (0.149)	-0.059 (0.045)	0.007 (0.030)	-0.072 (0.088)
Senior (vs. Sophomore)	0.391** (0.149)	-0.036 (0.046)	-0.029 (0.028)	0.020 (0.097)
NonNativeEnglish (vs. NativeEnglish)	0.340* (0.132)	0.011 (0.041)	5.696*** (0.090)	2.779 (0.118)
[Intercept]	-1.101 (2.564)	2.056*** (0.245)	0.316*** (0.075)	-5.587 (1.572)
[Parameter]	logs: 2.779 (0.118)	lnalpha: -5.587 (1.572)	lnalpha: -4.283 (0.142)	var(e.gpa): 0.167 (0.020)

Table A.9: Results of the Generalized Structural Equation Model (GSEM) Estimation. Each column represents a regression with the dependent variable in the title (***) $p < 0.001$; ** $p < 0.01$; * $p < 0.05$).

A.0.8 Effects of more days of practice on the correlation between GPA and exam scores

Figure A.1 shows the effects of more days of practice on the correlation between GPA and exam scores, regardless of treatment condition, for the within-class experiment. More days of practice lowered the correlation between GPA and final exam score, as indicated by the flatter curves for more days of practice.

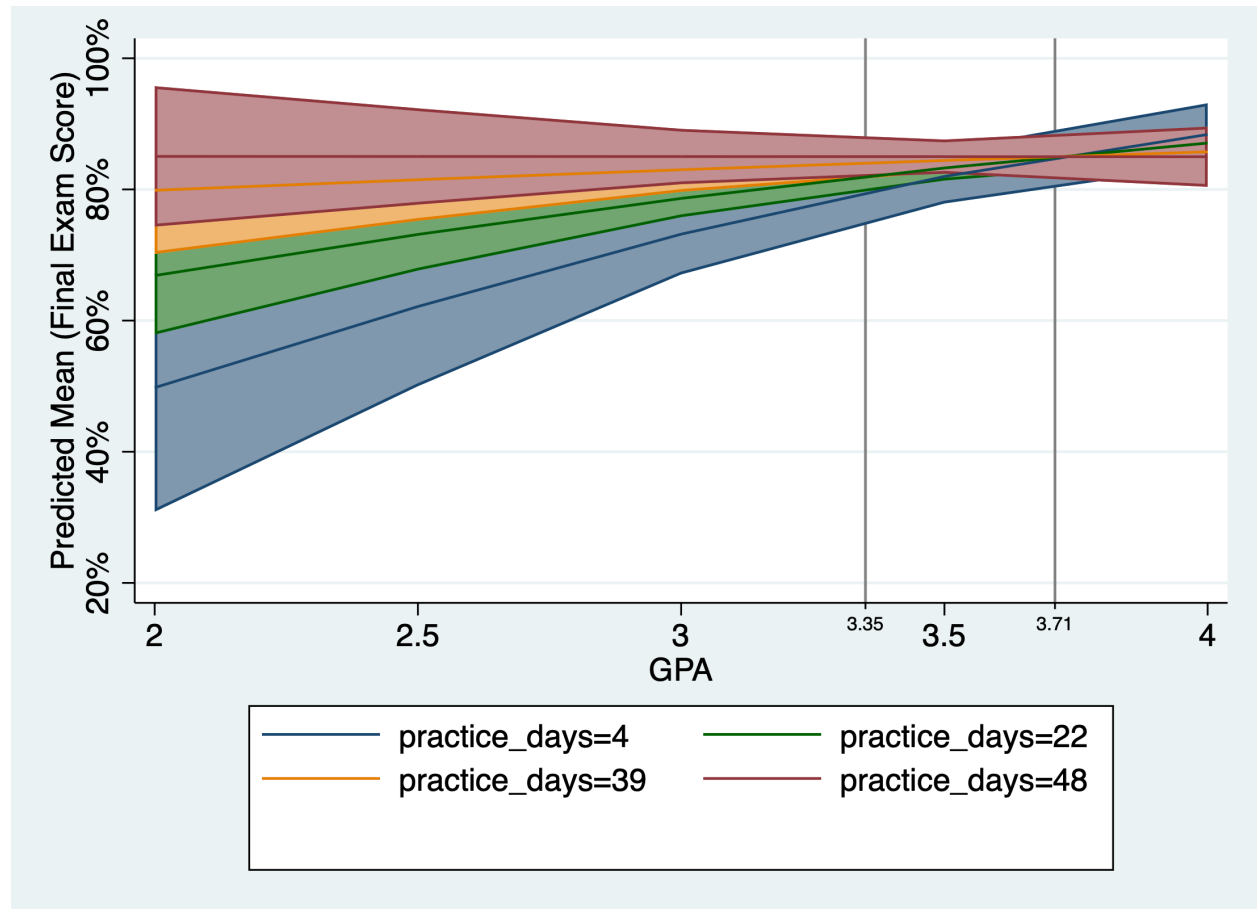


Figure A.1: Predictive Margins of Days Practiced with 95% CIs for the within-class experiment. Estimated effect of GPA on final exam scores for different numbers of days practiced.

A.0.9 Analysis of GPA correlation with final exam scores in other semesters

In three other semesters of the same course where we conducted the within-class experiment, all students were assigned to the counting days condition. As a robustness check, Figures A.2, A.2, and A.4 reproduce the counting days part of Figure 2.9 from the main study for these other

semesters. The correlation between GPA and final exam scores nearly disappeared in one of the semesters, but not in the other two.

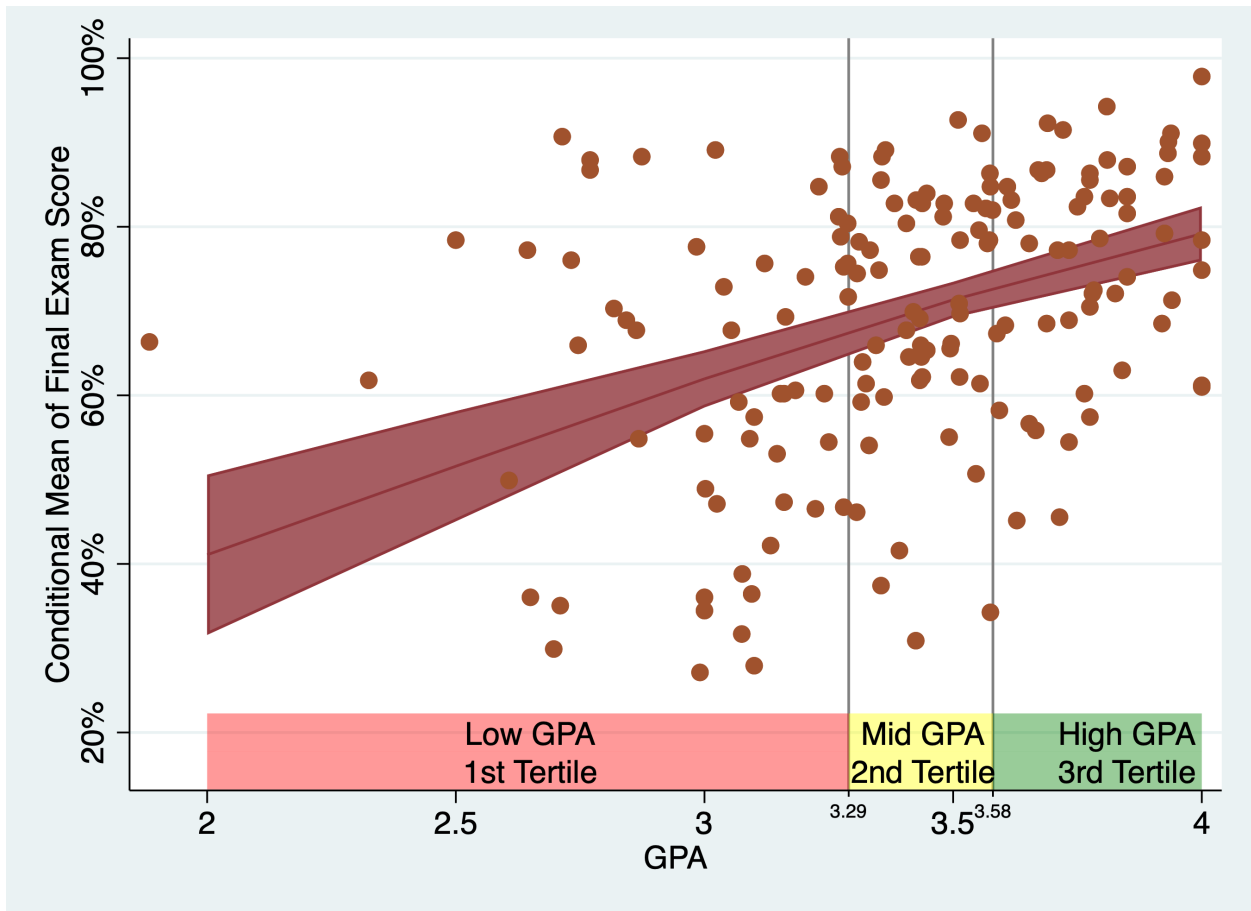


Figure A.2: Adjusted Predictions with 95% CIs in Winter 2018. Estimated effect of GPA on final exam scores based on the Beta regression model predictions.

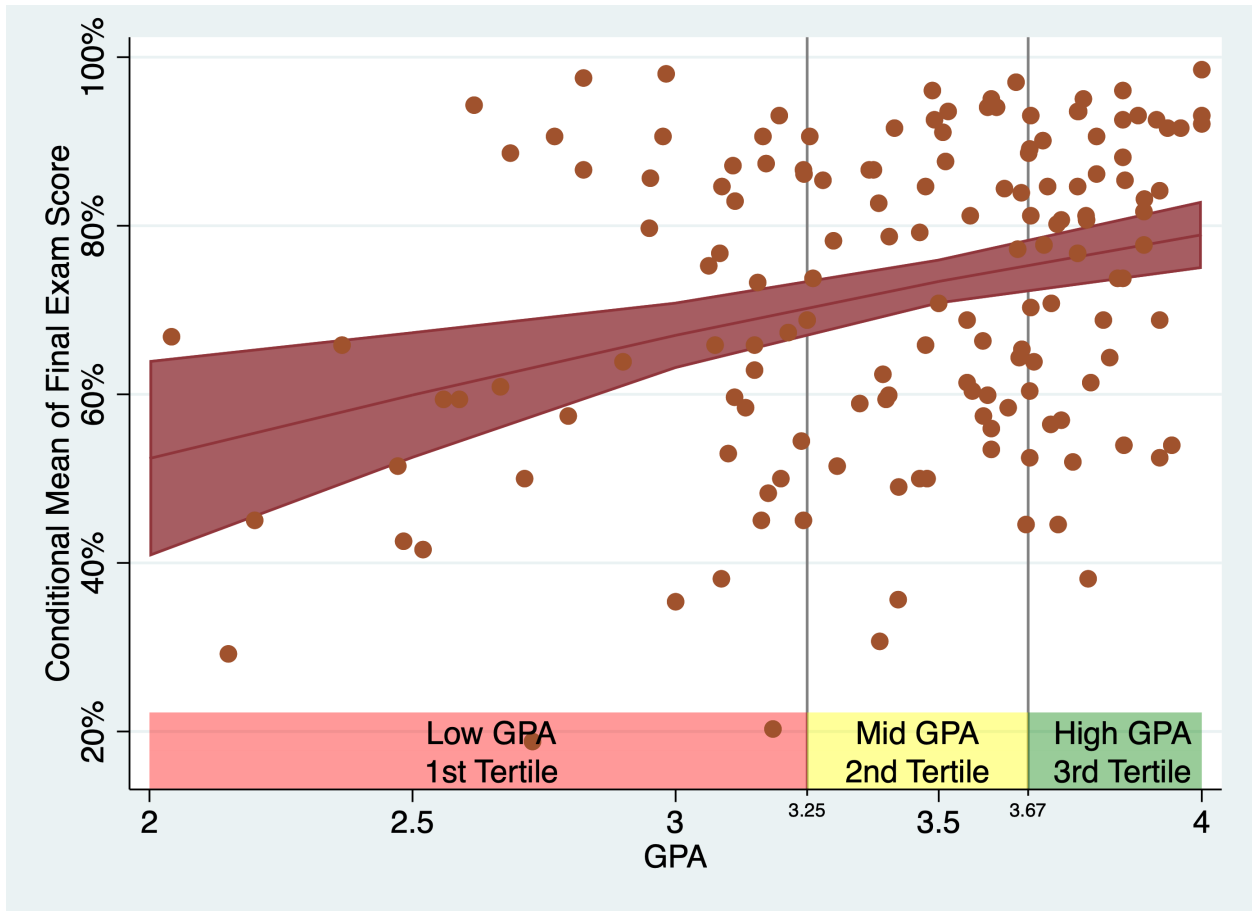


Figure A.3: Adjusted Predictions with 95% CIs in Winter 2019. Estimated effect of GPA on final exam scores based on the Beta regression model predictions.

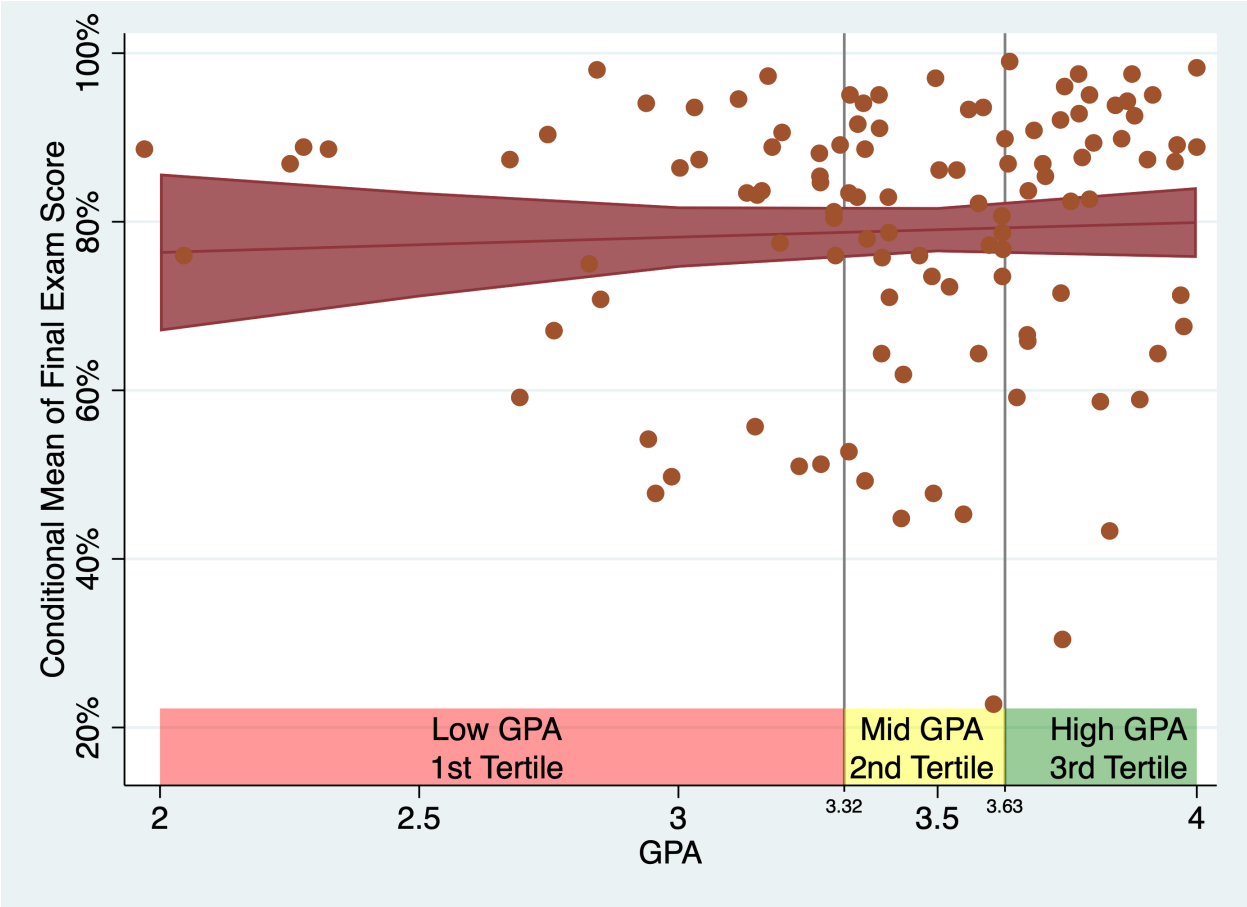


Figure A.4: Adjusted Predictions with 95% CIs in Fall 2019. Estimated effect of GPA on final exam scores based on the Beta regression model predictions.

APPENDIX B

Chapter 3 Appendix - Hybrid Map: Visualized Learning Pathways Between Micro-Topic Paragraphs Improve Readability, Recognition, and Recall Compared to Novakian Concept Maps

B.1 Appendix 1: Summary Statistics and Regression Results

To save space in Table B.4 and Table B.5 we replaced the passage titles with the indices in Table B.1 that match the subsections of this appendix section:

B.2 Appendix 2 - Passages in Different Conditions

B.2.1 Passage 1: The Hearing of the Barn Owl

The modified multiple-choice questions used for this passage are as follows:

1. A barn owl must be able to locate sounds in the vertical dimension mainly because it hunts:
 - (a) from the air.
 - (b) even when it can only partially see the animal it is hunting.
 - (c) animals that move quickly.
 - (d) while detecting sounds in both its right and left ears.

Question Type: Inferential

2. The author uses the expression “the azimuth of the sound” most nearly to refer to a sound’s:

Table B.1: Passage Specifications

Index Index	Title	ACT Category	Number of Phrases	Inferential Questions	Factual Questions	Total Questions
1	The Hearing of the Barn Owl	Natural sci-ences	55	6	4	10
2	The Jaws That Jump	Natural sci-ences	61	4	5	9
3	Reena	Literary narra-tive	64	6	4	10
4	Prima Bal-lerina	Literary narra-tive	59	7	3	10
5	How to watch television	Social sci-ences	54	8	1	9
6	Conservationists and Diplo-mat	Social sci-ences	72	4	4	8
7	The Buzz in Our Pockets	Humanities	76	8	2	10
8	Managerial Decision Making		179	3	6	9
9	The Quiet Sideman	Humanities	72	5	4	9

Table B.2: The Recognition Regression Results - Part 1

Hybrid Map	0.396** (0.188)
After 3 Days	-0.612*** (0.148)
After 1 Week	-0.573*** (0.150)
Inferential Question	-0.775*** (0.232)
2nd Passage	0.025 (0.179)
Recognition Pretest	0.705*** (0.238)
Hybrid Map:After 3 Days	0.012 (0.223)
Hybrid Map:After 1 Week	-0.075 (0.224)
Hybrid Map:Inferential Question	0.236 (0.213)
After 3 Days:Inferential Question	0.363* (0.192)
After 1 Week:Inferential Question	0.395** (0.194)
Hybrid Map:2nd Passage	0.171 (0.291)
After 3 Days:2nd Passage	0.060 (0.210)
After 1 Week:2nd Passage	-0.097 (0.211)
Inferential Question:2nd Passage	-0.050 (0.204)
Hybrid Map:Recognition Pretest	-0.509 (0.352)
After 3 Days:Recognition Pretest	0.174 (0.318)
After 1 Week:Recognition Pretest	0.141 (0.320)
Inferential Question:Recognition Pretest	-0.016 (0.284)
2nd Passage:Recognition Pretest	-0.100 (0.333)
Hybrid Map:After 3 Days:Inferential Question	0.089 (0.289)
Hybrid Map:After 1 Week:Inferential Question	0.020 (0.290)
Hybrid Map:After 3 Days:2nd Passage	0.118 (0.311)
Hybrid Map:After 1 Week:2nd Passage	0.208 (0.312)
Hybrid Map:Inferential Question:2nd Passage	0.113 (0.301)
After 3 Days:Inferential Question:2nd Passage	0.185 (0.277)
After 1 Week:Inferential Question:2nd Passage	0.225 (0.279)
Hybrid Map:After 3 Days:Recognition Pretest	-0.027 (0.473)
Hybrid Map:After 1 Week:Recognition Pretest	0.117 (0.477)
Hybrid Map:Inferential Question:Recognition Pretest	0.399 (0.424)
After 3 Days:Inferential Question:Recognition Pretest	-0.133 (0.383)
After 1 Week:Inferential Question:Recognition Pretest	-0.199 (0.386)
Hybrid Map:2nd Passage:Recognition Pretest	0.285 (0.484)
After 3 Days:2nd Passage:Recognition Pretest	0.194 (0.450)
After 1 Week:2nd Passage:Recognition Pretest	0.589 (0.459)
Inferential Question:2nd Passage:Recognition Pretest	0.146 (0.400)
Hybrid Map:After 3 Days:Inferential Question:2nd Passage	-0.573 (0.410)
Hybrid Map:After 1 Week:Inferential Question:2nd Passage	-0.556 (0.411)
Hybrid Map:After 3 Days:Inferential Question:Recognition Pretest	0.029 (0.576)
Hybrid Map:After 1 Week:Inferential Question:Recognition Pretest	0.071 (0.581)
Hybrid Map:After 3 Days:2nd Passage:Recognition Pretest	-0.090 (0.657)
Hybrid Map:After 1 Week:2nd Passage:Recognition Pretest	-0.448 (0.665)

Table B.3: The Recognition Regression Results - Part 2

Hybrid Map:Inferential:2nd Passage:Pretest	-0.412 (0.590)
After 3 Days:Inferential:2nd Passage:Pretest	-0.173 (0.547)
After 1 Week:Inferential:2nd Passage:Pretest	-0.344 (0.556)
Hybrid Map:After 3 Days:Inferential:2nd Passage:Pretest	0.377 (0.808)
Hybrid Map:After 1 Week:Inferential:2nd Passage:Pretest	0.305 (0.816)
Constant	1.630*** (0.248)
Observations	22,773

Note:

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

- (a) fluctuation between high and low frequencies.
- (b) location in the horizontal dimension.
- (c) transformation into a map of space.
- (d) loudness and intensity.

Question Type: Factual

3. The word exploiting most nearly means:

- (a) imposing upon.
- (b) improving.
- (c) victimizing.
- (d) making use of.

Question Type: Inferential

4. Which of the following behaviors of a barn owl does the author provide as the strongest evidence of the bird's ability to detect subtle changes in the origin of a sound?

- (a) locating sound originating from small prey.
- (b) catching prey in complete darkness.
- (c) realigning its talons as a mouse turns and runs.
- (d) swooping down on stationary prey.

Question Type: Inferential

Table B.4: The Recall Regression Results - Part 1

	<i>Dependent variable:</i>
	Recall Score
Hybrid Map	0.025** (0.012)
After 3 Days	-0.013 (0.009)
After 1 Week	0.008 (0.009)
2nd Passage	0.0002 (0.012)
Pretest Score Ratio	0.017 (0.018)
Passage: How to Watch Television	-0.169*** (0.006)
Passage: Managerial Decision Making	-0.243*** (0.005)
Passage: Prima Ballerina	-0.085*** (0.005)
Passage: Reena	-0.121*** (0.005)
Passage: The Buzz in Our Pockets	-0.167*** (0.006)
Passage: The Hearing of the Barn Owl	-0.208*** (0.005)
Passage: The Jaws That Jump	-0.168*** (0.005)
Passage: The Quiet Sideman	-0.165*** (0.006)
Hybrid Map:After 3 Days	-0.006 (0.013)
Hybrid Map:After 1 Week	-0.013 (0.013)
Hybrid Map:2nd Passage	-0.007 (0.018)
After 3 Days:2nd Passage	0.003 (0.014)
After 1 Week:2nd Passage	-0.009 (0.015)
Hybrid Map:Pretest Score Ratio	-0.054** (0.027)
After 3 Days:Pretest Score Ratio	0.008 (0.023)
After 1 Week:Pretest Score Ratio	-0.016 (0.023)
2nd Passage:Pretest Score Ratio	0.028 (0.028)
Hybrid Map:After 3 Days:2nd Passage	-0.004 (0.020)
Hybrid Map:After 1 Week:2nd Passage	0.012 (0.020)
Hybrid Map:After 3 Days:Pretest Score Ratio	-0.004 (0.034)
Hybrid Map:After 1 Week:Pretest Score Ratio	0.019 (0.034)
Hybrid Map:2nd Passage:Pretest Score Ratio	0.055 (0.039)
After 3 Days:2nd Passage:Pretest Score Ratio	-0.009 (0.036)
After 1 Week:2nd Passage:Pretest Score Ratio	0.013 (0.036)

Table B.5: The Recall Regression Results - Part 2

	<i>Dependent variable:</i>
	Recall Score
Hybrid Map:After 3 Days:2nd Passage:Pretest Score Ratio	0.019 (0.050)
Hybrid Map:After 1 Week:2nd Passage:Pretest Score Ratio	-0.026 (0.050)
Constant	0.306*** (0.009)
Observations	2,432

Note: *p<0.1; **p<0.05; ***p<0.01

Table B.6: Summary Statistics of demographic variables after merging small categories into larger ones.

Variable	Number	Percent
Ethnicity	419	
... African-American	27	6.4%
... Asian	205	48.9%
... Hispanic or Latino	25	6%
... Other/Not specified	19	4.5%
... White / Caucasian	143	34.1%
Institution	419	
... College	147	35.1%
... University	272	64.9%
Education	419	
... Graduate	47	11.2%
... Undergraduate	372	88.8%
Language	419	
... Chinese	46	11%
... English	361	86.2%
... Other	12	2.9%
Major	419	
... Engineering	92	22%
... Humanities and Arts	226	53.9%
... Sciences	101	24.1%

5. The passage indicates that each neuron in the network of neurons in the barn owl's midbrain is excited only by sounds:
- (a) from one particular species of animal.
 - (b) from one small region of space.
 - (c) falling within one specific frequency.
 - (d) falling within one predictable timing pattern.

Question Type: Inferential

6. The author's use of the word "deadly" most nearly serves to:
- (a) hint that the barn owl's method of attack is sometimes harmful to the owl itself.
 - (b) imply that the barn owl's prowess as a hunter is both alarming and regrettable.
 - (c) reiterate that the barn owl is feared by many animals for its ability to swiftly kill.
 - (d) emphasize that the barn owl's means of hunting is both remarkable and lethal.

Question Type: Inferential

7. The author directly states that which of the following features of the barn owl is the most visually striking?
- (a) its aerodynamic flight.
 - (b) its coloring.
 - (c) its face.
 - (d) its talons.

Question Type: Factual

8. According to the passage, in terms of length and width, a barn owl's troughs are:
- (a) wider than they are long.
 - (b) longer than they are wide.
 - (c) about as wide as they are long.
 - (d) variable in terms of their relative length and width.

Question Type: Factual

9. The author most likely refers to the feathers that cover the barn owl's facial structure as being "acoustically transparent" to emphasize that the feathers are:
- (a) shaped into two flaps that protect the owl's ear openings.
 - (b) textured and dense enough to block unnecessary sensory stimuli.
 - (c) arranged in several layers that allow sound to be amplified.
 - (d) fine enough to allow sound to pass through them unfiltered.

Question Type: Inferential

10. Based on the passage, which of the following statements most accurately compares a human's ability to locate the source of a sound in azimuth and elevation to the barn owl's ability to do so?
- (a) the barn owl is about as accurate as a human in azimuth but is about three times more accurate in elevation.
 - (b) the barn owl is about three times more accurate than a human in both azimuth and elevation.
 - (c) the barn owl is about as accurate as a human in both azimuth and elevation.
 - (d) the barn owl is about three times more accurate as a human in azimuth but is about as accurate in elevation.

Question Type: Factual

The following shows the original ACT reading comprehension passage in linear format. This passage in Hybrid Map (H) format is shown in Figure B.1. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent Novakian concept maps (K) are shown in Figure B.2, Figure B.3, Figure B.4, Figure B.5, Figure B.6, Figure B.7, Figure B.8 and Figure B.9. The interactive version that the participants studied through is available [here on Draw.io](#).

The Hearing of the Barn Owl

For the barn owl life depends on hearing. A nocturnal hunter, the bird must be able to find field mice solely by the rustling and squeaking sounds they make as they traverse runways in snow or grass. Like predators that hunt on the ground, the barn owl must be able to locate its prey quickly and precisely in the horizontal plane. Since the bird hunts from the air, it must also be able to determine its angle of elevation above the

animal it is hunting. The owl has solved this problem very successfully: it can locate sounds in azimuth (the horizontal dimension) and elevation (the vertical dimension) better than any other animal whose hearing has been tested.

What accounts for this acuity? The answer lies in the owl's ability to utilize subtle differences between the sound in its left ear and that in its right. The ears are generally at slightly different distances from the source of a sound, so that sound waves reach them at slightly different times. The barn owl is particularly sensitive to these minute differences, exploiting them to determine the azimuth of the sound. In addition, the sound is perceived as being somewhat louder by the ear that is closer to the source, and this difference offers further clues to horizontal location. For the barn owl the difference in loudness also helps to specify elevation because of an unusual asymmetry in the owl's ears. The right ear and its opening are directed slightly upward; the left ear and its opening are directed downward. For this reason, the right ear is more sensitive to sounds from above and the left ear to sounds from below.

These differences in timing and loudness provide enough information for the bird to accurately locate sounds both horizontally and vertically. To be of service to the owl, however, the information must be organized and interpreted. Much of the processing is accomplished in brain centers near the beginning of the auditory pathway. From these centers nerve impulses travel to a network of neurons in the midbrain that are arranged in the form of a map of space. Each neuron in this network is excited only by sounds from one small region of space. From this structure impulses are relayed to the higher brain centers. The selection of sensory cues and their transformation into a map of space is what enables the barn owl to locate its prey in total darkness with deadly accuracy.

The most visually striking anatomical feature of the barn owl, and the one that plays the most important role in its location of prey, is the face. The skull is relatively narrow and small, and the face is large and round, made up primarily of layers of stiff, dense feathers arrayed in tightly packed rows. The feathered structure, called the facial ruff, forms a surface that is a very efficient reflector of high-frequency sounds.

Two troughs run through the ruff from the forehead to the lower jaw, each about two centimeters wide and nine centimeters long. The troughs are similar in shape to the fleshy exterior of the human ear, and they serve the same purpose: to collect high-frequency sounds from a large volume of space and funnel them into the ear canals. The troughs join below the beak. The ear openings themselves are hidden under the preaural flaps: two flaps of skin that project to the side next to the eyes. The entire

elaborate facial structure is hidden under a layer of particularly fine feathers that are acoustically transparent.

The barn owl is capable of locating the source of a sound within a range of one to two degrees in both azimuth and elevation; one degree is about the width of a little finger at arm's length. Surprisingly, until the barn owl was tested, man was the species with the greatest known ability to locate the source of a sound; human beings are about as accurate as the owl in azimuth but are three times worse in elevation.

The sensitivity of the barn owl's hearing is shown both by its capacity to locate distant sounds and by its ability to orient its talons for the final strike. When the owl swoops down on a mouse, even in a completely dark experimental chamber, it quickly aligns its talons with the body axis of the mouse. This behavior is not accidental. When the mouse turns and runs in a different direction, the owl realigns its talons accordingly. This behavior clearly increases the probability of a successful strike; it also implies that the owl not only identifies the location of the sound source with extreme accuracy but also detects subtle changes in the origin of the sound from which it infers the direction of movement of the prey.

B.2.1.1 Key Phrases and their Boolean Expressions for The Hearing of the Barn Owl

1. Key Phrase: Barn owls are nocturnal hunters.

- Included Keyword: nocturnal
 - Alternatives for nocturnal: night, dark, light, bright, dusk, black, late, sun, moon, twilight, midnight, nighttime
- Included Keyword: hunt
 - Keyword Alternatives for hunt: locat, catch, detect, find, found, spot, discover, chas, follow, stalk, attack, search, seek, prey, food, pursu, captur, sens, identif, trac, target, predator

2. Key Phrase: The bird (barn owl) must find prey through sound.

- Included Keyword: prey
 - Keyword Alternatives for prey: mouse, mice, rodent, rat, animal, hunt, creature, critter, organism, vermin, varmint, species, food, catch, chase, pursue, track, scout, game, target, prize

- Included Keyword: sound
 - Keyword Alternatives for sound: rustl, squeak, cr, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion
3. Key Phrase: For the barn owl life depends on hearing.
- Included Keyword: depend
 - Keyword Alternatives: life, rely, reli, need, liv, surviv, exist, necessit, essential, fundamental, foundation, key, requi, die, starv, vital, must, imperative, urgen, paramount, indispensable, quintessential, critical, death, pass, expire, perish, succumb, demise, end, terminate
 - Included Keyword: hear
 - Keyword Alternatives: listen, sound, noise
4. Key Phrase: The bird (barn owl) locate prey like field mice.
- Included Keyword: mouse
 - Keyword Alternatives: mice, rodent, rat
5. Key Phrase: The bird (barn owl) find field mice solely by the rustling and squeaking sounds they make.
- Included Keyword: mice
 - Keyword Alternatives: mice, rodent, rat
 - Included Keyword: sound
 - Keyword Alternatives: hear, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, commotion, cry, crie, disturb, sono
 - Included Keyword: locat
 - Keyword Alternatives: sens, discover, identif, find, found, set, detect, seek, track, detect, pinpoint, determin, recogni, catch, captur, pursu, spot, follow, ascertain
6. Key Phrase: The bird (barn owl) find field mice as they traverse runways in snow or grass.
- Included Keyword: mouse
 - Keyword Alternatives: mice, rodent, rat

- Included Keyword: trave
 - Keyword Alternatives: cross, navigat, mov, pass, over, journey, trek, roam, explor, through, run, cut, transit, proceed, wander, hik, paddl, tread, trail, track, path, foot, print, mark, trac, groov, rut, impress, rout, channel, line, lining, cours, walk, lane, aisle, corridor, alley, green, rink, snow, grass
- Included Keyword: find
 - Keyword Alternatives: locat, sens, discover, identif, found, set, detect, seek, track, detect, pinpoint, determin, recogni, catch, captur, pursu, spot, follow, ascertain

7. Key Phrase: Barn owls locate prey quickly and precisely like predators that hunt on the ground.

- Included Keyword: locat
 - Keyword Alternatives: find, discover, pinpoint, detect, spot, track, trac
- Included Keyword: ground
 - Keyword Alternatives: earth, land, field, terrain, soil, floor, base
- Included Keyword: similar
 - Keyword Alternatives: same, close, equal, like, compar, equiv, analogous, match, akin, identi, congru, resembl
- Included Keyword: predator
 - Keyword Alternatives: hunter, prowler, other

8. Key Phrase: Barn owls must locate prey quickly in horizontal plane.

- Included Keyword: horizon
 - Keyword Alternatives: azimuth, axis, dimension, plane, level, lateral, straight, flat, left, right, east, west
- Included Keyword: quick
 - Keyword Alternatives: fast, speed, slow, hast, rapid, pac, swift, lag, dawdl, sloth, prompt, snap, optimiz, energ, effect, complet, proficien, agil, electric, accelerat, dash, flash, sonic, brisk, fleet, expedit, hurr, rush, nipp, immediate, zip, breakneck, whiz, nimbl, light, instant, sudden, pop, spik, stab, velocit, slouch, slug, snail, languid, jiff, celerit, efficien, expedien

9. Key Phrase: Barn owls must locate prey precisely in horizontal plane.

- Included Keyword: horizon
 - Keyword Alternatives: azimuth, axis, dimension, plane, level, lateral, straight, flat, left, right, east, west

10. Key Phrase: The bird (barn owl) hunt from air.

- Included Keyword: hunt
 - Keyword Alternatives: catch, chas, stalk, track, attack, find, discover, pinpoint, detect, scout, locat, trac, chas, pursu, found, spot, follow, search, seek, prey, food, captur, sens, identif, target
- Included Keyword: air
 - Keyword Alternatives: elevat, height, vertic, above, sky, altitude, distanc, avian, ski

11. Key Phrase: The bird (barn owl) must determine angle of elevation above the prey it is hunting.

- Included Keyword: angle
 - Keyword Alternatives: orient, direct, vector, degree
- Included Keyword: elevat
 - Keyword Alternatives: height, vertic, above, altitude, distance, plane, below, axis, dimension

12. Key Phrase: The barn owl can locate sounds in azimuth (horizontal dimension).

- Included Keyword: horizon
 - Keyword Alternatives: azimuth, axis, dimension, plane, level, lateral, straight, flat, left, right, east, west
- Included Keyword: sound
 - Keyword Alternatives: decibel, sound, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie

13. Key Phrase: The barn owl can locate sounds in elevation (vertical dimension).

- Included Keyword: vertical
 - Keyword Alternatives: axis, dimension, level, elevat, up, down, north, south, perpendicular, straight, longtiud, plane, altitude, above, below, height
 - Included Keyword: sound
 - Keyword Alternatives: decibel, sound, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, commotion, cry, crie, disturb
14. Key Phrase: The barn owl can locate sounds better than any other animal (whose hearing has been tested).
- Included Keyword: locat
 - Keyword Alternatives: hear, detect, find, identif, sens, found, track, follow, recogni, determin, trac, unearth, spot, pinpoint
 - Included Keyword: sound
 - Keyword Alternatives: decibel, rustl, utter, yel, squeak, hear, nois, cry, crie, audi, tone, echo, acoustic, disturb, commotion, shuffl
 - Included Keyword: animal
 - Keyword Alternatives: creature, other, human, fauna, organism, critter, species
15. Key Phrase: Barn owls have acuity and sensitivity to differences in loudness.
- Included Keyword: sens
 - Keyword Alternatives: acuity, hear, judg, keen, discriminat, identif, detect, receptive, recept, perce, respon, aware, conscious, detect, notice, determin, observ, intuit, discern, recogn
 - Included Keyword: differ
 - Keyword Alternatives: varia, contrast, deviat, distinct, discrepan, incong, imbalance, gap, inequal, independen, unequal, dispar, similar, consisten
 - Included Keyword: loudness
 - Keyword Alternatives: loud, volum, pitch, power, sound, nois, frequenc, intensit, ton, decibel, sonor

16. Key Phrase: The barn owl's acuity lies in its ability to utilize subtle differences between the sound in its left and right ears.

- Included Keyword: differ
 - Keyword Alternatives: contrast, deviat, distinct, discrepan, incong, imbalance, gap, inequal, unequal, independen, vari
- Included Keyword: left
 - Keyword Alternatives: right, between, two, 2, east, west, ear
- Included Keyword: sound
 - Keyword Alternatives: hear, rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie

17. Key Phrase: The barn owl's left and right ears locate at slightly different distances from source of sound.

- Included Keyword: ear
 - Keyword Alternatives: sourc, left, right, audi, canal, east, west
- Included Keyword: locat
 - Keyword Alternatives: hear, detect, find, identif, sens, found, track, follow, recogni, determine
- Included Keyword: differ
 - Keyword Alternatives: varia, contrast, deviat, distinct, discrepan, incong, imbalance, gap, unequal, independen, inequal
- Included Keyword: distance
 - Keyword Alternatives: spot, point, place, span, interval, range, space, area, room, rang, expans, zon, distanc, region, place, expanse, territor, extent, stretch, length

18. Key Phrase: The barn owl's left and right ears receive sound waves at slightly different times.

- Included Keyword: ear
 - Keyword Alternatives: canal, left, right, audi, east, west
- Included Keyword: receiv

- Keyword Alternatives: take, get, obtain, collect, experienc, hear, gather, come, pick, acquir, detect, retriev, taking, attain, fetch, procur, captur, garner, accumul, snag, coming
 - Included Keyword: differ
 - Keyword Alternatives: varia, contrast, deviat, distinct, discrepan, incong, gap, unequal, independen, inequal, imbalanc
 - Included Keyword: sound
 - Keyword Alternatives: wave, hear, rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie, oscillat, vibrat, undulat, ripple, frequenc
19. Key Phrase: The barn owl is particularly sensitive to these minute (time) differences of sound waves.
- Included Keyword: time
 - Keyword Alternatives: interval, moment, count
 - Included Keyword: sens
 - Keyword Alternatives: recept, perce, respon, aware, conscious, detect, notice, determin, observ, intuit, discern, recogni
 - Included Keyword: differ
 - Keyword Alternatives: vari, contrast, deviat, distinct, discrepan, incong, imbalance, gap, inequal, independen, unequal
20. Key Phrase: The barn owl exploits the minute differences in when sound waves reach each ear (interaural time differences) to determine the azimuth (horizontal dimension) of the sound.
- Included Keyword: differ
 - Keyword Alternatives: contrast, deviat, distinct, discrepan, incong, imbalance, gap, unequal, independen, inequal, vari
 - Included Keyword: ear
 - Keyword Alternatives: canal, left, right, audi, east, west

- Included Keyword: receive
 - Keyword Alternatives: take, get, obtain, collect, experience, hear, gather, come, pick, detect, retrieve, acquire, taking, attain
 - Included Keyword: sound
 - Keyword Alternatives: wave, sound, hear, rustle, decibel, listen, rustle, squeak, yell, noise, utter, shuffle, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie, oscillate, vibrate, undulate, ripple, frequency
21. Key Phrase: Barn owls exploit minute differences in time to determine the elevation (vertical dimension) of sound.
- Included Keyword: differ
 - Keyword Alternatives: vary, contrast, deviate, distinct, discrepant, incongruous, imbalance, gap, unequal, independent, unequal, disparate, similar, consistent
 - Included Keyword: elevation
 - Keyword Alternatives: vertical, axis, dimension, plane, height, up, down, north, south
 - Included Keyword: sound
 - Keyword Alternatives: hear, rustle, decibel, listen, rustle, squeak, yell, noise, utter, shuffle, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie
 - Included Keyword: time
 - Keyword Alternatives: count, moment, interval
22. Key Phrase: The sound is perceived (as being somewhat) louder by the ear closer to the source.
- Included Keyword: sound
 - Keyword Alternatives: hear, rustle, decibel, listen, rustle, squeak, yell, noise, utter, shuffle, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie
 - Included Keyword: loud
 - Keyword Alternatives: noise, strong, roar, bellow, thunder, rumble, boom, yell, shout, raucous, blast, pierce, deaf, split, clamor

- Included Keyword: sourc
 - Keyword Alternatives: prox, near, neighbo, within, distance, audi, clos, nigh, vicinit, adjacent, approach, face, toward
- Included Keyword: ear
 - Keyword Alternatives:

23. Key Phrase: This difference (in loudness of the sound source) offers further clues (for the barn owl) to horizontal (azimuth) location.

- Included Keyword: horizon
 - Keyword Alternatives: azimuth, axis, dimension, plane, east, west, left, right, level, lateral, straight, flat
- Included Keyword: differ
 - Keyword Alternatives: vari, contrast, deviat, distinct, discrepan, incong, imbalance, gap, inequal, independen, unequal, dispar, similar, consisten
- Included Keyword: clue
 - Keyword Alternatives: hint, indicat, sign, cue, lead, pointer, eviden, trail, trac, suggest, inkl, intimat, prompt, signal, tip, info, insight, key, whisper, impl, mark, remind, hunch, notion, note, noting, glimps, guid, direct, steer, navigat, sheph, conduct, assist, instruct, advis, escort, accompan, aid, help, support, influen, counsel, mentor, coach, point

24. Key Phrase: Barn owls measure differences in loudness to offer clues for vertical location (elevation).

- Included Keyword: differ
 - Keyword Alternatives: vari, contrast, deviat, distinct, discrepan, incong, imbalance, gap, inequal, independen, unequal, dispar, similar, consisten
- Included Keyword: vertic
 - Keyword Alternatives: elevat, axis, dimension, plane, location, height, north, south, up, down
- Included Keyword: loud

- Keyword Alternatives: volum, pitch, power, sound, nois, frequenc, intensit, ton, decibel, sonor

25. Key Phrase: The difference in loudness helps barn owls specify elevation (vertical dimension) due to an unusual asymmetry in their ears.

- Included Keyword: elevat
 - Keyword Alternatives: plane, north, south, up, down, vertic, axis, dimension, plane, above, below, height
- Included Keyword: differ
 - Keyword Alternatives: vari, contrast, deviat, distinct, discrepan, incong, imbalance, gap, inequal, independen, unequal, dispar, similar, consisten
- Included Keyword: asymmet
 - Keyword Alternatives: incongruity, lopsided, skew, proportion, unequal, uniform, symmet, inequ, unequ, even, regular, congruen
- Included Keyword: loud
 - Keyword Alternatives: volum, pitch, power, sound, hear, rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie, sonor

26. Key Phrase: Barn owls can perceive differences to loudness because of an unusual asymmetry in the owl's ears.

- Included Keyword: differ
 - Keyword Alternatives: vari, contrast, deviat, distinct, discrepan, incong, imbalance, gap, inequal, independen, unequal, dispar, dissimilar, inconsisten
- Included Keyword: loud
 - Keyword Alternatives: volum, pitch, power, sound, hear, rustl, decibel, listen, squeak, yel, nois, shuffl, utter, audi, tone, echo, acoustic, disturbance, commotion, cry, crie, sonor
- Included Keyword: asymmet
 - Keyword Alternatives: incongruity, lopside, skew, proportion, uneven, uniform, symmet, inequ, unequ

27. Key Phrase: The barn owl's right ear and its opening are directed slightly upward.

- Included Keyword: up
 - Keyword Alternatives: above, sky, over, elev, vertical, north, beyond, ascend, high
- Included Keyword: ear
 - Keyword Alternatives: right, canal
- Included Keyword: open
 - Keyword Alternatives: hole, gap, entrance, direct, tilt, orient, situat, point, face, facing, position, plac, fix, aim, slight

28. Key Phrase: The barn owl's left ear and its opening are directed (slightly) downward.

- Included Keyword: down
 - Keyword Alternatives: below, under, bottom, beneath, hide, hiding, hidden, low, inferior, nether, sub
- Included Keyword: ear
 - Keyword Alternatives: left, canal
- Included Keyword: open
 - Keyword Alternatives: hole, gap, entrance, direct, tilt, orient, situat, point, face, facing, position, plac, fix, aim, slight

29. Key Phrase: The barn owl's right ear is more sensitive to sounds from above.

- Included Keyword: up
 - Keyword Alternatives: above, sky, over, elev, vertical, north, south, upper, beyond, ascend, high
- Included Keyword: ear
 - Keyword Alternatives: right, canal
- Included Keyword: sens
 - Keyword Alternatives: recept, perce, respon, aware, conscious, detect, notice, determin, observ, intuit, discern, recogni, react, notic, touchy, attent

30. Key Phrase: The barn owl's left ear is more sensitive to sounds from below.

- Included Keyword: ear
 - Keyword Alternatives: left, canal
- Included Keyword: sens
 - Keyword Alternatives: recept, perce, respon, aware, conscious, detect, determin, observ, intuit, discern, recogni, react, notic, touchy, attent
- Included Keyword: down
 - Keyword Alternatives: below, under, bottom, beneath, hide, hiding, hidden, low, inferior, nether, sub

31. Key Phrase: Barn owls must organize and interpret sound information.

- Included Keyword: organize
 - Keyword Alternatives: arrang, sort, process, interpret, translat, comprehend, understand, adjust, analyz, coordinate, manage, order, analyze, decode, translate, render, construct, decipher
- Included Keyword: sound
 - Keyword Alternatives: noise, audi, acoust, loud, disturbance, tone, echo

32. Key Phrase: Information processing is accomplished in brain centers.

- Included Keyword: process
 - Keyword Alternatives: clarif, verif, sort, organiz, comprehen, analy, assess, eval, interpret, manag, deal, conduc, operat, work, info, knowledge, data, intelligence, detail, input, cogni
- Included Keyword: accomplish
 - Keyword Alternatives: done, occur, fulfill, realize, attain, perform, execute, complet, brought, bring, carr, achiev, conclud
- Included Keyword: brain
 - Keyword Alternatives: cerebr, center, mind, mental, head, noodle, noggin

33. Key Phrase: Brain centers are located near the beginning of the auditory pathway.

- Included Keyword: brain
 - Keyword Alternatives: cerebr, center, mind, mental, head, noodle
- Included Keyword: audi
 - Keyword Alternatives: acoustic, sonic, aural, auricular, sound, hear
- Included Keyword: path
 - Keyword Alternatives: passage, network, system, channel, setup, config, complex, structur, apparatus, mechan, route

34. Key Phrase: Nerve impulses travel to a network of neurons in the midbrain.

- Included Keyword: puls
 - Keyword Alternatives: stimul, signal, message, current, wave, cue, prompt, communicat, neuron, nerv, cell, vib, oscillat, throb, nexus, connection, circuit, web, net
- Included Keyword: trav
 - Keyword Alternatives: mov, proceed, carr, advanc, through, journey, go, shift, loc, trans, migrat, commut, voyag
- Included Keyword: midbrain
 - Keyword Alternatives: middle, brain

35. Key Phrase: Nerve impulses are arranged in the form of a map of space.

- Included Keyword: puls
 - Keyword Alternatives: stimul, signal, message, current, wave, cue, prompt, communicat, neuron, net, nerv, cell, vib, oscillat, throb, nexus, connection, circuit, web
- Included Keyword: map
 - Keyword Alternatives: layout, represent, diagram, sketch, outlin, imag, rang, region, spac, area, terr, section, site, location, zone, field, sector, place

36. Key Phrase: Each neuron (in this network of the midbrain) gets excited by sounds from one small region of space.

- Included Keyword: region
 - Keyword Alternatives: spac, area, terr, section, site, location, zone, field, sector, place
- Included Keyword: neur
 - Keyword Alternatives: brain, impulse, stimul, signal, message, current, wave, cue, prompt, communicat, nerv, net, cell, nexus, connection, circuit, web
- Included Keyword: sound
 - Keyword Alternatives: hear, rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie

37. Key Phrase: In a network of neurons, impulses are relayed to the higher brain centers.

- Included Keyword: pulse
 - Keyword Alternatives: stimul, signal, message, current, wave, cue, prompt, communicat, neuron, nerv, cell, vib, oscillat, throb, nexus, connection, circuit, web, net
- Included Keyword: relay
 - Keyword Alternatives: convey, transmit, carr, transfer, commun, pass, dispatch, forward, send, sent, disseminat
- Included Keyword: high
 - Keyword Alternatives: up, superior, elev, better, great, supreme, increas, augment, ascend, advanc, enchanc
- Included Keyword: brain
 - Keyword Alternatives: cerebr, center, mind, mental, head, noodle, noggin

38. Key Phrase: Sound processing in neural networks involves a selection of sensory cues.

- Included Keyword: sens
 - Keyword Alternatives: audi, aural, cue, signal, prompt, indicat, clue, hint, trigger, point, suggest, gestur, marker, acoust, sound, hint, sign, lead, tip, perce, input
- Included Keyword: process

- Keyword Alternatives: clarif, verif, sort, organiz, comprehen, analy, assess, eval, interpret, manag, deal, conduc, operat, work, info, knowledge, data, intelligence, detail, input, cogni, neur, network, hear, rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie

39. Key Phrase: Sound processing in neural networks involves the transformation of sensory cues into a map of space.

- Included Keyword: process
 - Keyword Alternatives: clarif, verif, sort, organiz, comprehen, analy, assess, eval, interpret, manag, deal, conduc, operat, work, info, knowledge, data, intelligence, detail, input, cogni, neur, network, sound, hear, rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie
- Included Keyword: form
 - Keyword Alternatives: trans, chang, modif, morph, convert, mak, translat, turn, model, mold, construct, arrang, buil, organiz, alter, shap, config
- Included Keyword: sens
 - Keyword Alternatives: audi, aural, acoust, sound, cue, signal, prompt, indicat, clue, hint, trigger, point, suggest, gestur, marker, hint, sign, lead, tip, perce
- Included Keyword: map
 - Keyword Alternatives: layout, represent, diagram, sketch, outlin, imag, rang, re-gion, spac, area, terr, section, site, location, zone, field, sector, place

40. Key Phrase: Sound processing in neural networks enables barn owls to locate prey in total darkness with deadly accuracy.

- Included Keyword: process
 - Keyword Alternatives: clarif, verif, sort, organiz, comprehen, analy, assess, eval, interpret, manag, deal, conduc, operat, work, info, knowledge, data, intelligence, detail, input, cogni, neur, network
- Included Keyword: locat

- Keyword Alternatives: sens, discover, identif, find, found, set, detect, seek, track, detect, pinpoint, determin, recogni, catch, captur, pursu, follow, attack, spot, prey, stalk, chas

- Included Keyword: dark

- Keyword Alternatives: night, nocturnal, light, obscurity, bright, black, day, late, sun, moon, dusk

41. Key Phrase: The most visually striking anatomical feature of the barn owl is the face.

- Included Keyword: fac

- Keyword Alternatives: head, crani, dome, noggin

- Included Keyword: striking

- Keyword Alternatives: prominen, significan, distinct, stand, extraordinary, salien, incredible, recogniz, identif, unique, notic, attention, discern, distinguish, observe, divine, espy, look, note, remark, astonishing, bizarre, conspicuous, dazzling, fascinating, handsome, impressive, memorable, outstanding, remarkable, salient, startling, stunning, unusual, wonderful, wondrous, confounding, staggering, ordinary, prominent, catch, surpris, nota

42. Key Phrase: The barn owl's face plays the most important role in locating prey.

- Included Keyword: role

- Keyword Alternatives: fuction, job, responsibility, task, part, purpose, because, allows

- Included Keyword: face

- Keyword Alternatives: head, noggin, mug, dome, cranium, feature, fac, structure, anatom

- Included Keyword: prey

- Keyword Alternatives: mouse, mice, rodent, rat, animal, hunt, creature, critter, organism, vermin, varmint, species, food, catch, chase, pursue, track, scout, game, target, prize

43. Key Phrase: The barn owl's skull is (relatively) narrow and small.

- Included Keyword: skull
 - Keyword Alternatives: crani, bone, skel
- Included Keyword: narrow
 - Keyword Alternatives: small, tiny, little, slender, thin, slim, mini, diminutive, petite, lean, compact

44. Key Phrase: The barn owl's face is (relatively) large and round.

- Included Keyword: fac
 - Keyword Alternatives: head, noggin, mug, dome
- Included Keyword: large
 - Keyword Alternatives: fat, big, round, rotund, pudgy, massive, spher, circular, huge, oval, giga, giant, grand, nourmous, broad, mongous, jumbo, stupend, whopp, considerable, full, great, heft, mass, substant, wide, ample, bulk, colos

45. Key Phrase: The barn owl's face is (primarily) made up of layers of feathers.

- Included Keyword: fac
 - Keyword Alternatives: head, crani, dome, noggin
- Included Keyword: layer
 - Keyword Alternatives: level, sheet, coat, surface, bed, overl, tier, veil, band
- Included Keyword: feather
 - Keyword Alternatives: plume, fluff

46. Key Phrase: The barn owl's face feathers are stiff and dense.

- Included Keyword: fac
 - Keyword Alternatives: head, crani, dome, noggin, mug
- Included Keyword: feather
 - Keyword Alternatives: plume, fluff
- Included Keyword: stiff

- Keyword Alternatives: dens, rigid, firm, ample, thick, hard, concentrat, impenetrable, pack, pact, solid, inflexible, unyielding, sturdy, tense, immovable, compact, crowd, heavy, clump, tight, concentrate

47. Key Phrase: The barn owl's face feathers are arrayed in tightly packed rows.

- Included Keyword: fac
 - Keyword Alternatives: head, crani, dome, noggin, mug
- Included Keyword: feather
 - Keyword Alternatives: plume, fluff
- Included Keyword: tight
 - Keyword Alternatives: dens, rigid, firm, ample, thick, hard, concentrat, impenetrable, pact, solid, inflexible, unyielding, sturdy, tense, immovable, compact, crowd, heavy, clump, tight, concentrate, stiff, dens, rigid, firm, ample, thick, hard, concentrat, impenetrable, row, array, series, file, line, pack

48. Key Phrase: The feathered structure (of the barn owl's face) is called the facial ruff.

- Included Keyword: fac
 - Keyword Alternatives: head, crani, dome, noggin, mug
- Included Keyword: ruff
 - Keyword Alternatives:

49. Key Phrase: The facial ruff (of the barn owl) forms a surface that is a very efficient reflector of high-frequency sounds.

- Included Keyword: reflect
 - Keyword Alternatives: mirror, echo, prject, show, reproduce, mimic, duplicate, imitate
- Included Keyword: sound
 - Keyword Alternatives: decibel, sound, listen, rustl, squeak, cr, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion

50. Key Phrase: The face structure of barn owls contains two troughs.

- Included Keyword: trough
 - Keyword Alternatives: feather, feature, characteristic, structure
- Included Keyword: face
 - Keyword Alternatives: head, noggin, mug, dome, cranium, feature, fac, structure, anatom

51. Key Phrase: Two troughs (of the barn owl) run through the ruff from the forehead to the lower jaw.

- Included Keyword: trough
 - Keyword Alternatives:
- Included Keyword: forehead
 - Keyword Alternatives: noggin, mug, dome, brow, head
- Included Keyword: jaw
 - Keyword Alternatives: beak, mouth, mandible, chops, maw, chin

52. Key Phrase: Each trough is (about) two centimeters wide.

- Included Keyword: trough
 - Keyword Alternatives:
- Included Keyword: two
 - Keyword Alternatives: 2
- Included Keyword: centimeter
 - Keyword Alternatives: cm

53. Key Phrase: Each trough are (about) nine centimeters long.

- Included Keyword: nine
 - Keyword Alternatives: 9
- Included Keyword: centimet
 - Keyword Alternatives: cm

- Included Keyword: trough
 - Keyword Alternatives:

54. Key Phrase: The (two) troughs are similar in shape to the fleshy exterior of the human ear.

- Included Keyword: similar
 - Keyword Alternatives: resembl, match, same, close, equal, like, compar, equiv, analogous, resemble, match, akin, identi, congru
- Included Keyword: troughs
 - Keyword Alternatives:
- Included Keyword: human
 - Keyword Alternatives: person, people, folks, men, dude, man
- Included Keyword: ear
 - Keyword Alternatives:

55. Key Phrase: The (two) troughs serve the same purpose as the fleshy exterior of the human ear.

- Included Keyword: purpos
 - Keyword Alternatives: intent, goal, objective, aim, plan, design, mission, function, reason, motive, rationale, resolut, determin, motiv, role, duty, duti, task, responsib, job, operat, perform, use, usage, servic, work, occup, position, capacit, assign, activit, part, contribut, action
- Included Keyword: human
 - Keyword Alternatives: person, people, folk, men, dude, man
- Included Keyword: ear
 - Keyword Alternatives: aural, canal, flesh, meat, juic, succulen, plump, pulp, soft, spong, pudg, flab, rotund, chub, port, corpulen, chunk, bulb
- Included Keyword: trough
 - Keyword Alternatives:

56. Key Phrase: The (two) troughs (of the barn owl) collect high frequency sounds from a large volume of space.

- Included Keyword: trough
 - Keyword Alternatives:
- Included Keyword: collec
 - Keyword Alternatives: gather, cumulate, converge, pick, hear, locat, hear, detect, find, identif, sens, found, track, follow, recogni, determin, agregat, receiv, get, accumulate, amass, compile, assemble, cluster, garner
- Included Keyword: space
 - Keyword Alternatives: area, room, rang, expans, zon, region, place, expanse, territor, distanc
- Included Keyword: sound
 - Keyword Alternatives: rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie

57. Key Phrase: The (two) troughs funnel high frequency sounds into the ear canals.

- Included Keyword: trough
 - Keyword Alternatives: feather, feature, characteristic, structure
- Included Keyword: sound
 - Keyword Alternatives: rustl, decibel, listen, rustl, squeak, cr, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion
- Included Keyword: funnel
 - Keyword Alternatives: feed, direct, transfer, conv, concentrat, mov, siphon, takes, collect, gather, guid, channel, receiv, filt, send, pas

58. Key Phrase: The (two) troughs are joined below the beak.

- Included Keyword: beak
 - Keyword Alternatives: jaw, mouth, mandiblle, chops, maw, chin
- Included Keyword: troughs

- Keyword Alternatives:
 - Included Keyword: join
 - Keyword Alternatives: run, go, end, abid, place, halt, terminat, resid, locat, settl, lie, nest, connect, unit, combin, link, associat, merg, coupl, meet
59. Key Phrase: Ear openings are hidden under the preaural flaps.
- Included Keyword: preaural
 - Keyword Alternatives:
 - Included Keyword: under
 - Keyword Alternatives: below, down, bottom, beneath, hide, low, inferior, nether, sub, hiding, hidden
 - Included Keyword: ear
 - Keyword Alternatives:
60. Key Phrase: Preaural flaps are two flaps of skin projected to the side next to the eyes.
- Included Keyword: next
 - Keyword Alternatives: close, near, proxim, adjacent, around by, neighbor, side, project, beside, along, around, border, touch, Neighbor, Proxi, Within
 - Included Keyword: flap
 - Keyword Alternatives: overhang, fold, cover, pouch, drape, sag
 - Included Keyword: preaural
 - Keyword Alternatives:
 - Included Keyword: eye
 - Keyword Alternatives:
61. Key Phrase: The entire elaborate facial structure is hidden under a layer of particularly fine feathers.
- Included Keyword: fac
 - Keyword Alternatives: head, mug, noggin, dome

- Included Keyword: hidden
 - Keyword Alternatives: cover, under, below, veil, overla, conceal, shroud
- Included Keyword: feather
 - Keyword Alternatives: plum

62. Key Phrase: The layer of fine facial feathers is acoustically transparent.

- Included Keyword: fac
 - Keyword Alternatives: head, mug, noggin, dome
- Included Keyword: feather
 - Keyword Alternatives: plum
- Included Keyword: acoustic
 - Keyword Alternatives: sound, noise, son, phonic, audit
- Included Keyword: transparen
 - Keyword Alternatives: through, pass, travel, past, across

63. Key Phrase: The barn owl is capable of locating the source of a sound (in both azimuth and elevation) within a range of one to two degrees.

- Included Keyword: locat
 - Keyword Alternatives: hear, detect, find, identif, sens, found, track, follow, recogni, determin, trac, unearth, identify, spot, pinpoint
- Included Keyword: sound
 - Keyword Alternatives: rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, crie, cry
- Included Keyword: source
 - Keyword Alternatives: origin, root, begin, generat, degree, unit, point, caus, grad

64. Key Phrase: One degree is about width of a little finger at arm's length.

- Included Keyword: degree

- Keyword Alternatives: point, grade, unit
 - Included Keyword: finger
 - Keyword Alternatives: digit, thumb, extremity, pink
65. Key Phrase: Until the barn owl was tested, humans had the best known ability for locating the source of a sound.
- Included Keyword: test
 - Keyword Alternatives: discover, research, found, check, experiment, final, search, comp, exam, analy, prov, assess, prob, scrut, eval, inspect, confirm, stud, investigat, corrobora
 - Included Keyword: ability
 - Keyword Alternatives: able, could, can, power, gift, intelligence, skill, talent, aptitude, endowment, might, competency, expert, faculty, capacity, pro, potential
 - Included Keyword: human
 - Keyword Alternatives: person, people, men, dude, man, folk
 - Included Keyword: great
 - Keyword Alternatives: best, most, prime, dominant, top, highest, premier, superior, better, excellent, super, special, common, different, one, 1, distinct, novel, extra, ordinary, usual, memor, stand, out, excel, impress, remark, magnificent, striking, prominent, notable, spect, admir, first, high, might, above, more, single, top, precedent, rival, parallel, amazing, comparable, awe, astound, astonish, credible, believe, wonder, surprising, fantastic, splendid, sense, talent, ability, genius, gift, skill, fine, exceed, surpass, transcend, beyond, tower, equal, peer, forget, impact, significant, cool, terrific, marvel, glorious, match, real, some, world, monument, grand, wild, stupefying, good
66. Key Phrase: Human beings locating sound in the azimuth (horizontal dimension) have similar accuracy as barn owls.
- Included Keyword: human
 - Keyword Alternatives: person, people, folks, men, dude, man
 - Included Keyword: locate

- Keyword Alternatives: hear, detect, find, identif, sens, found, track, follow, recogni, determin, trac
- Included Keyword: azimuth
 - Keyword Alternatives: horizon, axis, dimension, plane
- Included Keyword: similar
 - Keyword Alternatives: like, same, close, equal, like, compar, equiv, analogous, resembl, match, akin, identi, congru

67. Key Phrase: Human beings locating sound in elevation (vertical dimension) are three times worse than barn owls.

- Included Keyword: human
 - Keyword Alternatives: person, people, folks, men, dude, man
- Included Keyword: elevat
 - Keyword Alternatives: vertic, axis, dimension, plane, altitude, above, below, height, up, down, north, south
- Included Keyword: worse
 - Keyword Alternatives: inferior, less, subpar, weak, poor, regress, better, comparison, superior, optimal, outstanding, excellent, terrible, contrast, opposed, relation, convers, relative

68. Key Phrase: Sensitivity of the owl's hearing is shown by its capacity to locate distant sounds.

- Included Keyword: hear
 - Keyword Alternatives: sens, recog, listen, determin, acuity, perce
- Included Keyword: locat
 - Keyword Alternatives: sens, discover, identif, find, found, set, detect, seek, track, detect, pinpoint, determin, recogni, catch, captur, pursu, spot, follow
- Included Keyword: distan
 - Keyword Alternatives: far, remote, length, sound, remov

69. Key Phrase: Sensitivity of the owl's hearing is shown by its ability to orient talons (for the final strike).

- Included Keyword: orient
 - Keyword Alternatives: align, position, set, arrang, aim, angle, direct, situate, adjust, line, coordinat, alter, rotat, move, moving, shift
- Included Keyword: talon
 - Keyword Alternatives: claw, hook, feet
- Included Keyword: hear
 - Keyword Alternatives: sens, recog, acuity, perce, listen, determin, detect, rece, gather, register, notic, take, taking, pick, hark, discern
- Included Keyword: sens
 - Keyword Alternatives: audi, aural, acoust, sound, cue, signal, prompt, indicat, clue, hint, trigger, point, suggest, gestur, marker, hint, sign, lead, tip

70. Key Phrase: Even in complete darkness (In a completely dark experimental chamber), the owl swoops down on the prey (mouse).

- Included Keyword: dark
 - Keyword Alternatives: night, nocturnal, light, black, day, sun, moon, dusk
- Included Keyword: experiment
 - Keyword Alternatives: control, test, investigat, trial, exam, observ, lab, assess, stud
- Included Keyword: prey
 - Keyword Alternatives: mouse, mice, animal, game, creature, rodent, rat, critter, organism, specie, quarr, target
- Included Keyword: chamber
 - Keyword Alternatives: room, facilit, locat, area, closur, spac, case, casing, contain, cavit, compartment, box, vessel, zone, field, sector, place, region, terr, site

71. Key Phrase: Even in complete darkness (In a completely dark experimental chamber), the barn owl aligns its talons with the body axis of the prey (mouse).

- Included Keyword: align
 - Keyword Alternatives: orient, position, set, arrang, aim, angle, direct, situate, adjust, line, coordinat, alter, rotat, move, moving, shift
- Included Keyword: talon
 - Keyword Alternatives: claw, hook, feet
- Included Keyword: prey
 - Keyword Alternatives: rodent, prey, mice, rat, game, mouse, animal, organism, critter, creature, specie, food, quarr, target

72. Key Phrase: The ability to align talons is not an accidental behavior.

- Included Keyword: align
 - Keyword Alternatives: orient, position, set, arrang, aim, angle, direct, situate, adjust, line, coordinat, alter, rotat, move, moving, shift
- Included Keyword: talon
 - Keyword Alternatives: claw, hook, feet
- Included Keyword: accident
 - Keyword Alternatives: coincide, purpos, random, mistake, chance, incident, deliberat, fortuitous, serendip, luck, voluntar, plan, prearrang, purpose, design, will, conscious, evolut, hishap, advertent, inten, expect, happen, foresee, fluk, haphazard, premediat, spontaneous, calculat, method, mean

73. Key Phrase: The ability to realign talons when the prey (mouse) turns and runs in a different direction.

- Included Keyword: align
 - Keyword Alternatives: orient, position, set, arrang, aim, angle, direct, situate, adjust, line, coordinat, alter, rotat, move, moving, shift
- Included Keyword: talon
 - Keyword Alternatives: claw, hook, feet
- Included Keyword: prey

- Keyword Alternatives: mouse, mice, animal, game, creature, rodent, rat, critter, organism, specie, food, quarr, target
- Included Keyword: turn
 - Keyword Alternatives: run, dodg, flee, eva, avoid, chang, mov, pivot, switch, away, direction, twist, escap, bolt, dash, leav, path, rotat, scram, getaway, skedaddle, retreat, sprint, hightail, absquatulat, elud, free, veer, detour

74. Key Phrase: The ability to realign talons to increase probability of successful strike.

- Included Keyword: align
 - Keyword Alternatives: orient, position, set, arrang, aim, angle, direct, situate, adjust, line, coordinat, alter, rotat, move, moving, shift
- Included Keyword: probab
 - Keyword Alternatives: chance, like, odds, prosp, possib, expect, chanc, odds, potential, plausib, feasib, anticipat
- Included Keyword: strik
 - Keyword Alternatives: attack, kill, smite, catch, blow, hit, assault, offens, lung, swoop, whack, wallop, sock, bash, swip

75. Key Phrase: Realigning talons implies that the barn owl identifies the sound source with extreme accuracy.

- Included Keyword: align
 - Keyword Alternatives: orient, position, set, arrang, aim, angle, direct, situate, adjust, line, alter, coordinat, rotat, move, moving, shift
- Included Keyword: talon
 - Keyword Alternatives: claw, hook, feet
- Included Keyword: sound
 - Keyword Alternatives: noise, utter, cr, rustl, squeak, yel, sourc
- Included Keyword: accura
 - Keyword Alternatives: precis, exact, correct

- Included Keyword: identif
 - Keyword Alternatives: sens, discover, find, found, set, detect, seek, track, detect, pinpoint, determin, recogni, catch, captur, pursu, spot, follow, isolat, tie, link, connect, assoc, plac, discover, figur, nam, singl, grasp, discern, finger, mark, notic, note, observ

76. Key Phrase: Realigning talons implies that the barn owl detects subtle changes in the origin of the sound.

- Included Keyword: align
 - Keyword Alternatives: orient, position, set, arrang, aim, angle, direct, situate, adjust, line, alter, coordinat, rotat, move, moving, shift
- Included Keyword: talon
 - Keyword Alternatives: claw, hook, feet
- Included Keyword: detect
 - Keyword Alternatives: locat, disting, find, identif, sens, found, differ, perceiv, discover, discern, mark, perce, uncover, descry, figur, recog, nam, singl, pinpoint, plac, track, determin, observ, notic, note, differentiat, discern, separat, discriminat, sort, tell, make, specif
- Included Keyword: chang
 - Keyword Alternatives: differ, discre, distinct, varia, disparit, similar, subtl, shift, tweak, modif, origin, slight, faint, nuanc, gent, delicat, minut, imperceptibl

77. Key Phrase: The barn owl detects subtle changes in the sound origin to infer movement direction of the prey.

- Included Keyword: chang
 - Keyword Alternatives: differ, discre, distinct, varia, disparit, similar, subtl, shift, tweak, modif, origin, slight, faint, nuanc, gent, delicat, minut, imperceptibl
- Included Keyword: sound
 - Keyword Alternatives: hear, rustl, decibel, listen, rustl, squeak, yel, nois, utter, shuffl, hear, audi, tone, echo, acoustic, disturbance, commotion, cry, crie

- Included Keyword: origin
 - Keyword Alternatives: root, sourc, locat, bas, from, plac, mov, direction, motion, path, activit, rout, trail, trajector, cours, orient, go, bear, track, pass, where, travel

- Included Keyword: detect
 - Keyword Alternatives: locat, disting, find, identif, sens, found, differ, perciev, discover, discern, mark, perce, uncover, descry, figur, recog, nam, singl, pinpoint, plac, track, observ, notic, determin, note, differentiat, discern, separat, discriminat, classif, sort, tell, make

- Included Keyword: prey
 - Keyword Alternatives: mice, rat, game, mouse, rodent, animal, creature, organism, critter, food, quarr, target

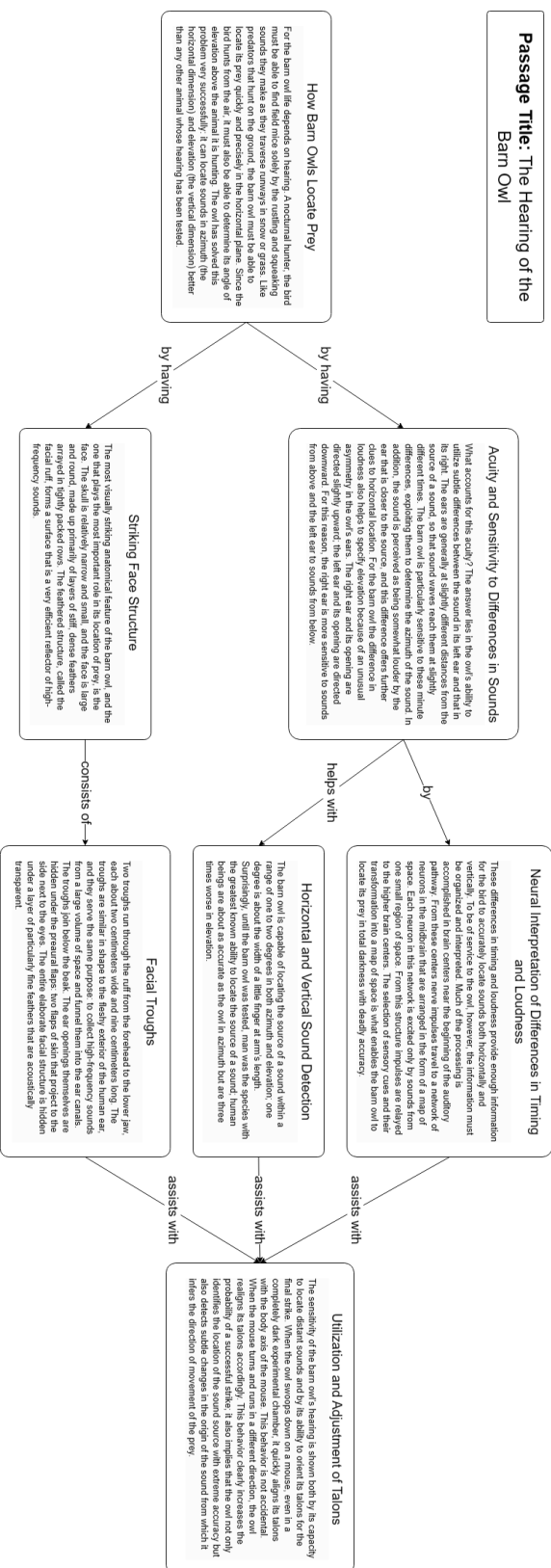


Figure B.1: Passage 1: The Hearing of the Barn Owl in Hybrid Map (H) condition

Focus Question: What is unique about barn owls' hearing and where do their sound detection abilities come from?

Passage Title: The Hearing of the Barn Owl

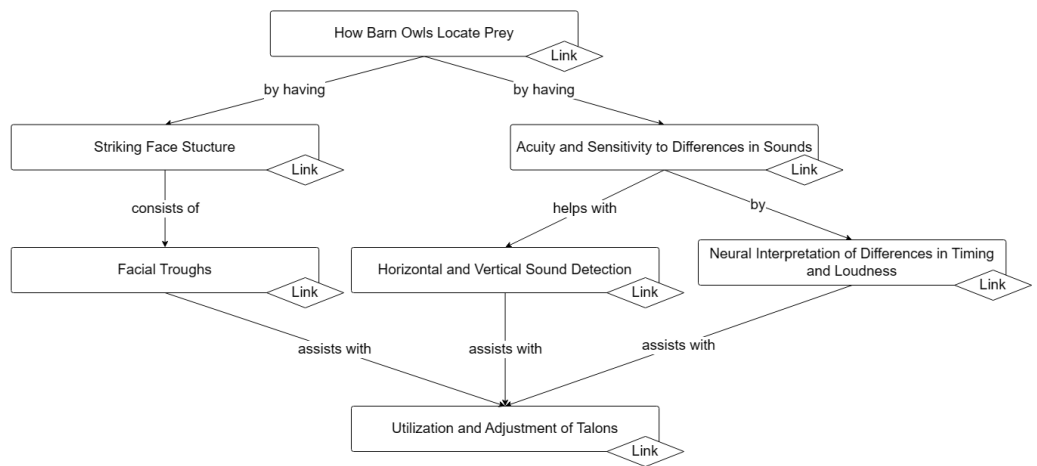


Figure B.2: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - Master-map

Back to Main Page

Paragraph Title: How Barn Owls Locate Prey

Focus Question: How do barn owls locate prey?

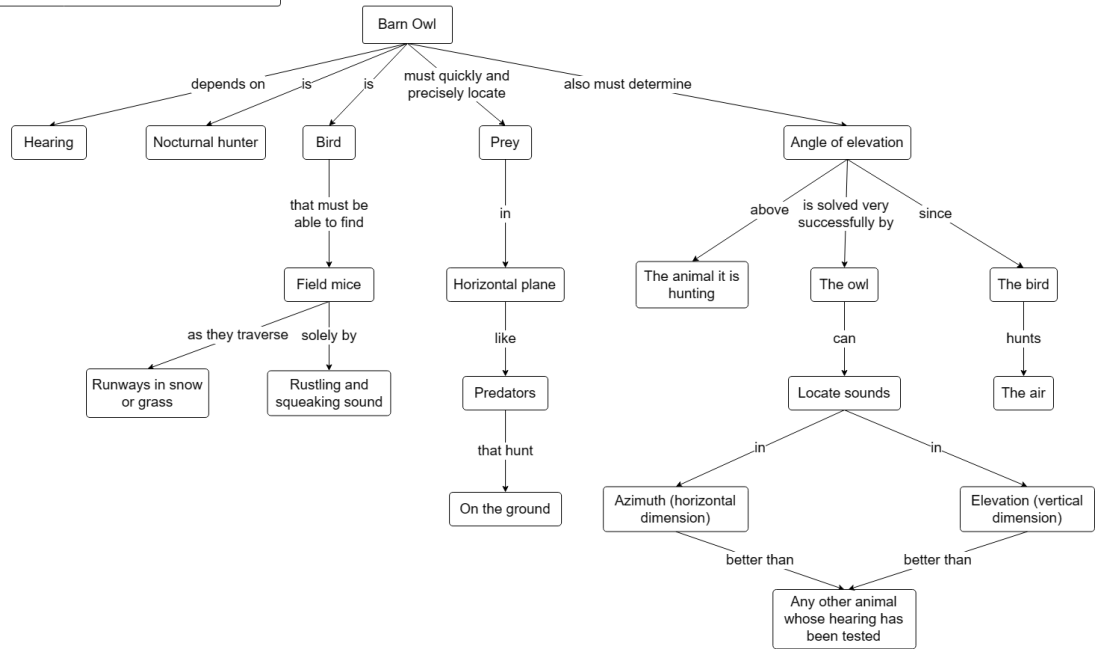


Figure B.3: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - mini-map1

Back to Main Page

Paragraph Title: Striking Face Structure

Focus Question: How are barn owls' faces structured and what purpose does it serve?

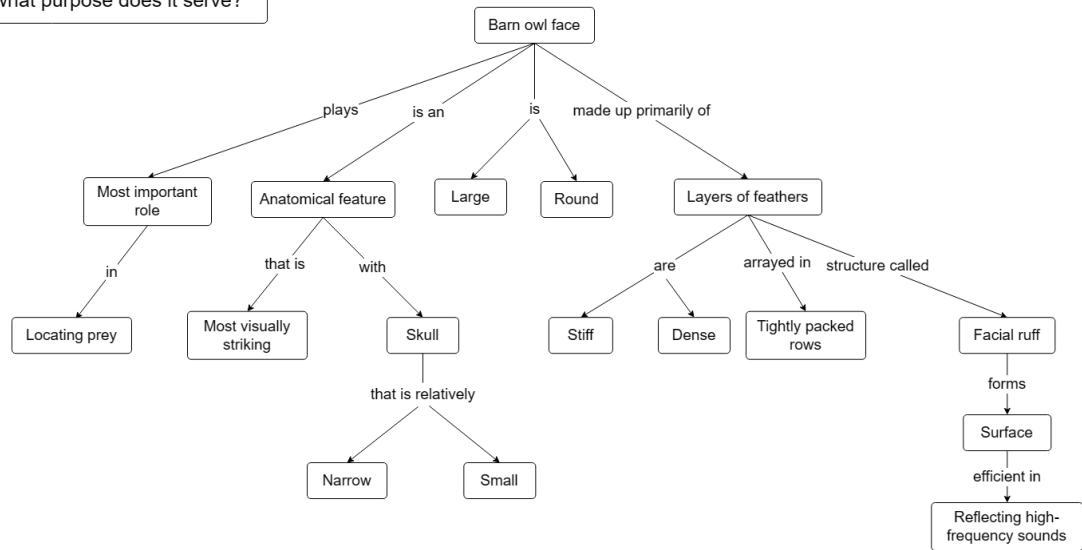


Figure B.4: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - mini-map2

Back to Main Page

Paragraph Title: Horizontal and Vertical Sound Detection

Focus Question: What are barn owls' abilities to detect sound?

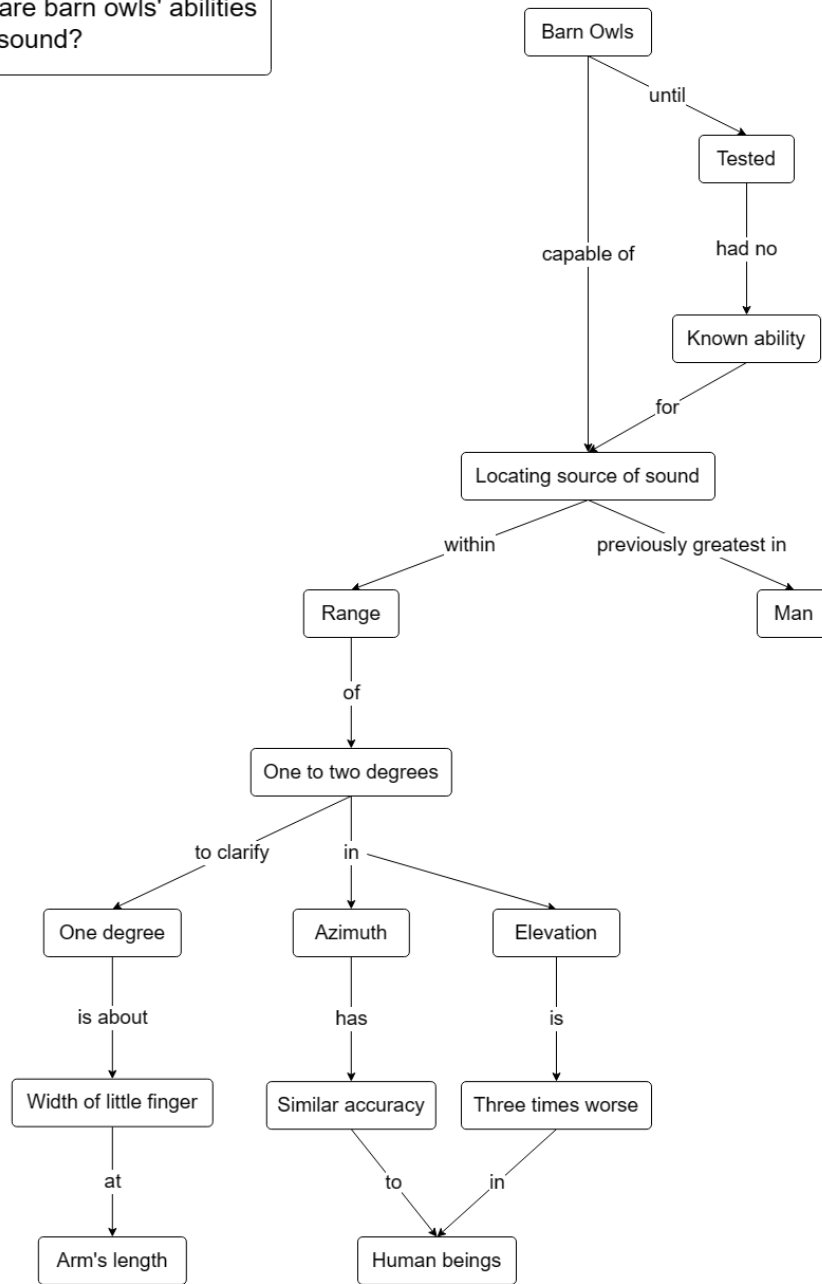


Figure B.5: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - mini-map3

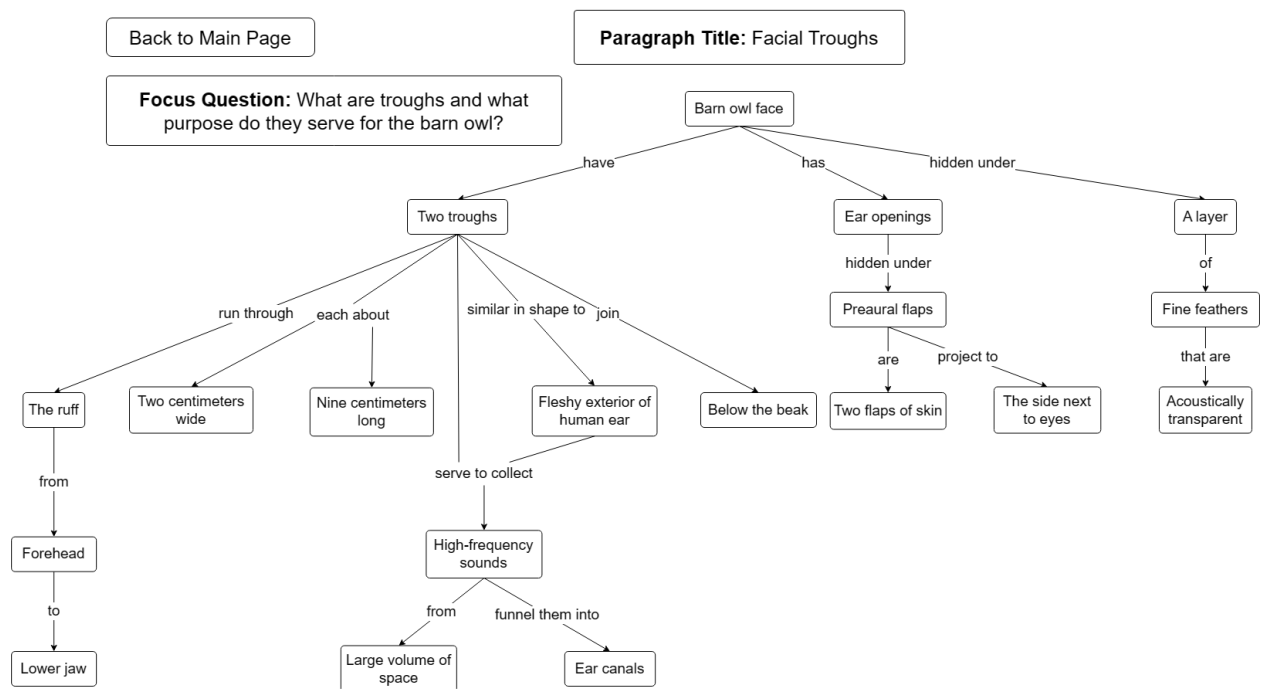


Figure B.6: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - mini-map4

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Paragraph Title: Acuity and Sensitivity to Differences in Sounds

Focus Question: What accounts for barn owls' acuity and sensitivity to differences in loudness?

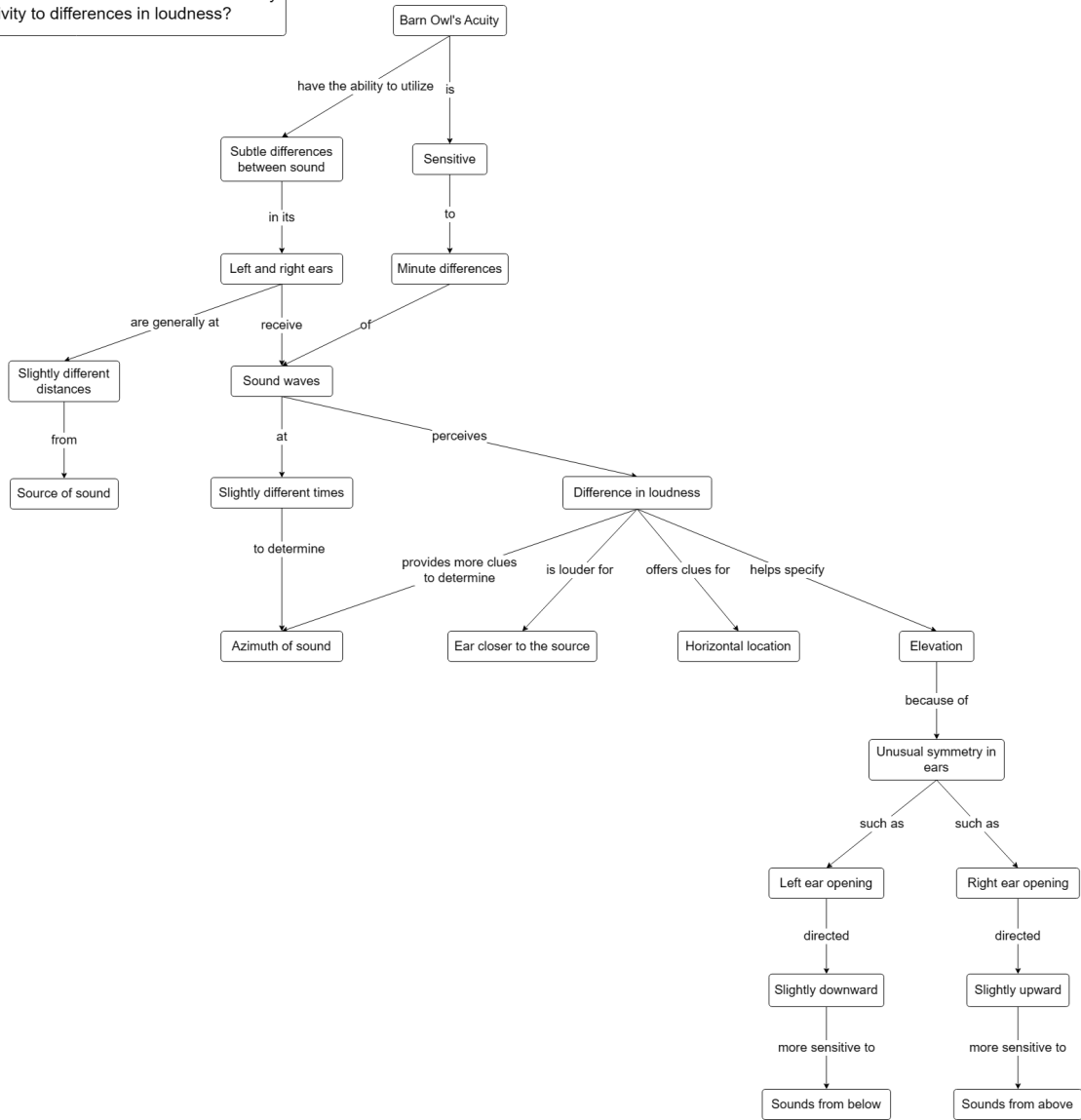


Figure B.7: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - mini-map5

Back to Main Page

Paragraph Title: Neural Interpretation of Differences in Timing and Loudness

Focus Question: How are differences in timing and loudness processed in the brain centers, and how do they assist the barn owl?

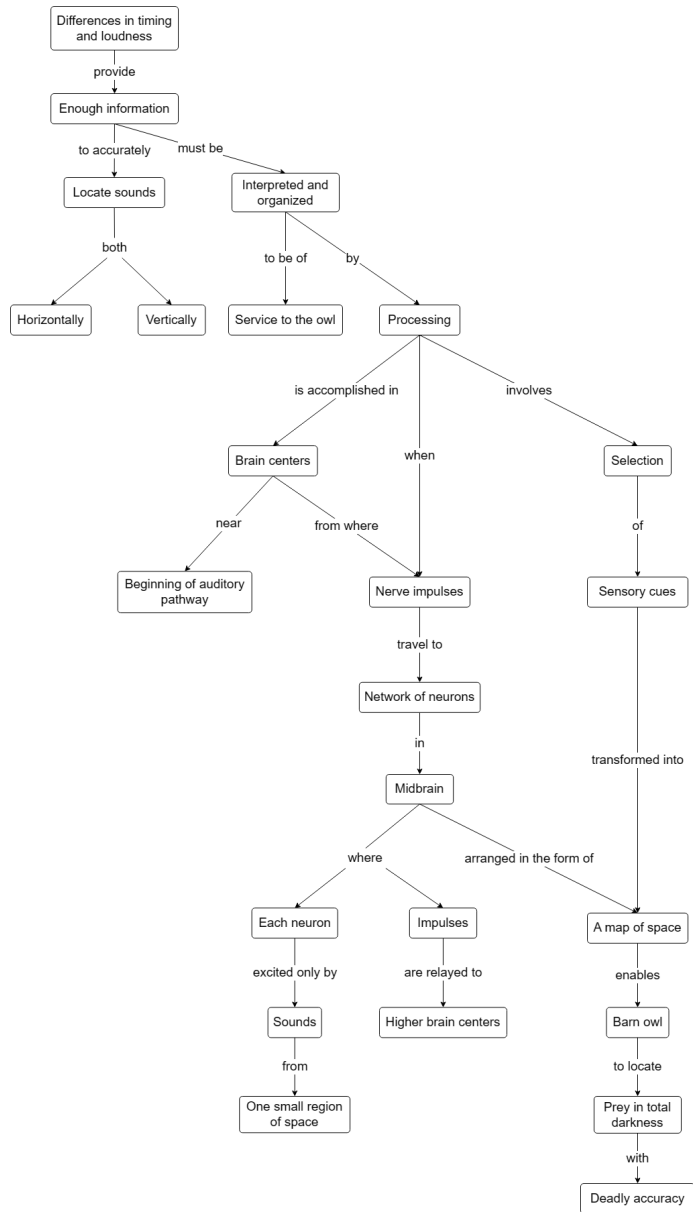


Figure B.8: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - mini-map6

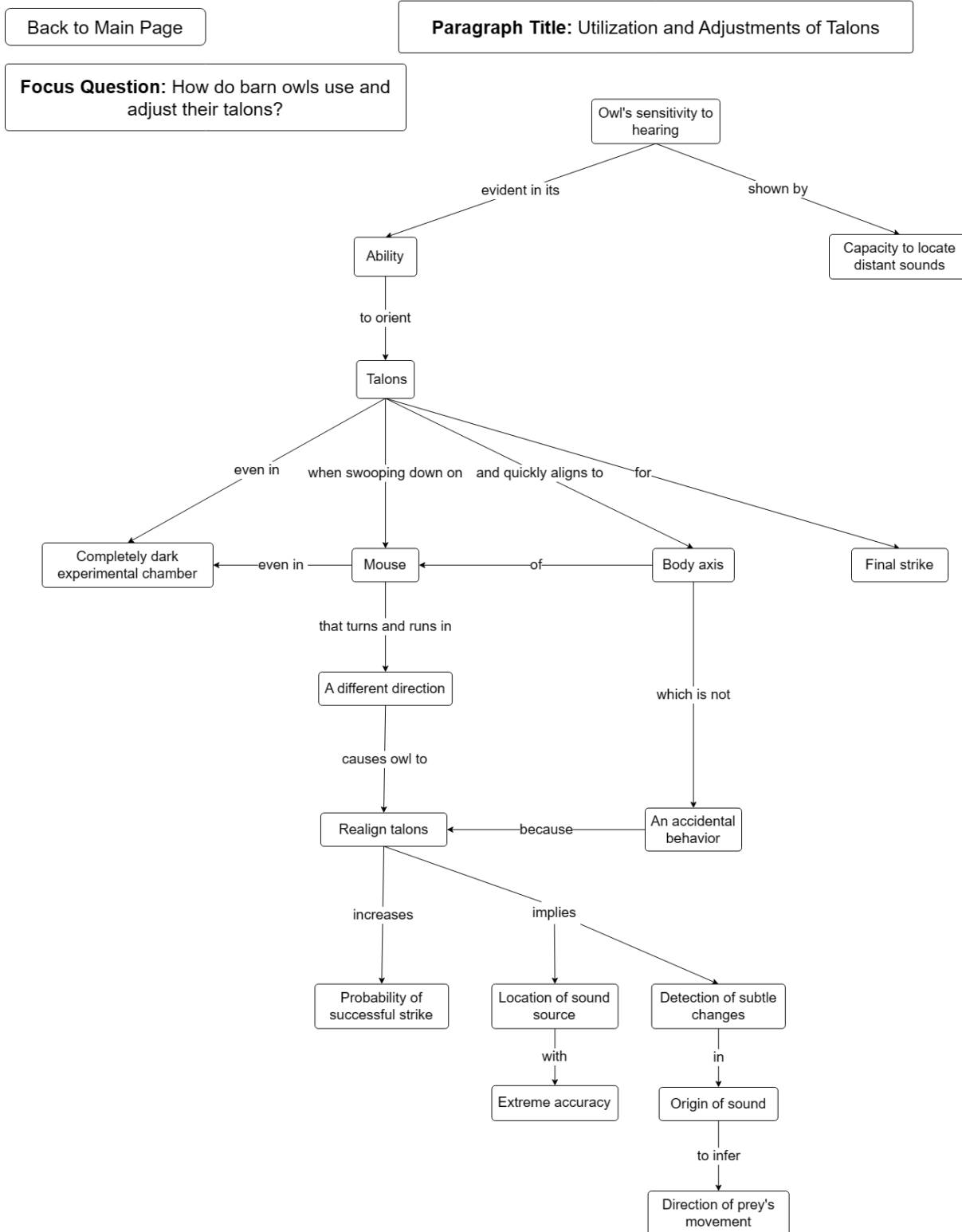


Figure B.9: Passage 1: The Hearing of the Barn Owl in Novakian Knowledge Model (K) condition - mini-map7

B.2.2 Passage 2: The Jaws That Jump

The modified multiple-choice questions used for this passage are as follows:

1. The primary purpose of the passage is to:
 - (a) provide an overview of the mechanics and key operations of the jaws of trap-jaw ants.
 - (b) analyze Patek and Baio’s techniques for filming two defensive maneuvers of trap-jaw ants.
 - (c) compare the jaws of *Odontomachus bauri* to the jaws of other species of ants.
 - (d) describe the evolution of the ability of trap-jaw ants to perform an escape jump.

Question Type: Inferential

2. The phrase “well-defended prey” most nearly refers to prey that:
 - (a) have a hard outer shell.
 - (b) attack with a lethal bite.
 - (c) travel and attack in groups.
 - (d) move quickly.

Question Type: Inferential

3. The passage makes clear that the main source of the speed of the jaws of the trap-jaw ant is the:
 - (a) ease of movement of the hinge of the jaw.
 - (b) continuous, steady firing of the jaw’s mandibles.
 - (c) light weight of the jaw in relation to the ant’s body weight.
 - (d) release of energy stored by muscles of the jaw.

Question Type: Factual

4. The author uses the analogy of trying to grab popcorn as it pops in order to describe the trap-jaw ants’ ability to:
 - (a) generate heat with their jaw movements.
 - (b) move to high ground in order to attack prey.

- (c) attack intruders by tossing them out of the nest.
- (d) bounce around frantically when intruders approach.

Question Type: Inferential

5. The word domain most nearly means:

- (a) living space.
- (b) area of expertise.
- (c) taxonomic category.
- (d) local jurisdiction.

Question Type: Inferential

6. One main purpose of the discussion of the evolution of trap-jaw ants is to suggest that unlike their bouncer-defense jump, the trap-jaw ants' escape jump may have arisen through:

- (a) the ants' trying and failing to bite intruders.
- (b) a change in the structure of the mandibles of several lineages of ants.
- (c) an accidental behavior of the ants.
- (d) the ants' experiencing a positive outcome when they would attack in a large group.

Question Type: Factual

7. The passage points to which of the following as a characteristic of trap-jaw ants' mandibles that prevents the ants from harming themselves with their powerful bite?

- (a) A hinge prevents the mandibles from snapping together forcefully.
- (b) Mandibles with cushioned inner edges provide a buffer when the mandibles snap shut.
- (c) A latch mechanism prevents the mandibles from closing completely.
- (d) The mandibles begin to decelerate before they meet.

Question Type: Factual

8. As described in the passages, one benefit of the trap-jaw ant's escape jump is that it allows an ant to:

- (a) land in position to launch a new attack on a predator.

- (b) confuse a predator with a quick, sudden sting.
- (c) signal to other ants using a predictable movement.
- (d) point itself in whichever direction it chooses to escape.

Question Type: Factual

9. When a trap-jaw ant uses the bouncer-defense jump effectively on an intruder, which creature(s), if any, will be propelled either out of the nest or in another direction?
- (a) the intruder only
 - (b) the attacking ant only
 - (c) the attacking ant and the intruder
 - (d) neither the attacking ant nor the intruder

Question Type: Factual

The following shows the original ACT reading comprehension passage in linear format. This passage was obtained from ACT Practice test 2015 (available at actstudent.org). This passage in Hybrid Map (H) format is shown in Figure B.10. The interactive version that the participants studied through is available [here on Draw.io](http://Draw.io). Its equivalent Novakian concept maps (K) are shown in Figure B.11, Figure B.12, Figure B.13, Figure B.14, Figure B.15, Figure B.16, Figure B.17, and Figure B.18. The interactive version that the participants studied through is available [here on Draw.io](http://Draw.io).

The Jaws That Jump

Recently I was reminded of just how powerful ants can be when inflicting damage on intruders. A team of biomechanists has studied the incredibly speedy bite of a group of Central and South American ants. The team clocked the bite as the fastest on the planet—and discovered that it also gives the ants the unique ability to jump with their jaws, adding to an impressive array of already known defenses.

Trap-jaw ants nest in leaf litter, rather than underground or in mounds. There they often feed on well-armored and elusive prey, including other species of ants. As they stalk their dinner, the trap-jaws hold their mandibles wide apart, often cocked open at 180 degrees or more by a latch mechanism. When minute trigger hairs on the inner edge of the mandible come in contact with something, the jaws snap shut at speeds now known to reach 145 miles per hour. No passerby could outrace that. The astoundingly

high speed gives the jaws, despite their light weight, enough force to crack open the armor of most prey and get at the tasty meat inside.

The key to the jaws' speed (and their even more amazing acceleration) is that the release comes from stored energy produced by the strong but slow muscles of the jaw. Think how an archer slowly draws an arrow in a bowstring against the flex of a bow: nearly all the energy from the archer's muscles pours into the flexing of the bow. When released, the energy stored in the bow wings the arrow toward its target much faster than the archer could by throwing the arrow like a javelin. The biomechanics of energy storage is the domain of Sheila N. Patek and Joseph E. Baio, both biomechanists at the University of California, Berkeley. They teamed up with two ant experts, Brian L. Fisher of the California Academy of Sciences in San Francisco and Andrew V. Suarez of the University of Illinois at Urbana-Champaign, to look at the trap-jaw ant *Odontomachus bauri*.

Fisher, Suarez, and other field biologists had already noted that catching *O. bauri* was like grabbing for popping popcorn—and very hot popcorn at that, because a painful sting goes with an ant's trap-jaw bite. The insects bounced around in a dizzying frenzy and propelled themselves many times their body length when biologists or smaller intruders approached them. Patek and Baio made high-speed video images of their movements, and discovered that the secret of their self-propulsion was the well-executed “firing” of their mandibles. They also observed that mandibles started to decelerate before they meet—possibly to avoid self-inflicted damage. Most important, the ants had two distinct modes of aerial locomotion.

In the so-called escape jump, an ant orients its head and jaws perpendicular to the ground, then slams its face straight down. That triggers the cocked mandibles to release with a force 400 times the ant's body weight, launching the insect ten or more body lengths nearly straight into the air. The ant doesn't seem to go in any particular direction, but the jump is presumably fast and unpredictable enough to help the insect evade, say, the probing tongue of a lizard. Not only can the jumping ant gain height and sow confusion, but it may also get to a new vantage point from which to relaunch an attack.

The second kind of jaw-propelled locomotion is even more common than escape jumping. If an intruder enters the ants' nest, one of the ants bangs its jaws against the intruder, which triggers the trap-jaw and propels the interloper (if small enough) in one direction, out of the nest, and the ant in the other. Often the force sends the ant skimming an inch off the ground for nearly a foot. The attack, for obvious reasons,

is known as the “bouncer defense.” In the wild, gangs of defending ants team up to attack hostile strangers, sending them head over heels out of the nest.

From an evolutionary point of view, the trap-jaws are an intriguing story. The ants clearly evolved an entirely new function, propulsion, for a system that was already useful—chewing up prey. Several lineages of trap-jaw ants have independently hit on the tactic of storing energy in their jaws to penetrate well-defended prey. In *Odontomachus*, the horizontal, bouncer-defense jump could have arisen out of attempts to bite intruders, but the high, escape jump—with jaws aimed directly at the ground—must have arisen from a different, perhaps accidental kind of behavior. Such a serendipitous event would have been a rare instance in which banging one’s head against the ground got good results.

B.2.2.1 Key Phrases and their Boolean Expressions for The Jaws That Jump

1. Key Phrase: Ants inflict damage on intruders powerfully (the author recalled).

- Included Keyword: damag
 - Keyword Alternatives: harm, destruct, ruin, destroy, detrimen, injur, loss, wreck, devastat, spoil, micheif, deterior, break, defac, disrupt, eros, erod, debilitat, wound, hurt, fortun, advers, afflict, inflict, depriv, impact, marr, havoc, blow, trauma, impair, disabl, bruis, maim, fractur, cripl, pain, figur, agon, ail, cut, scratch, weaken, capacitat, stress, lacerat, sprain, dislocat, gash, crush, distort, graz
- Included Keyword: trud
 - Keyword Alternatives: trespass, invad, roach, violat, interlop, one, other, snoop, thing, infiltrat, infring, predator, enem, foreign, alien, out, strang, animal, creature, organism, critter, specie, beast, encounter, meet, ambush, aggr, assail, disrupt, disturb, raid, danger, threat, menac, pest, jeopard, risk, peril, attack, sieg, troubl, intimidat, pursu, thing, life, lives, hostil, visit, guest, antagon, bad, strange
- Included Keyword: power
 - Keyword Alternatives: energy, vital, forc, momentum, potenc, punch, potent, kinetic, strong, strength, might, robust, potent, vigor, formidabl, effect, impact, energ, intens, hard, tough, rough, slam, musc, firm, dynam, solid, resilien, yield

2. Key Phrase: Biomechanists have studied the incredibly speedy bite of trap-jaw ants.

- Included Keyword: biomechan

- Keyword Alternatives: research, scien
 - Included Keyword: bite
 - Keyword Alternatives: chomp, gnaw, gnash, chew, munch, chaw, snap, champ, grind, crunch, crush, masticat, mash, strik, attack, hit, blow, impact
 - Included Keyword: speed
 - Keyword Alternatives: fast, quick, slow, hast, rapid, pac, swift, lag, dawdl, sloth, prompt, snap, optimiz, energ, efficien, effect, complet, proficien, agil, electric, accelerat, dash, flash, sonic, jiffy, brisk, fleet, velocity, celerity, hurr, rush, expedit
3. Key Phrase: Trap-jaw ants are a group of Central and South American ants.
- Included Keyword: Central
 - Keyword Alternatives: South, America
4. Key Phrase: Trap-jaw ants bites are the fastest on the planet (clocked by the team of biomechanists).
- Included Keyword: planet
 - Keyword Alternatives: earth, Earth, world, globe, nature
 - Included Keyword: fast
 - Keyword Alternatives: speed, quick, slow, hast, rapid, pac, swift, lag, dawdl, sloth, prompt, snap, optimiz, energ, effect, complet, proficien, agil, electric, accelerat, dash, flash, sonic, brisk, fleet, expedit, hurr, rush, nipp, immediate, zip, breakneck, whiz, nimbl, light, instant, sudden, pop, spik, stab, velocit, slouch, slug, snail, languid, jiff, celerit, efficien
5. Key Phrase: It was discovered (by researchers) that trap-jaw ants can jump with their jaws.
- Included Keyword: jump
 - Keyword Alternatives: eap, bounc, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampoline, somersault
 - Included Keyword: jaw

- Keyword Alternatives: mouth, bone, maxilla, appendage, limb, protuberance, chop, maw, mandib, pincer
 - Included Keyword: discover
 - Keyword Alternatives: found, cover, identif, detect, discern, unearth, lear, explor, stumb, realiz, encounter, figur, research, examin, stud, analy, explor, quir, investigat, prob, learn, experiment, inquisit, question, test, survey, observ, inspect, view, assess, brainstorm, check, look, ponder, think, reason, reflect, find, data, result, thought, info, discuss, conclu, proce, trial, session, document, know, work, understand, understood, measur, exercis
6. Key Phrase: Trap-jaw ants have the unique ability to jump with their jaws (due to the speed of their bite).
- Included Keyword: jump
 - Keyword Alternatives: leap, bounc, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampolin, somersault
 - Included Keyword: jaw
 - Keyword Alternatives: mouth, bone, maxilla, appendage, limb, protuberance, chop, maw, mandib, pincer
7. Key Phrase: Jumping with their jaws adds to the impressive array of trap-jaw ants' already known defenses.
- Included Keyword: defen
 - Keyword Alternatives: protect, safe, maneuver, aegis, mechan, guard, caution, avoid, measur, tactic, method, mean, techniq, prevent, avert, counter, act, repon, mov, deter, discourag
 - Included Keyword: jump
 - Keyword Alternatives: leap, bounc, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampolin, somersault
 - Included Keyword: jaw

- Keyword Alternatives: mandib, mouth, bone, maxilla, appendage, limb, protuberance, pincer, chop, maw

8. Key Phrase: Trap-jaw ants nest in leaf litter (rather than underground or in mounds).

- Included Keyword: leaf
 - Keyword Alternatives: litter, plant, compos, soil, duff, foliage, leave, organic, greenery, flora, terra, tree, earth, vegetation, herb, shrub, verdure, detritus, humus, peat, mulch, bark, twig
- Included Keyword: nest
 - Keyword Alternatives: burrow, breed, den, lair, hous, home, habit, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, rais, roost, perch, domicile, refug, shelter, abode, snug

9. Key Phrase: Trap-jaw ants feed on well-armored prey.

- Included Keyword: feed
 - Keyword Alternatives: eat, feast, fed, consum, food, meal, grub, snack, sust, nourish, fuel, diet, nutrition, devour, live, subsist, surviv, depend, menu, sat, fill, indulg, energ, sourc, maintain, intake, appetite, tast, crav, hunger, munch, chomp, din, gest, chow, nosh, forag, gobbl
- Included Keyword: armo
 - Keyword Alternatives: protect, shield, fortifi, shell, exoskeleton, resist, guard, secur, plat, cas, mail, cover, bulwark, ward, barr, wall, durab, fort, tough, strong, sturd, tank, heav, robust, built, solid, firm, stiff, cuirass, screen, carapace, panopl, chain, defen, hauberk, gauntlet, casque, helm, aegis, targe, cuisse, metal, steel, iron, bronz, reinforc, support, shelter, pregnable, bastion, immun, fend, sentr, sentinel, resilien, hard, rug, might, power, herculean, burl, stout, tenaci, penetra, vulnerab, domitab, yield, formid, brawn, bulk, beef, vincib, exorab, assail, potent
- Included Keyword: prey
 - Keyword Alternatives: specie, ant, animal, creature, organism, critter, insect, bug, vermin, life, beast, pest, crawl, worm, flies, spider, beetle, termite, arachnid, food, quarr, target, game

10. Key Phrase: Trap-jaw ants feed on elusive prey.

- Included Keyword: feed
 - Keyword Alternatives: eat, feast, fed, consum, food, meal, grub, snack, sust, nourish, fuel, diet, nutrition, devour, live, subsist, surviv, depend, menu, sat, fill, indulg, energ, sourc, maintain, intake, appetite, tast, crav, hunger, munch, chomp, din, gest, chow, nosh, forag, gobbl
- Included Keyword: elus
 - Keyword Alternatives: evasiv, trick, sneak, deceive, slip, sly, cunning, wily, wili, devious, shrewd, cautio, vigil, shift, mislead, catch, grasp, pin, fugitive, captur, escap, elud, deceit, slick, tangib, enigma, attain, access, flee, vague, cryptic, myster, clandestine, stealth, camo, hid, conspicu, mysti, puzzl, hazy, hazi, obscur, ambigu, dodg, deft, find, found, trac, clever, craft, secret, covert, furtive, obtrusive, subtle, quiet, cognito, surreptitious, undercover, discreet, conceal, priv, hush, shroud, guile, espionage, shadow, dupe, wit, disgui, dupi, bamboozl, hoodwink, swindl, delud
- Included Keyword: prey
 - Keyword Alternatives: specie, ant, animal, creature, organism, critter, insect, bug, vermin, life, beast, pest, crawl, worm, flies, spider, beetle, termite, arachnid, food, quarr, target, game

11. Key Phrase: Trap-jaw ants feed on other species of ants.

- Included Keyword: feed
 - Keyword Alternatives: eat, feast, fed, consum, food, meal, grub, snack, sust, nourish, fuel, diet, nutrition, devour, subsist, surviv, depend, menu, sat, fill, indulg, sourc, maintain, intake, appetite, tast, crav, hunger, munch, chomp, din, gest, chow, nosh, forag, gobbl
- Included Keyword: ant
 - Keyword Alternatives: cannibal, species, formicidae, insect

12. Key Phrase: Trap-jaw ants stalk their dinner (prey).

- Included Keyword: stalk
 - Keyword Alternatives: follow, track, pursue, chase, shadow, creep, hunt, trail, after, seek, ambush, prowl, tail, sneak

- Included Keyword: prey
 - Keyword Alternatives: victim, target, specie, ant, animal, creature, organism, critter, insect, bug, vermin, life, beast, pest, crawl, worm, flies, spider, beetle, termite, arachnid, food, quarr, target, game
13. Key Phrase: Trap-jaw ants hold their mandibles wide apart, often at 180 degrees.
- Included Keyword: mandib
 - Keyword Alternatives: jaw, mouth, bone, maxilla, appendage, limb, protuberance, chop, maw, pincer
 - Included Keyword: wide
 - Keyword Alternatives: 180, eighty, angle, degree
14. Key Phrase: Mandibles are cocked open by a latch mechanism.
- Included Keyword: mandib
 - Keyword Alternatives: jaw, mouth, bone, maxilla, appendage, limb, protuberance, pincer, chop, maw
 - Included Keyword: cock
 - Keyword Alternatives: slant, angle, tilt, incline, pitch, bend, cant, camber, set, tip, pull, set, prepar, position, open, prim
 - Included Keyword: latch
 - Keyword Alternatives: fasten, secure, lock, bolt, hitch, catch, clasp, hook, clamp, clench, grip, hold, connect
15. Key Phrase: Jaw snaps shut after minute trigger hairs on the mandible come in contact with something.
- Included Keyword: jaw
 - Keyword Alternatives: mouth, bone, maxilla, appendage, limb, protuberance, chop, maw, pincer, mandib
 - Included Keyword: snap
 - Keyword Alternatives: bite, shut, swing, pinch, clamp, shoot, launch, together, lock, seal, slam, clasp, tighten, clos, accelerat

- Included Keyword: trigger
 - Keyword Alternatives: prompt, off, stir, spark, hair, provok, stimulat, intiat, activat, generat, kindl, rous, excit, react, trip, engag, spark, releas

16. Key Phrase: Jaws snap shut at speeds now known to reach 145 miles per hour.

- Included Keyword: jaw
 - Keyword Alternatives: mandib, jaw, mouth, bone, maxilla, appendage, limb, protuberance, pincer, chop, maw, bite, chomp, snap, shut, clench
- Included Keyword: 145
 - Keyword Alternatives: over, about, around, between, near, five, rough, park, mph, 100, 11, 12, 13, 14, 15, 16, 17, 18, 19, reach, above, high, upward, past, beyond, exceed, proxim, almost, circa, border, neighbor, vicinit, ballpark

17. Key Phrase: No passerby can outrace that astoundingly high speed of their (trap-jaw ants') jaws.

- Included Keyword: race
 - Keyword Alternatives: pass, out, exceed, beyond, past, conte, fight, rival, match, transcend, sur, meet, beat, defeat, top, best, triumph, trump, compet, challeng, fac, tak, eclips, strip, win, los, won
- Included Keyword: jaw
 - Keyword Alternatives: mandib, mouth, bone, maxilla, appendage, limb, protuberance, pincer, chop, maw
- Included Keyword: speed
 - Keyword Alternatives: fast, quick, slow, hast, rapid, pac, swift, lag, dawdl, sloth, prompt, snap, optimiz, energ, effect, complet, proficien, agil, electric, accelerat, dash, flash, sonic, brisk, fleet, expedit, hurr, rush, nipp, immediate, zip, breakneck, whiz, nimbl, light, instant, sudden, pop, spik, stab, velocit, slouch, slug, snail, languid, jiff, celerit, efficien

18. Key Phrase: Jaws have enough force to crack open the armor of most prey (to reach the meat inside despite their light weight).

- Included Keyword: crack

- Keyword Alternatives: break, destroy, crush, beat, trump, crumbl, mash, quash, fractur, shatter, tear, shred, minc, pop, ruptur, split, demolish, disintergrat, bust, snap, splinter, nullify, crunch, burst, open, pry, pop, cleav, penetrat, punctur, spear, stab, jab, impal, bayonet, drill, permeat, pierc, cut, clamp, perforat, prob, bore, sink, knif, prick, thrust, pervad, bite, biting, chomp, gnaw, gnash, chew, munch, chaw, snap, champ, grind, crunch, crush, masticat, mash, strik, attack, hit, blow, impact
- Included Keyword: armo
 - Keyword Alternatives: protect, shield, fortifi, shell, exoskeleton, resist, guard, secur, plat, cas, mail, cover, bulwark, ward, barr, wall, durab, fort, tough, strong, sturd, tank, heav, robust, built, solid, firm, stiff, cuirass, screen, carapace, panopl, chain, defen, hauberk, gauntlet, casque, helm, aegis, targe, cuisse, metal, steel, iron, bronz, reinforc, support, shelter, pregnable, bastion, immun, fend, sentr, sentinel, resilien, hard, rug, might, power, herculean, burl, stout, tenaci, penetra, vulnerab, domitab, yield, formid, brawn, bulk, beef, vincib, exorab, assail, potent
- Included Keyword: jaw
 - Keyword Alternatives: mandib, mouth, bone, maxilla, appendage, limb, protuberance, chop, maw, pincer

19. Key Phrase: Trap-jaw ants store energy in their jaws.

- Included Keyword: energy
 - Keyword Alternatives: power, strength, vital, might, forc, momentum, potenc, punch, vigor, intens, potent, kinetic
- Included Keyword: jaw
 - Keyword Alternatives: mandib, mouth, bone, maxilla, appendage, limb, protuberance, pincer, chop, maw
- Included Keyword: stor
 - Keyword Alternatives: reserv, hoard, sav, secur, deposit, gather, stock, stash, conserv, cach, cumulat, suppl, collect, mass, hold, retain, carry, carri, keep, surg, stream, spik, expan, hous, stow, maintain

20. Key Phrase: Energy release from strong but slow muscles is the key for the jaw's speed (and acceleration).

- Included Keyword: energy
 - Keyword Alternatives: power, strength, vital, might, forc, momentum, potenc, punch, vigor, intens, potent, kinetic
- Included Keyword: muscle
 - Keyword Alternatives: strong
- Included Keyword: speed
 - Keyword Alternatives: fast, quick, slow, hast, rapid, pac, swift, lag, dawdl, sloth, prompt, snap, optimiz, energ, effect, complet, proficien, agil, electric, accelerat, dash, flash, sonic, brisk, fleet, expedit, hurr, rush, nipp, immediate, zip, breakneck, whiz, nimbl, light, instant, sudden, pop, spik, stab, velocit, slouch, slug, snail, languid, jiff, celerit, efficien

21. Key Phrase: The energy stored in trap-jaw ants' jaws are similar to an archer drawing an arrow in a bowstring against the flex of a bow.

- Included Keyword: energy
 - Keyword Alternatives: power, strength, vital, might, forc, momentum, potenc, punch, vigor, intens, bow, string, arrow, javelin

22. Key Phrase: Nearly all the energy from the archer's muscles pours into the flexing of the bow.

- Included Keyword: energ
 - Keyword Alternatives: vital, forc, momentum, potenc, punch, potent, kinetic, strong, strength, might, robust, potent, vigor, formidabl, effect, impact, intens, hard, tough, rough, slam, musc, firm, dynam, solid, resilien, yield, power
- Included Keyword: muscle
 - Keyword Alternatives:
- Included Keyword: bow
 - Keyword Alternatives: string

23. Key Phrase: Archers use bowstring to shoot an arrow toward its target faster than throwing the arrow like a javelin.

- Included Keyword: bow
 - Keyword Alternatives: string
 - Included Keyword: javelin
 - Keyword Alternatives: spear, harpoon, lance
24. Key Phrase: Key Phrase: Sheila N. Patek is a biomechanist at the University of California, Berkeley.
- Included Keyword: Sheila N. Patek
 - Keyword Alternatives: Sheila, Patek, Berkeley, University, UCB, Cal
25. Key Phrase: Joseph E. Baio is a biomechanist at the University of California, Berkeley.
- Included Keyword: Joseph E. Baio
 - Keyword Alternatives: Joseph, Baio, Berkeley, University, UCB, Cal
26. Key Phrase: Sheila N. Patek and Joseph E. Baio are experts in the biomechanics of energy storage.
- Included Keyword: Sheila N. Patek
 - Keyword Alternatives: Sheila, Patek, Joseph, Baio, Joseph
 - Included Keyword: energy storage
 - Keyword Alternatives:
27. Key Phrase: Two biomechanists teamed up with two ant experts to look at trap-jaw ants.
- Included Keyword: bio
 - Keyword Alternatives: mech, expert, Brian, Fisher, Sheila, Patek, Joesph, Baio, University, California, San, Fran, Andrew, Suarez, Illinois, Urbana, Champaign, scien, Calif, Academ, profess, research, special, adept, skill, guru, maven, virtuos, master, practi
 - Included Keyword: two
 - Keyword Alternatives: 2, four, 4

28. Key Phrase: Brian L. Fisher of the California Academy of Sciences in San Francisco is an ant expert.
- Included Keyword: Brian L. Fisher
 - Keyword Alternatives: Brian, Fisher, SF, Cal, Academy
29. Key Phrase: Andrew V. Suarez of the University of Illinois at Urbana-Champaign is an ant expert.
- Included Keyword: Andrew V. Suarez
 - Keyword Alternatives: Andrew, Suarez, UIUC, Illinois, University
30. Key Phrase: Trap-jaw ants are known as *Odontomachus bauri*.
- Included Keyword: *Odontomachus bauri*
 - Keyword Alternatives: O., bauri
31. Key Phrase: Catching *O. bauri* (trap-jaw ants) is like grabbing for popping hot popcorn (as noted by field biologists).
- Included Keyword: catch
 - Keyword Alternatives: grab, captur, tak, snag, bag, trap, clutch, clench, snatch, detain, hold, carry, confin, secur, hang, snar, seiz, grasp, apprehend, net, nab, hook
 - Included Keyword: popcorn
 - Keyword Alternatives: pop-corn, pop
32. Key Phrase: Painful sting goes with an ant's trap-jaw bite (as noted by field biologists).
- Included Keyword: sting
 - Keyword Alternatives: prick, pierce, punctur, stab, burn, pain, tingl, sore, irritat, afflict, sens, throb, ach
 - Included Keyword: bite
 - Keyword Alternatives: chomp, gnaw, gnash, chew, munch, chaw, snap, champ, grind, crunch, crush, masticat, mash, strik, attack, hit, blow, impact
33. Key Phrase: The insects (trap-jaw ants) bounced around in a dizzying frenzy.

- Included Keyword: frenz
 - Keyword Alternatives: activ, Fur, craz, frantic, hyst, commotion, turm, agitat, excit, frenetic, fur, disturb, chao, mad, insane, fever
- Included Keyword: bounc
 - Keyword Alternatives: bounc, prop, launch, jump, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, project, cast, heav, hop, avanc, progress, vault, push, forc, fly, flie, send, sent, flown, blow, soar, blew, shot, shoot, punt, went, flew, thrust, jump, leap, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampoline, somersault

34. Key Phrase: Trap-jaw ants propel themselves many times their body length.

- Included Keyword: prop
 - Keyword Alternatives: launch, jump, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, fly, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, bounc, project, cast, heav, hop, avanc, progress, vault, push, forc, fly, flie, send, sent, flown, blow, soar, blew, shot, shoot, punt, went, flew, thrust, body, length

35. Key Phrase: Trap-jaw ants jump when biologists or smaller intruders approach them.

- Included Keyword: jump
 - Keyword Alternatives: startl, prop, launch, jump, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, fly, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, bounc, project, cast, heav, hop, avanc, progress, vault, shock, surpris, stun, other, scar, agitat, alarm, flinch, spook, fright, near
- Included Keyword: biol
 - Keyword Alternatives: intrud, scientist, approach, invad, trespass, unwelcome, interlop, interfer, intercept, uninvit, crash, burglar, perpetr, infiltrat, raid, meddl, nuisanc, snoop, obrud, visit, unwanted, interrupt, annoy, pest, conven, irrita, troubl, terror, bother, panic, fear, dread, concern, content, shock, surpris, stun, other, scar, agitat, alarm, flinch, spook, fright, near, flie, flie, proxim, startl, clos, other, vicin, within, along, neighbor, reach

36. Key Phrase: Researchers (Patek and Baio) made high-speed video images to discover the secret of trap-jaw ants' self-propulsion.

- Included Keyword: video
 - Keyword Alternatives: record, camera, software, tap, media, imag, film, movie, footage, visual, flick, clip

37. Key Phrase: Secret of trap-jaw ants' self-propulsion is the well-executed “firing” of their mandibles (as discovered by Patek and Baio).

- Included Keyword: mandib
 - Keyword Alternatives: jaw, mouth, bone, maxilla, appendage, limb, protuberance, pincer, chop, maw
- Included Keyword: prop
 - Keyword Alternatives: prop, launch, jump, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, bounc, project, cast, heav, hop, advanc, progress, vault, push, flew, fly, flie, sent, sprang, flown, blow, soar, blew, shot, went, punt, threw, sprung, drov

38. Key Phrase: Trap-jaw ants' mandibles started to decelerate before they meet (as observed by Patek and Baio).

- Included Keyword: decelerat
 - Keyword Alternatives: slow, stop, brak, halt, slack, less, declin, drop, speed, ebb, moment, minim, rate, down, velocit, accelerat, decreas, reduc
- Included Keyword: mandib
 - Keyword Alternatives: jaw, mouth, bone, maxilla, appendage, limb, protuberance, pincer, chop, maw

39. Key Phrase: Deceleration of mandibles possibly helps to avoid self-inflicted damage (as observed by Patek and Baio).

- Included Keyword: decelerat
 - Keyword Alternatives: low, stop, brak, halt, slack, less, declin, drop, speed, ebb, moment, minim, rate, down, velocit, accelerat, decreas, reduc

- Included Keyword: mandib
 - Keyword Alternatives: jaw, mouth, bone, maxilla, appendage, limb, protuberance, pincer, maw, chop
- Included Keyword: damag
 - Keyword Alternatives: injur, harm, wound, pain, hurt, ruin, impair, accident, debilitat, destr, wreck, los, mar, trauma, suffer, strong, health, safe, ab, intact, poor, good, weak, degrad, deteriorat, diminish, afflict, bad, disorder, disfigur, hard, mishap, problem, fail, issue, danger, incident, complicat, break, troubl

40. Key Phrase: Trap-jaw ants have two distinct modes of aerial locomotion (as observed by Patek and Baio).

- Included Keyword: 2
 - Keyword Alternatives: two, another, one, first, second
- Included Keyword: locomot
 - Keyword Alternatives: aer, air, prop, launch, jump, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, fly, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, bounc, project, cast, heav, hop, advanc, progress, vault, threw, sprang, sprung, flie, drov, sent, flew, shot, flown, distinct, strat, mode, way, type, kind, mechanism, style, mean, method, technique, action, form, operation, option, strateg, tactic, manuever, scheme, conduct, manner, performanc, gestur, respon, behav, protocol, approach, process, fashion, modus, operandi, procedure, routine, custom, medium, avenue, route, channel, system, practic, course, path

41. Key Phrase: In the escape jump, an ant orients its head and jaws perpendicular to the ground.

- Included Keyword: escape jump
 - Keyword Alternatives: defen, protect, safe, maneuver, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert
- Included Keyword: perpendicular
 - Keyword Alternatives: head, jaw, vertical, orthogonal, 90, degree, 90-degree, normal

42. Key Phrase: In the escape jump, trap-jaw ants slam their face straight down.

- Included Keyword: escape jump
 - Keyword Alternatives: defen, protect, safe, maneuver, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert
- Included Keyword: slam
 - Keyword Alternatives: fac, bang, head, boom, crack, pound, smack, smash, crash, bash, hit, strik, bump, thud, clang, clatter, wallop, whack, wham, knock, ram, thrash, impact, thump, beat, colli, swat, clobber, bonk

43. Key Phrase: In the escape jump, cocked mandibles are released with a force 400 times the ant's body weight.

- Included Keyword: escape jump
 - Keyword Alternatives: defen, protect, safe, maneuver, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert
- Included Keyword: 400
 - Keyword Alternatives: hundred, force, str, power, energy, might, momentum, vigor, intens, pressure, exert, potenc, punch, kick, bit, chomp, gnaw, gnash, chew, munch, chaw, snap, champ, grind, crunch, crush, masticat, mash, strik, shut, clos, clamp, pinch, ground
- Included Keyword: weight
 - Keyword Alternatives: mass, pound
- Included Keyword: mandib
 - Keyword Alternatives: jaw, mouth, bone, maxilla, appendage, limb, protuberance, pincer, maw, chop, catapult, fling, sling, forc, driv, lung, fir, blast, eject, spring, leap, hurl, bound, skip, bounc, project, cast, heav, hop, advanc, progress, vault, push, forc, fly, flie, send, sent, flown, blow, soar, blew, punt, went, flew, thrust, threw, shot, sprung, drov, launch, prop, throw, jump, sprang

44. Key Phrase: Escape jump launches the insect (trap-jaw ant) ten or more body lengths nearly straight into the air.

- Included Keyword: ten

- Keyword Alternatives: 10, big, huge, immense, large, long, soaring, steep, tremendous, giant, grand, altitudinous, colossal, eminent, formidable, gigantic, towering, uplifted, upraised, high, sky, elevat, height, magnitude, range, space, span, stretch, ranginess, elongat, expans, extensive, length, loft, tall, protract

- Included Keyword: jump

- Keyword Alternatives: jump, bounce, prop, launch, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, project, cast, heav, hop, advanc, progress, vault, push, fly, flie, sent, flown, soar, blew, shot, punt, went, hur, ricochet, boomerang, recoil, lop, lob, rocket, pogo, yeet, trampolin, somersault, threw, sprung, sprang, drov

45. Key Phrase: During the escape jump, the ant doesn't seem to go in any particular direction.

- Included Keyword: escape jump

- Keyword Alternatives: defen, safe, maneuver, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert

- Included Keyword: direct

- Keyword Alternatives: locat, plac, area, way, course, trajector, position, spot, mark, path, point, line, end, track, region, angl, side, left, right, forward, back, front, else, apart, lateral, site, zone, sect, orient, arrang, locale, quarter, territor, vector, altitude, route, aspect

- Included Keyword: particular

- Keyword Alternatives: specif, special, unique, distinct, individual, peculiar, singl, singu, exclus, precis, concret, exact, detail, characteristic, identi, common, select, certain, explicit, defin, usual, notab, personal, idiosyncra, identif, clear, obvious, eviden, apparent, plain, manifest, transparen, notic, blatant, conspicuous, palpable, overt, simpl, recogni, random, haphazard, arbitrar, chanc, predict, system, casual, accident, regular, order, plan, discriminat, fortuit, expect, sequen, scatter, general,

universal, generic, collect, compass, broad, vague, overall, inclusiv, exclusiv, comprehens, standard, convention, ordinar, routin, typical, averag, widespread, global, ambigu, miscellan, approx, limit, restrict, shar, public, normal

46. Key Phrase: Escape jump is presumably fast.

- Included Keyword: escape jump
 - Keyword Alternatives: defen, protect, safe, maneuv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert
- Included Keyword: fast
 - Keyword Alternatives: speed, quick, slow, hast, rapid, pac, swift, lag, dawdl, sloth, prompt, snap, optimiz, energ, effect, complet, proficien, agil, electric, accelerat, dash, flash, sonic, brisk, fleet, expedit, hurr, rush, nipp, immediate, zip, breakneck, whiz, nimbl, light, instant, sudden, pop, spik, stab, velocit, slouch, slug, snail, languid, jiff, celerit, efficien

47. Key Phrase: Escape jump is presumably unpredictable.

- Included Keyword: escape jump
 - Keyword Alternatives: defen, protect, safe, maneuv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert
- Included Keyword: predict
 - Keyword Alternatives: fluctuat, capricious, chang, volatil, consisten, spontan, var, regula, reliab, sporadic, normal, crazy, insan, eccentric, strange, unusual, foresee, foresight, certain, erratic, stabl, stabi, fickl, whim, regular, control, chao, arbitrar, rely, reli, tumult, anticipat, prompt, plan, chanc, random, expect, haphazard, precis, determin, quixotic, turbulen, constant, calcul, stead, depend, order, set, secur, fix, method, system

48. Key Phrase: Escape jump helps the insect evade threats (ex. probing tongue of a lizard).

- Included Keyword: escape jump

- Keyword Alternatives: defen, protect, safe, maneuv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert
- Included Keyword: eva
 - Keyword Alternatives: dodge, threat, away, escap, avoid, elud, flee, sidestep, clear, lose, shake, slip, distanc, past, ditch, sneak, vanish, beat, scam, danger, risk, peril, hazard, warn, vulnerab, troubl, susceptib, certain, concern, suspici, predict, worr, hesistat, contingen, disturb, convenienc, predicament, problem, struggl, suffer, strain, difficult, hard, agita, burden, eas, fear, prevent, depart, retreat, intrud, trespass, attack, dea, predator

49. Key Phrase: Escape jump helps the ants gain height.

- Included Keyword: escape
 - Keyword Alternatives: jump
- Included Keyword: height
 - Keyword Alternatives: high, elevat, above, vertic, zenith, peak, altitude, ascen, rise, upward, top, summit

50. Key Phrase: Escape jump helps the ants sow confusion.

- Included Keyword: escape jump
 - Keyword Alternatives: defen, protect, safe, maneuv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert
- Included Keyword: sow
 - Keyword Alternatives: confus, plant, grow, propagat, build, rais, develop, establish, cultivat, extend, wide, stretch, expand, large, swell, increase, bolst, morph, shape, mend, mutat, invit, boost, augment, promot, set, elevat, bring, shov, plac, amplif, magnif, intens, orient, distract, concern, suspici, worr, hesistat, contingen, disturb, convenienc, predicament, problem, struggl, strain, difficult, hard, agita, burden, complicat

51. Key Phrase: Escape jump helps the ant get to a new vantage point to relaunch an attack.

- Included Keyword: jump
 - Keyword Alternatives: bounc, prop, launch, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, project, cast, heav, hop, advanc, progress, vault, push, forc, fly, flie, send, sent, flown, blow, soar, blew, shot, shoot, punt, went, flew, thrust, leap, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampoline, somersault, escap, flee, away, avoid, eva, run, retreat, evac, withdraw
- Included Keyword: attack
 - Keyword Alternatives: chomp, gnaw, gnash, chew, munch, chaw, snap, champ, grind, crunch, crush, masticat, mash, strik, bite, hit, blow, impact, vantage, view, angle, orient, point, refer, way, locat, plac, position, stanc, stand, perspective, aspect, direct, outlook, spot, mark, look, aim, lead, method, manner, proce, avenue, operat, cours, approach, technique, arrang, rout, path, plan, plot, construct, creat, assault, blitz, barrag, offens, charg, bombard, pelt, storm, rain

52. Key Phrase: The bouncer-defense jump (jaw-propelled locomotion) is more common than the escape-jump.

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, maneuv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: common
 - Keyword Alternatives: often, frequen, more, usual, likel, probab, consisten, typical, tim, less, rar, scarc, regular, custom, recur, occasion, most, few, normal, ordinar, hard, main, proportion, bare, little, primar, abundant, small, large, much, low, high, reduc, lack, min, max, substantial, limit, great, again, over, ever, period, system, routine, always, never, religious, faith, instead, oppos, compar, contrast, prefer, opt, choos, go-to, goto, first, last, second, wide, prevalen, popular, standard, averag, general, recurren, habit, tradition, univers, exploit, exercis, deploy,

harness, access, implement, leverag, secondar, convention, ubiquit, familiar, public

- Included Keyword: escape jump
 - Keyword Alternatives: defen, protect, safe, maneu, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, eva, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert

53. Key Phrase: Bouncer-defense jump is done when an intruder enters the trap-jaw ants' nest.

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, maneu, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: trud
 - Keyword Alternatives: trespass, invad, roach, imping, violat, want, interlop, enter, snoop, sneak, welcom, infiltrat, infring, prowl, predator, enem, foreign, alien, out, strang, com, invit, animal, creature, organism, critter, specie, beast, break, crash, barg, close, encounter, stumbl, bump, meet, ambush, contact, face, find, see, disrupt, disturb, breach, broke, burgl, force, raid, sack, danger, threat, menac, pest, jeopard, risk, peril, stack, attack, sieg, troubl, harass, intimidat, pursu, one, other, thing, life

54. Key Phrase: For bouncer-defense jump, one of the ants bangs its jaws against the intruder (if an intruder enters the ants' nest).

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, maneu, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: jaw

- Keyword Alternatives: mandible, mouth, bone, maxilla, appendage, limb, protuberance, pincer, maw, chop
- Included Keyword: trud
 - Keyword Alternatives: trespass, invad, roach, violat, interlop, snoop, ingiltrat, infringing, predator, enem, foreign, alien, out, strang, animal, creature, organism, critter, specie, beast, encounter, meet, ambush, contact, find, disrupt, disrupt, raid, danger, threat, menac, pest, jeopard, risk, peril, attack, sieg, troubl, intimidat, pursu, one, other, thing, life, lives, hostil, aggr, assail, visit, guest, antagon, bad

55. Key Phrase: Banging jaws against the intruder triggers the trap-jaw.

- Included Keyword: trap
 - Keyword Alternatives: jaw, mouth, bone, maxilla, appendage, limb, protuberance, maw, chop, mandib, pinc
- Included Keyword: trigger
 - Keyword Alternatives: prompt, off, stir, spark, provo, bring, caus, start, elicit, provok, stimulat, initiat, activat, generat, kindl, rous, excit
- Included Keyword: trud
 - Keyword Alternatives: trespass, invad, roach, violat, interlop, one, other, snoop, thing, infiltrat, infringing, predator, enem, foreign, alien, out, strang, animal, creature, organism, critter, specie, beast, encounter, meet, ambush, contact, find, disrupt, disturb, raid, danger, threat, menac, pest, jeopard, risk, peril, attack, sieg, troubl, intimidat, pursu, one, other, thing, life, lives, hostil, aggr, assail, visit, guest, antagon, bad

56. Key Phrase: Bouncer-defense jump propels the interloper (if small enough) in one direction, out of the nest.

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, maneuver, mechan, guard, measure, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist

- Included Keyword: direct
 - Keyword Alternatives: locat, plac, area, way, course, trajector, position, spot, mark, path, point, line, end, track, region, angl, side, left, right, forward, back, front, else, apart, lateral, site, zone, sect, orient, arrang, locale, quarter, territor, vector, altitude, route, aspect
- Included Keyword: trud
 - Keyword Alternatives: trespass, invad, roach, imping, violat, want, interlop, enter, snoop, sneak, welcom, infiltrat, infring, prowl, predator, enem, foreign, alien, out, strang, com, invit, animal, creature, organism, critter, specie, beast, break, crash, barg, close, encounter, stumbl, bump, meet, ambush, contact, face, find, see, disrupt, disturb, breach, broke, burgl, force, raid, sack, danger, threat, menace, pest, jeopard, risk, peril, stack, attack, sieg, troubl, harass, intimidat, pursu, one, other, thing, life, hostil, aggr, assail, visit, guest, antagon, bad

57. Key Phrase: Bouncer-defense jump propels the ant in the other direction, away from the interloper.

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, manouv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: prop
 - Keyword Alternatives: bounc, jump, launch, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, project, cast, heav, hop, avanc, progress, vault, push, forc, fly, flie, send, sent, flown, blow, soar, blew, shot, shoot, punt, went, flew, thrust, jump, leap, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampolin, somersault, displac
- Included Keyword: other
 - Keyword Alternatives: oppos, differ, left, right, forward, back, front, seperat, alt, vers, cross, counter, rear, contra, polar, out, away

58. Key Phrase: Bouncer defense jump often sends the ant an inch off the ground (vertical).

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, manouv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: inch
 - Keyword Alternatives: cm, centimeter, ' ', abov, off, mm, meter, vertical, axis, 1in

59. Key Phrase: Bouncer defense jump often sends the ant nearly a foot away (horizontal).

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, manouv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: foot
 - Keyword Alternatives: inch, meter, ' ', cm, horizon, axis

60. Key Phrase: The attack is known as the “bouncer defense” for obvious reasons.

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc
- Included Keyword: obvious
 - Keyword Alternatives: clear, eviden, apparent, plain, transparen, manifest, mistak, observ, recogni, notic, patent, palpable, deni, deny, blatant, visib, overt, conspicuous

61. Key Phrase: In the wild, gangs of defending ants team up to send hostile strangers out of the nest.

- Included Keyword: send

- Keyword Alternatives: trap, jaw, bounc, defen, jump, bounc, prop, launch, throw, thrust, catapult, toss, fling, shoot, sling, mov, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, project, cast, heav, hop, advanc, progress, vault, push, forc, fly, flie, send, sent, flown, blow, soar, blew, shot, shoot, punt, went, flew, thrust, jump, leap, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampolin, somersault, out
- Included Keyword: team
 - Keyword Alternatives: crew, squad, gang, group, together, colon, other, ant, crew, ring, cluster, tandem
- Included Keyword: strang
 - Keyword Alternatives: trud, trespass, invad, roach, violat, interlop, one, other, snoop, thing, infiltrat, infring, predator, enem, foreign, alien, out, strang, animal, creature, organism, critter, specie, beast, encounter, meet, ambush, aggr, assail, disrupt, disturb, raid, danger, threat, menac, pest, jeopard, risk, peril, attack, sieg, troubl, intimidat, pursu, thing, life, lives, hostil, visit, guest, antagon, bad

62. Key Phrase: Trap-jaw ants are intriguing from an evolutionary point of view.

- Included Keyword: evol
 - Keyword Alternatives: adapt, grow, grew, advanc, develop, trans, pro, chang, morph, mutat, arise, arose, com, emerg, came, result, derive, stem, acquire, tain, gain, pick, flourish, establish, cultivat, form
- Included Keyword: intrigu
 - Keyword Alternatives: interest, memor, novel, signif, event, impress, mean, moment, monument, forget, last, distinguish, except, extra, great, compel, substan, out, curious, fascinat, gross, rivet, captivat, appeal, thought, absorb, grip, engag, immers, consum, allur, stimulat, thrill, entertain, enchant, charm, beguil, mesmer, spell, bind, attract, puzzl, curio, raptur, entic, excit, tempt, witch, seduc, myster, mystic, suspens, enigma, intricat, complex, conundrum, riddl, arous, piqu, thrall

63. Key Phrase: Trap-jaw ants evolved to use an already useful system of chewing up prey for propulsion.

- Included Keyword: evol

- Keyword Alternatives: adapt, grow, grew, advanc, develop, trans, pro, chang, morph, mutant, arise, arose, com, emerg, came, result, derive, stem, acquire, tain, gain, pick, flourish, establish, cultivate, form
- Included Keyword: chew
 - Keyword Alternatives: bit, chomp, gnaw, gnash, munch, chaw, snap, champ, grind, crunch, crush, masticat, mash, strik, attack, hit, blow, impact, assault, blitz, barrage, offense, charge, bombard, pelt, storm, rain
- Included Keyword: prop
 - Keyword Alternatives: chuck, push, throw, threw, toss, rocket, blast, whip, slung, yeet, pitch, heav, forc, fly, flie, send, sent, flown, blow, soar, blew, punt, went, flew, thrust, mov, shov, kick, catapult, cast, expel, driv, drove, knock, jump, leap, bounc, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, rocket, blast, pogo, project, yeet, trampolin, somersault

64. Key Phrase: Several lineages of trap-jaw ants have used the tactic of storing energy in their jaws to penetrate well-defended prey.

- Included Keyword: line
 - Keyword Alternatives: evol, type, kind, varia, famil, genus, specie, breed, descen, ancest, herit, progen, gene, strain, tax, class
- Included Keyword: jaw
 - Keyword Alternatives: mandible, mouth, bone, maxilla, appendage, limb, protuberance, maw, chop, pincer, energ, str, power, vital, might, forc, momentum, potenc, punch, vigor, intens, potent, kinetic, stor, cumulat, reserv, deposit, stash, suppl, stock, collect, mass, gather
- Included Keyword: defen
 - Keyword Alternatives: armo, protect, shield, fortifi, shell, exoskeleton, resist, guard, secur, plat, cas, mail, cover, bulwark, ward, barr, wall, safe, prevent, avert, counter
- Included Keyword: penetrat

- Keyword Alternatives: crack, break, destroy, crush, beat, trump, crumbl, mash, quash, fractur, shatter, tear, shred, minc, pop, ruptur, split, demolish, disintergrat, bust, snap, splinter, nullify, crunch, burst, open, pry, pop, cleav, punctur, spear, stab, jab, impal, bayonet, drill, permeat, pierc, cut, clamp, perforat, prob, bore, sink, knif, prick, thrust, pervad

65. Key Phrase: The bouncer-defense jump is horizontal.

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, maneuv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: horizon
 - Keyword Alternatives: azimuth, axis, dimension, plane

66. Key Phrase: Bouncer-defense jump could have arisen out of attempts to bite intruders.

- Included Keyword: bouncer-defense
 - Keyword Alternatives: bounc, defen, protect, safe, maneuv, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, shield, fort, keep, sentr, sentinel, doorm, watchm, block, barr, custodian, mitigat, vigil, buff, wall, screen, armo, ward, bulwark, cover, shelter, fend, personnel, gate, attendant, escort, janitor, officer, resist
- Included Keyword: arise
 - Keyword Alternatives: evol, adapt, grow, grew, advanc, develop, trans, pro, chang, morph, mutat, arose, com, emerg, came, result, deriv, stem, acquire, tain, gain, pick, flourish, establish, cult, form, rose
- Included Keyword: bit
 - Keyword Alternatives: chew, chomp, gnaw, gnash, munch, chaw, snap, champ, grind, crunch, crush, masticat, mash, strik, attack, hit, blow, impact, assault, blitz, barrag, offen, charg, bombard, pelt, storm, rain, nibbl, offen, peck
- Included Keyword: trud

- Keyword Alternatives: strange, trespass, invad, roach, violat, interlop, one, other, snoop, thing, infiltrat, infringing, predator, enem, foreign, alien, out, strang, animal, creature, organism, critter, specie, beast, encounter, meet, ambush, aggr, assail, disrupt, disturb, raid, danger, threat, menac, pest, jeopard, risk, peril, attack, sieg, troubl, intimidat, pursu, thing, life, lives, hostil, visit, guest, antagon, bad

67. Key Phrase: High, escape jump must have arisen from a different, perhaps accidental kind of behavior.

- Included Keyword: escape jump

- Keyword Alternatives: defen, protect, safe, manuev, mechan, guard, measur, tactic, method, mean, techniq, counter, act, repon, mov, protect, guard, secur, escap, flee, away, avoid, run, retreat, evac, withdraw, evad, elud, dodg, skedaddl, exit, evas, desert

- Included Keyword: jump

- Keyword Alternatives: bounc, prop, launch, throw, thrust, catapult, toss, fling, shoot, sling, mov, send, forc, driv, lung, chuck, fir, blast, eject, spring, leap, hurl, bound, skip, project, cast, heav, hop, advanc, progress, vault, push, forc, fly, flie, send, sent, flown, blow, soar, blew, shot, shoot, punt, went, flew, thrust, jump, leap, hur, vault, bound, lung, ricochet, hop, boomerang, recoil, spring, launch, eject, catapult, fling, flung, sling, sho, fir, lop, lob, prop, rocket, blast, pogo, project, yeet, trampoline, somersault

- Included Keyword: arise

- Keyword Alternatives: evol, adapt, grow, grew, advanc, develop, trans, pro, chang, morph, mutat, arose, com, emerg, came, result, deriv, stem, acquire, tain, gain, pick, flourish, establish, cult, form, rose

- Included Keyword: accident

- Keyword Alternatives: coincide, purpos, random, mistake, fluke, chance, incident, intention, deliberat, fortuitous, serendip, luck, voluntar, expect, evol, mishap, foresee, intend, predict, plan, fortu, gambl, fate, foresight, happenstanc, surpris, revelation, anticipat, abrupt, blue, astonish, sudden, certain, prompt, arbitrar

68. Key Phrase: Trap-jaw ants banging their heads against the ground (a rare instance/serendipitous event) could have led to good results (the evolution of the escape-jump).

- Included Keyword: bang
 - Keyword Alternatives: slam, boom, crack, pound, smack, smash, crash, bash, hit, strik, bump, thud, clang, clatter, wallop, whack, wham, knock, ram, thrash, impact, thump, beat, colli, swat, clobber, bonk

- Included Keyword: head
 - Keyword Alternatives: face, mug, noggin, dome

- Included Keyword: ground
 - Keyword Alternatives: earth, soil, land, terrain, surfac, floor, under, gravel, dirt, sod, clay, meadow, landscap, substrat, turf, foundation, bottom, top, exterior, outside, skin, layer, outer, superficial, cuticle, crust, field, yard, base

- Included Keyword: result
 - Keyword Alternatives: outcome, ffect, produc, yield, conclu, achiev, shot, output, fruit, resolut, impact, culminat, event, issu, terminat, reverberat, sequen, react, sequel, ramif, perform, return, emanat, attain, efficac, aftermath, corollar, retribut, contribut, develop, solution, impl, reali, collab, invest, help, support, assist, play, part, role, participat, furnish, donat, suppl, offer, giv, provid, pitch, hand, chip, impart, present, conduc, instrument

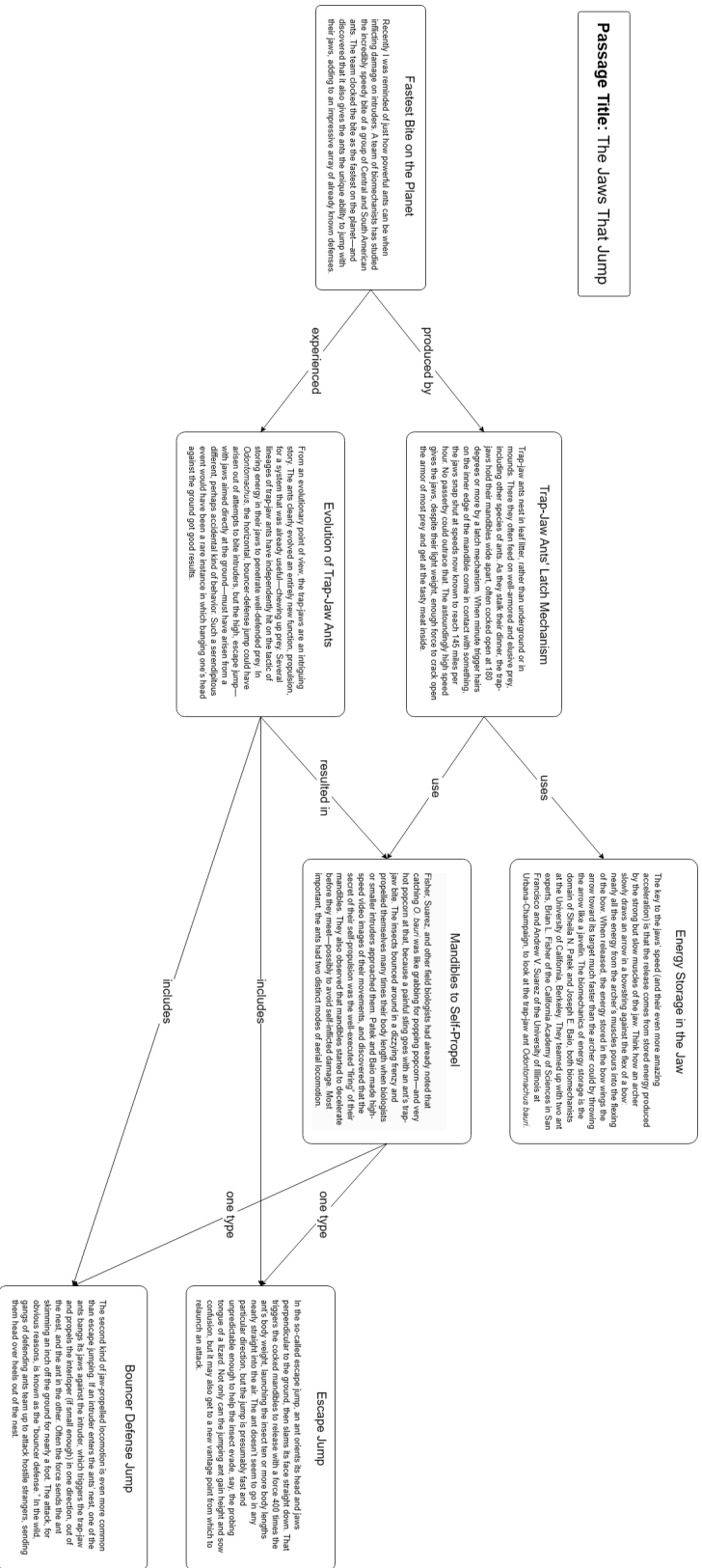


Figure B.10: Passage 2: The Jaws That Jump in Hybrid Map (H) condition

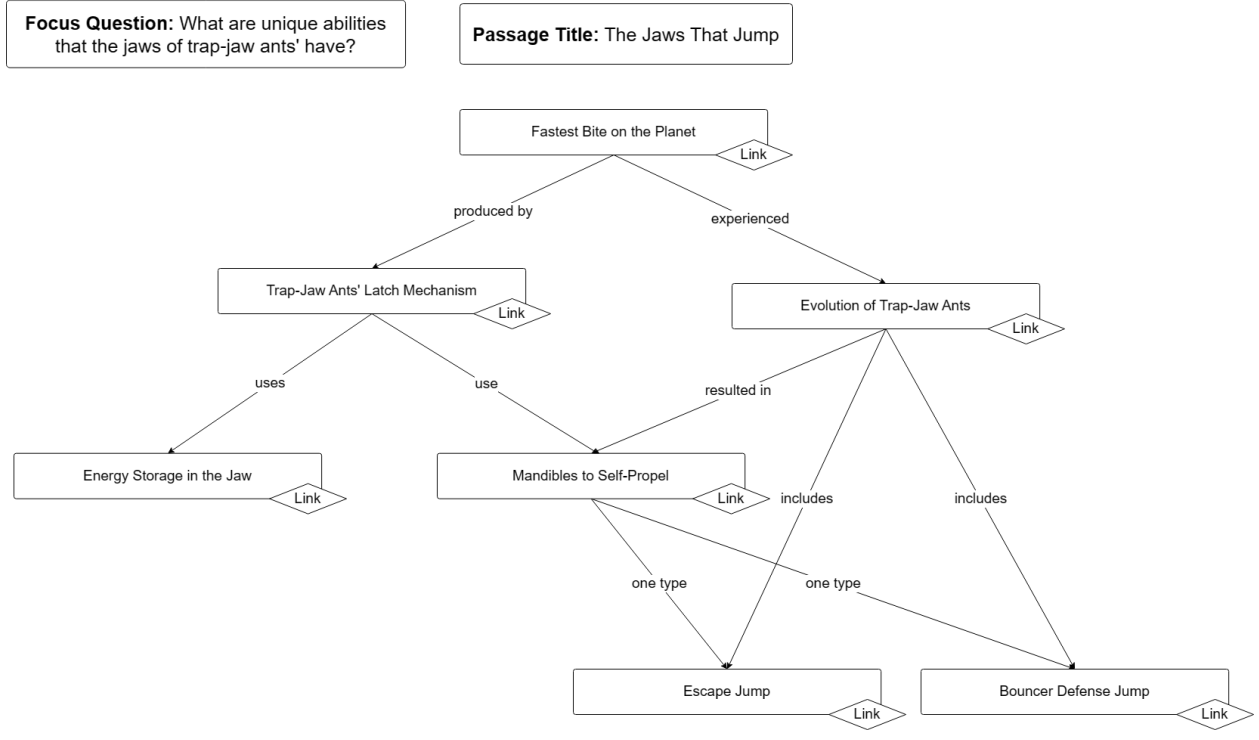


Figure B.11: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - Master-map

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Focus Question: What is unique about the group of Central and South American ants biomechanists studied?

Paragraph Title: Fastest Bite on the Planet

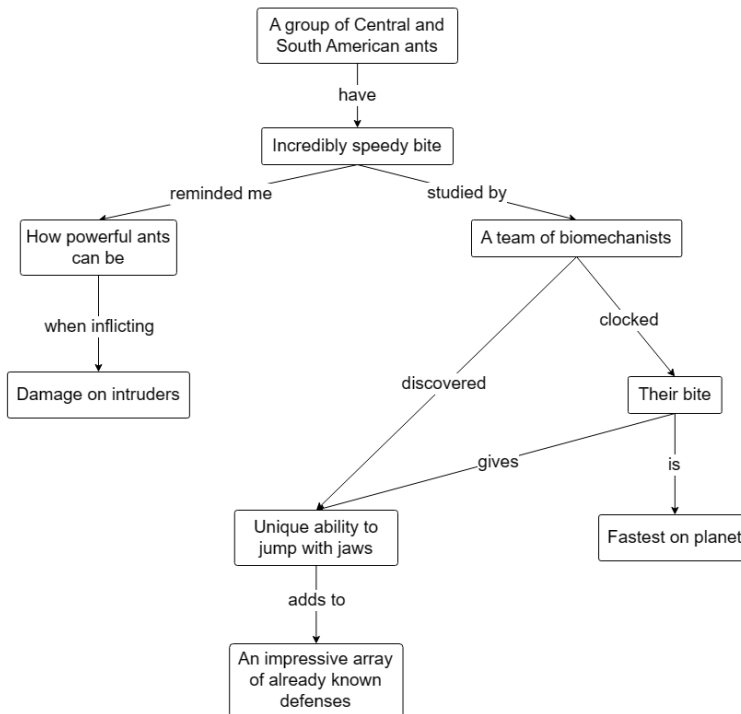


Figure B.12: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - mini-map1

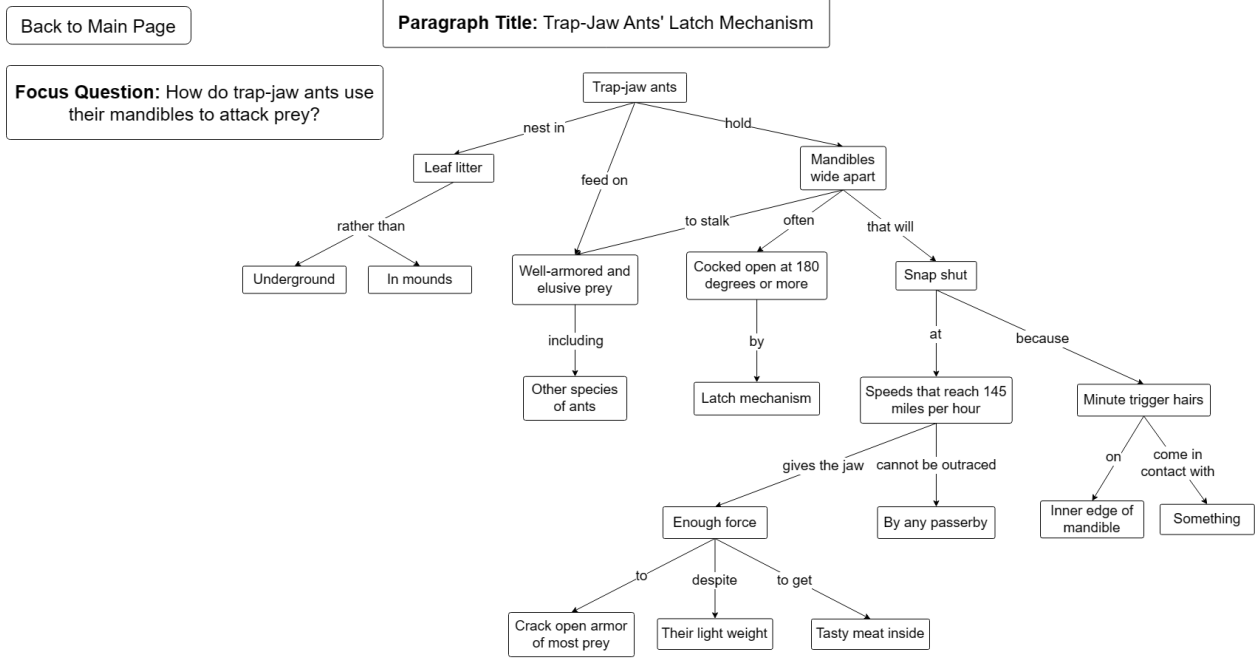


Figure B.13: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - mini-map2

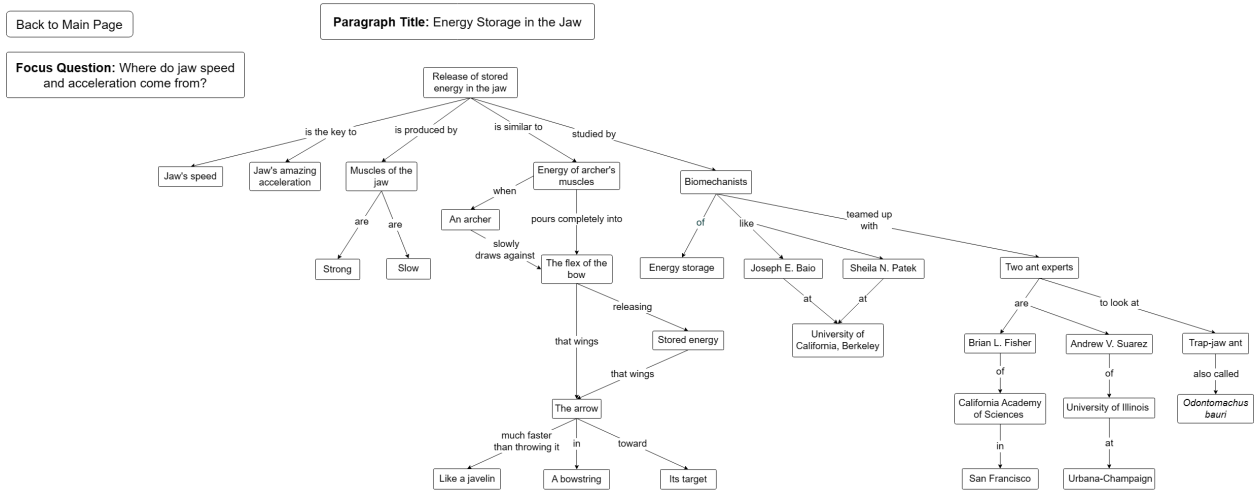


Figure B.14: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - mini-map3

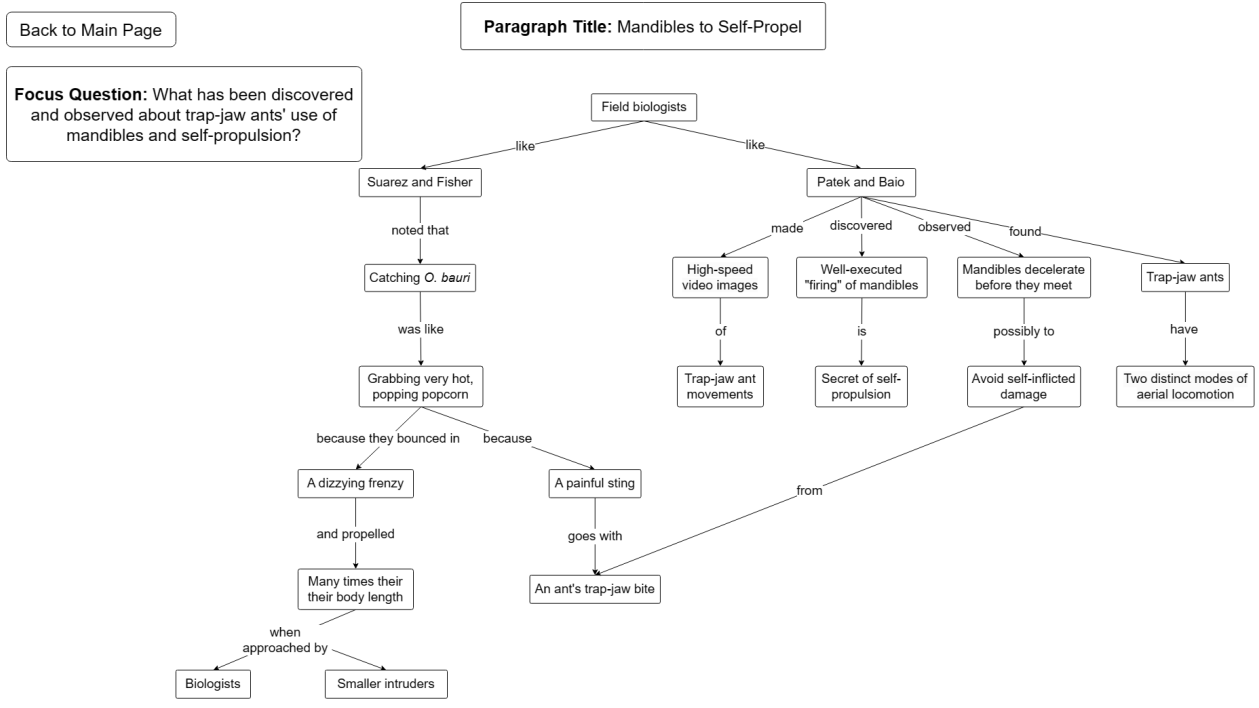


Figure B.15: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - mini-map4

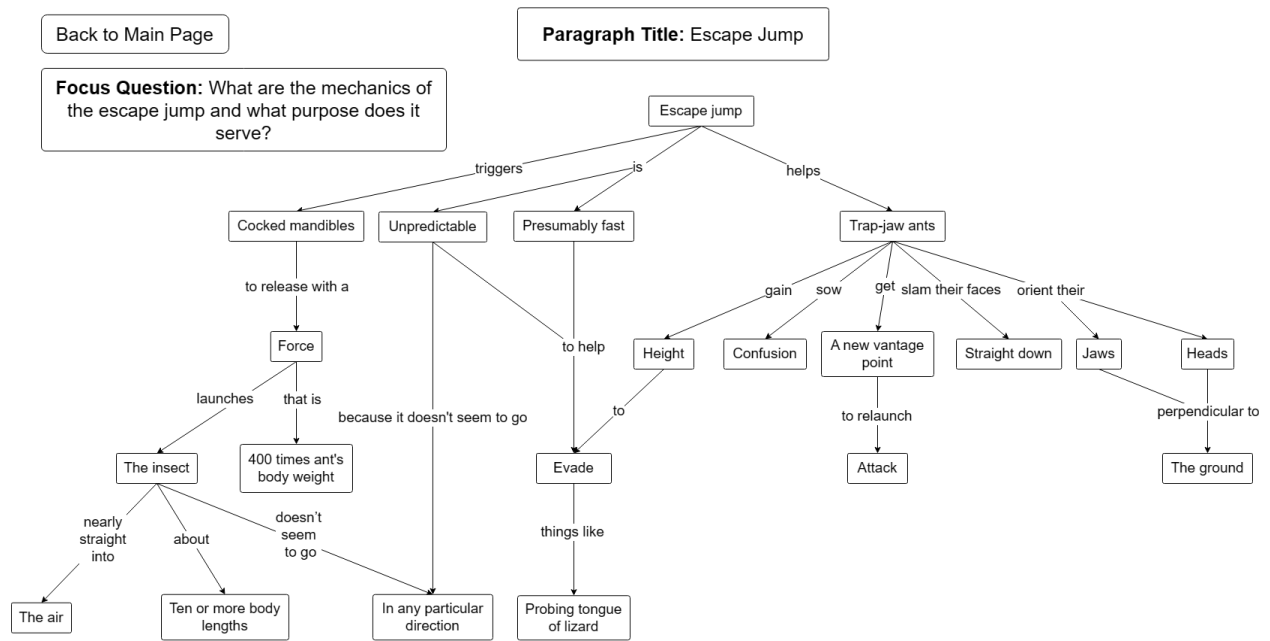


Figure B.16: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - mini-map5

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Focus Question: What are the mechanics of the bouncer defense and what purpose does it serve?

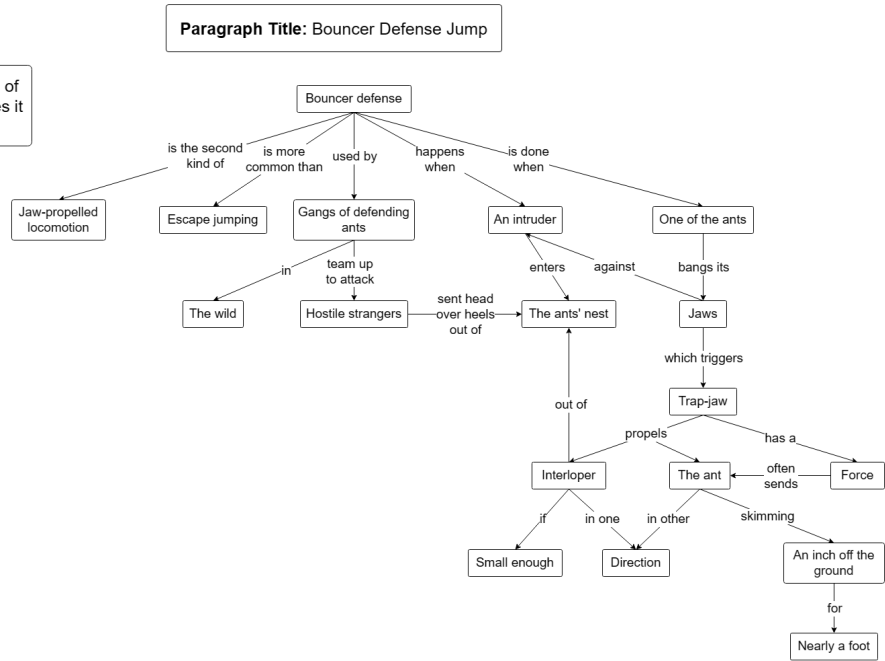


Figure B.17: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - mini-map6

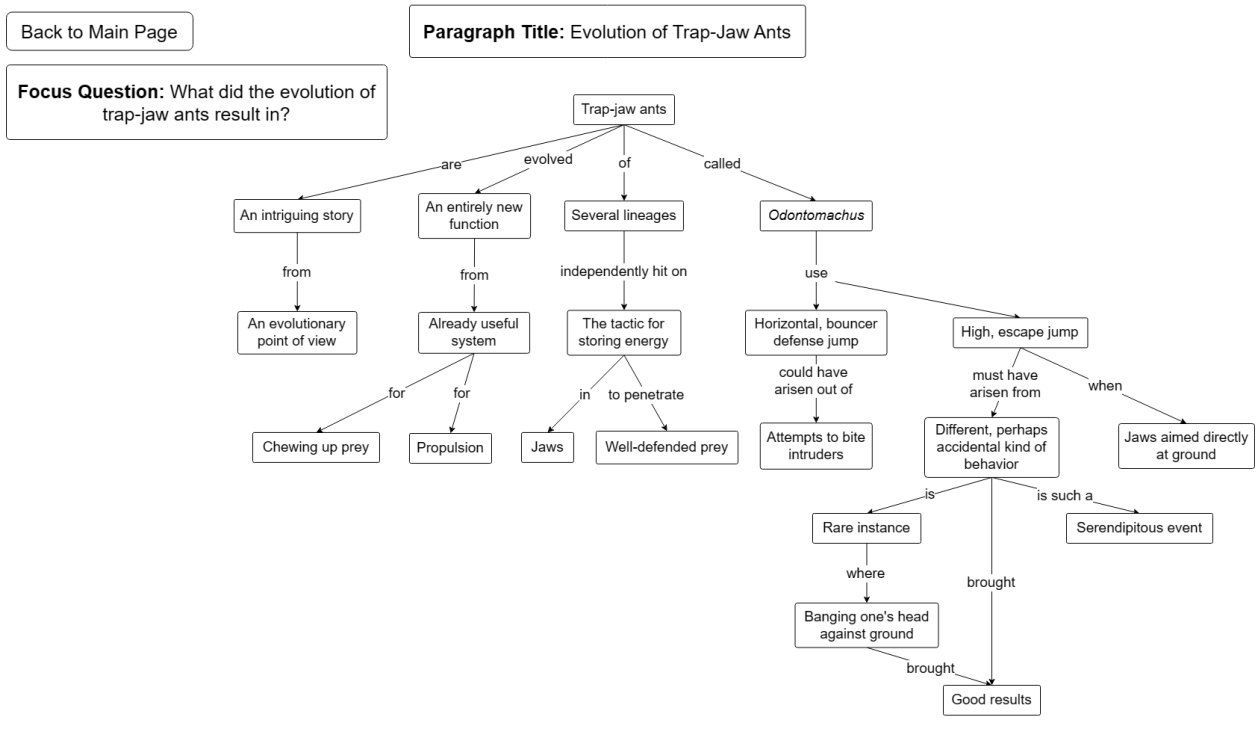


Figure B.18: Passage 2: The Jaws That Jump in Novakian Knowledge Model (K) condition - mini-map7

B.2.3 Passage 3: The Buzz in Our Pockets

The modified multiple-choice questions used for this passage are as follows:

1. The main idea of the passage is that:
 - (a) telephone conversations are defunct because they are so impermanent.
 - (b) telephones took the place of serious long-letter writing.
 - (c) text messages do not provide real interactions for the people who send them.
 - (d) text messaging is a popular medium whose social effects are debatable.

Question Type: Inferential

2. Based on the passage, with which of the following statements would Fields most likely agree?
 - (a) The frequent use of text messaging can limit people's other human experiences.
 - (b) Internet users lost their capacity for human experience when they started using Google.
 - (c) Text messages provide a quick, intimate way for people to communicate.
 - (d) Text messages force people to write more thoughtfully to one another.

Question Type: Inferential

3. How does the passage's author directly support her claim that the text message is more than a simple message?
 - (a) By citing examples from American culture in which text messaging plays a role
 - (b) By describing famous novels about the cultural role of texting in American society
 - (c) By listing the accomplishments of the two German men who created the medium of text messaging
 - (d) By showing that text messaging was initially limited to 160 characters

Question Type: Inferential

4. The passage's author most likely discusses the era before the War of Independence to:
 - (a) demonstrate how historical figures refused to use text-messaging technology.
 - (b) prompt the reader to do more research into the history of communication.

- (c) give a fun digression in an otherwise dry discussion of communication media.
- (d) show that forms of communication can provide historical records.

Question Type: Inferential

5. Which of the following people think or act in a way that is most similar to that of the naysayers described in the passage
- (a) Scientists who see improvements in medicine as an improvement in the quality of life
 - (b) Sports journalists who say that a change in rules will destroy the integrity of a sport
 - (c) Novelists who prefer to write on computers rather than with pen and paper
 - (d) Historians who would prefer to read official documents rather than letters

Question Type: Inferential

6. According to the passage, of the following, who were the earliest contributors to the development of the medium of the text message?
- (a) Fields and Chacon
 - (b) Scorsese and Franzen
 - (c) Franzen and Wallace
 - (d) Hillebrand and Ghillebaert

Question Type: Factual

7. A character in a short story published in 1994 had this to say about text messages: “Say what you will about the “decline of real interaction” I’ve had plenty of them that would’ve felt a lot more real if they’d happened in a sentence or two rather than a two-hour phone conversation” Based on the passage, would Hillebrand agree or disagree with this statement?
- (a) Disagree, because 160 characters proved to be an inadequate number of characters.
 - (b) Disagree, because he ultimately believed that most communication should occur by letter.
 - (c) Agree, because he felt that the telephone was no longer an effective communicator.
 - (d) Agree, because he thought that 160 characters was adequate to express most messages concisely.

Question Type: Factual

8. Based on the passage, why might *The Departed* have been considered a film interested in contemporary issues?
- (a) It made a recent communication medium, text messaging, central to its story.
 - (b) Its actors spoke in favor of text messaging, and the medium exploded in popularity after the film's release.
 - (c) It won an important award in honor of the quality of the filmmaking.
 - (d) It showed that letter writing was no longer a sufficient way to communicate.

Question Type: Inferential

9. Based on the passage, when the author cites the saying “time is money”, she most likely means that a text message:
- (a) is an inexpensive way to send a message.
 - (b) keeps a long-lasting record of people's conversations.
 - (c) is a quick way for people to communicate.
 - (d) allows an intimacy that can otherwise take a long time to develop.

Question Type: Inferential

10. Based on the passage, Chacon suggests the number of people with whom people's ancestors might have had interactions in order to:
- (a) state that the family unit is no longer as important as it once was.
 - (b) suggest that new media can connect people in new ways.
 - (c) imply that people in older times should have traveled more.
 - (d) encourage readers to explore what their ancestors said in letters.

Question Type: Inferential

The following shows the original ACT reading comprehension passage in linear format. This passage was obtained from Princeton Review ACT Prep 2021 (available at [ACT reading practice test 2](#)). This passage in Hybrid Map (H) format is shown in Figure B.19. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent Novakian

concept maps (K) are shown in Figure B.20, Figure B.21, Figure B.22, Figure B.23, Figure B.24, Figure B.25, Figure B.26 and Figure B.27. The interactive version that the participants studied through is available [here on Draw.io](#).

The Buzz in Our Pockets

To the extent that it has a creator at all, the text message, or SMS (short message service), was created in the early 1980s by Friedhelm Hillebrand and Bernard Ghillebaert, who wanted to find a way to send data over the parts of phone lines that were not being used in normal telephony. The first text messages were 160 characters long. Hillebrand suggested that “160 characters was sufficient to express most messages succinctly,” citing typical postcard and Telex lengths.

Although this form might seem to limit the way we communicate, the text message is the most widely used data application in the world, with about 80% of all cellphone users (3.5 billion people) using the medium. Text messages are already a part of the cultural landscape: they are mentioned in rap and rock songs; they show up in billboards and advertisements selling just about anything; and they’ve even cropped up in serious novels like Jonathan Franzen’s *Freedom* and David Foster Wallace’s *The Pale King*. Text messages, in fact, move the whole plot of Martin Scorsese’s 2006 film *The Departed*, a critical success and eventual Oscar winner for Best Picture.

But the text message is more than a cultural fad. It’s part of a broader shift in the way we connect with one another. Speaking on an actual telephone is basically defunct in 2013, not only for the economic reason that “time is money” and a text is quicker than a call, but also for a much older desire in all of us for permanence. With a text message, we’ve got a record of all our communications, and although we may cast them off quickly, even the shortest text message requires more pre-thought than a verbalized remark: we can’t go back to our recorded calls, but our texts live on our phones for as long as we choose to keep them there. The text message has made even our most fleeting conversations permanent - and in this way, the text harkens back to one of the earliest modes of communication, even before the telephone: the letter.

Although America was a sprawling, disparate place even before the War for Independence in the 1770s, its residents always felt the need to communicate with those farther and farther away. Ships carried people back and forth across the Atlantic Ocean, but they also carried correspondence, and we could even say that our very nation was founded in these written communiqués: much of what we know about the era comes from these letters. One day, text messages may provide a similar record of our own moment.

But it would be naïve to say that these quick notes are anything like the voluminous correspondence of ages past. In her recent monograph *Write Me a Letter*, Kari Fields wonders if the sophisticated concentration of that historical correspondence is even available to us anymore. Fields warns not only that we may have been “dumbed down” by our technologies but also that we may have lost one of the essential elements of the human experience. “The content of our communication with each other (‘I’ll be late to work today’; ‘I’ll be home at 10’; or even, ‘I love you’) may ultimately be the same,” Fields concedes, “but the real communication lives in the form - the tone, the unsteady hand on a particular word, the hasty erasures.” Perhaps Fields herself is missing the point: naysayers have said that everything from the printing press, to the radio, to the movie screen, to Google, has compromised the way we think and understand. It makes no difference whether a letter takes a month by boat, two weeks by Pony Express, a few days by post, or a few seconds by email. The medium, it seems safe to say, is not the message.

However, Fields is aware of all these earlier changes. She is as sophisticated a historian of these media as anyone working in the field today. We cannot deny that text messages and the Internet have isolated us from one another like never before. In addition to placing us alone at our computers or on our phones, these new technologies also force us to spread our limited attention spans thinner and thinner. We may have to think about the text messages we send, but we typically do so while looking at something else on the web, listening to music or podcasts, or seconds before or after sending messages to someone else. It’s not merely that our communications are getting shorter and shorter; it’s that the time we have for real interactions has shrunk. All of these new devices are supposed to be time-savers, but what they’ve really given us is more time to use the devices, to the point that a year without seeing a dear friend seems less daunting than a few hours without the phone.

Still, text messages may be our last, best surrogate for the intimacy of “real” communication. As Herberth Chacon observes in *I Like You...on Facebook*, “Whatever the limitations of this new medium of communication, people are interacting on a day-to-day basis with more people than their ancestors might have met in a lifetime.” Text messages have gained such currency because, for all their flaws, they do bring us together. After all, even if the words “I love you” are flashing up impersonally on a screen - stripped of all tone and affection - the words are nice to hear nonetheless, and even if our new definition of “friends” may not square with the old definition, it’s nice to know there’s a world out there that’s paying attention to us.

B.2.3.1 Key Phrases and their Boolean Expressions for The Buzz in Our Pockets

1. Key Phrase: Text messages are also known as SMS.
 - Included Keyword: SMS
 - Keyword Alternatives: service, short
 - Included Keyword: text
 - Keyword Alternatives: message, chat, communicat
2. Key Phrase: SMS is the abbreviation of short message service.
 - Included Keyword: SMS
 - Keyword Alternatives: short, service
 - Included Keyword: abbreviat
 - Keyword Alternatives: short, stand, acronym, mean
3. Key Phrase: SMS was (text messages were) created in the early 1980s.
 - Included Keyword: SMS
 - Keyword Alternatives: short, service, text, message, chat, communicat
 - Included Keyword: 80
 - Keyword Alternatives: eight, 20, twent, nine, 9, nineteen, 19
4. Key Phrase: SMS was (text messages were) created by Friedhelm Hillebrand.
 - Included Keyword: SMS
 - Keyword Alternatives: short, service, text, message, chat, communicat
 - Included Keyword: Friedhelm
 - Keyword Alternatives: Hillebrand
5. Key Phrase: SMS was (text messages were) created by Bernard Ghillebaert.
 - Included Keyword: SMS
 - Keyword Alternatives: short, service, text, message, chat, communicat

- Included Keyword: Bernard
 - Keyword Alternatives: Ghillebaert, Ghillebaet
6. Key Phrase: SMS (text messages were) was created to send data over the parts of phone lines that were not being used in normal telephony.
- Included Keyword: SMS
 - Keyword Alternatives: short, service, text, message, chat, communicat
 - Included Keyword: data
 - Keyword Alternatives: message, communicat, sen, record, info, input, talk, discuss, address, assign, trans, forward, direct, move, chang
 - Included Keyword: phone
 - Keyword Alternatives: line, wire, connect, telephon, trans, electric, audi
7. Key Phrase: The first text messages were 160 characters long.
- Included Keyword: SMS
 - Keyword Alternatives: text , message, chat , communicat, short, service
 - Included Keyword: 160
 - Keyword Alternatives: sixty, hundred, 1
8. Key Phrase: “160 characters was sufficient to express most messages succinctly.” (suggested by Hillebrand)
- Included Keyword: 160
 - Keyword Alternatives: sixty, hundred, 1
 - Included Keyword: suffic
 - Keyword Alternatives: succinct, success, effect, enough, able, accept, express, communicat, ample, necess, plent, satis, influen, convey, relat, sign, depict, show, reveal, descri, adequat, essen, prop, concis, brief, articulat, cohere, eloquen, indicat, brevit
9. Key Phrase: Typical postcard lengths are 160 characters.

- Included Keyword: card
 - Keyword Alternatives: post, mail, letter
- Included Keyword: 160
 - Keyword Alternatives: sixty, hundred, 1

10. Key Phrase: Typical Telex lengths are 160 characters.

- Included Keyword: telex
 - Keyword Alternatives: fax, telegram, telegraph, teleprint
- Included Keyword: 160
 - Keyword Alternatives: sixty, hundred, 1

11. Key Phrase: Text messages might seem to limit the way we communicate.

- Included Keyword: limit
 - Keyword Alternatives: restrict, bound, cap, max, ceiling, border, restrain, curb, barri, confine, threshold, end, reduce, extend, edge, contain, regulate, detriment, damage, harm, hurt, low, impair, injure, loss, lose, advantage, favor, deteriorate, back, hinder, deprive, ruin, deficit, influence, drawback, remove
- Included Keyword: communicate
 - Keyword Alternatives: talk, text, call, touch, buzz, pocket, phone, dial, ring, reach, tele, radio, contact, page, summon, alert, respond, reply, back, signal, mail, beep, interact, exchange, relay, share, transmit, convey, express, converse, articulate, voice, speak

12. Key Phrase: Text message is the most widely used data application in the world.

- Included Keyword: wide
 - Keyword Alternatives: number, best, big, popular, large, famous, crucial, commodity, prominent, need, single, necessary, worth, look, long, asset, important, competent, presence, rage, thing, trend, crazy, sensation, hit, significant, essence, basic, quint, vital, chief, principle, card, demand, main, primary, like, pivot, extensive, universal, prevalent, public, convention, ramp, ubiquitous, current, ordinary, regnant, massive, world, note, notable, most, common, valued, known, leading, preferred, favorite, favourite, contender, suited, suitable, ripe, vital, proliferation, prolific, present

- Included Keyword: use
 - Keyword Alternatives: usage, utili, adopt, usage, see, sought, talk, prevail, prais, prefer, celebrat, receiv, dispen, view, accept, catch, caught, lov, attract, valu, know, fund, approv, lead, favor, favour, die, dying, contend, rul, proliferat, employ, appl, operat, practic, spend, spent, exercis, expend, serv, control, dominat, manag, communicat
13. Key Phrase: About 80% of all cellphone users (3.5 billion people) use the medium (SMS).
- Included Keyword: 80
 - Keyword Alternatives: eight, 3.5, billion, 3, half
14. Key Phrase: Text messages are already a part of the cultural landscape.
- Included Keyword: cultur
 - Keyword Alternatives: soci, habit, life, live, custom, tradition, routin, practic, pattern, convention, day, daily, usual, standard, regular, typical, norm, general, familiar, cur, schedul, environment, using, time, period, circumstance, situation, condition, context, use, agenda, commun, manner, behavio, plan, program, contemporar, present, modern, groov, scen, trend, fad, activit, look, aspect, dimension, fashion, affair, business, work, person, people, public, popul, back, shap, status, trait, stag, featur, surround, system, world, univers, home, talk, friend, convers, memor, collect, concious, mind, cycl, styl, land, influen
15. Key Phrase: Text messages are mentioned in rap and rock songs.
- Included Keyword: rap
 - Keyword Alternatives: rock, R&B, rhythm, blues, R'n'B, hip-hop, hip hop, metal, punk, alternative, glam, garage, indie, pop, freestyl, grunge
 - Included Keyword: song
 - Keyword Alternatives: music, tune, melod, track, genr, harmon, sang, sung, sing, piece, composition, anthem, ballad
16. Key Phrase: Text messages show up in billboards and advertisements (selling just about anything).
- Included Keyword: adverti

- Keyword Alternatives: ads, ad, billboard, sell, consum, product, company, campaign, promo, announc, material, sale, pitch, broad, cast, spot, program, messag, flyer, endorse, jingle, ring, mercial, leaflet, post, socia, tech, web, sign, head, display, public, marquee, banner, street, road

17. Key Phrase: Text messages have cropped up in serious novels.

- Included Keyword: novel
 - Keyword Alternatives: publicat, book, literatur, writ, narrativ, fiction, pros, work, paper, essay, portfolio, author, print, articl, piece, texts, story, stories, tale

18. Key Phrase: “Freedom” is a serious novel by Jonathan Franzen.

- Included Keyword: Freedom
 - Keyword Alternatives: Jonathan, Franzen

19. Key Phrase: “The Pale King” is a serious novel by David Foster Wallace.

- Included Keyword: Pale
 - Keyword Alternatives: David, Wallace, Foster

20. Key Phrase: Text messages move the whole plot of a film (“The Departed”).

- Included Keyword: plot
 - Keyword Alternatives: narrativ, design, script, structur, sequenc, perform, event, direct, line, aspect, develop, progress, tale, chronicl, story, stories, view, out, center, arc, climax, conflict, resolution, twist, turn, action, screenplay, scen, theme, premise, drama, adventure
- Included Keyword: film
 - Keyword Alternatives: movie, flick, pictur, show, featur, Departed

21. Key Phrase: “The Departed” is Martin Scorsese’s film.

- Included Keyword: Departed
 - Keyword Alternatives: Martin, Scorsese, 2006

22. Key Phrase: “The Departed” is a 2006 film.

- Included Keyword: 2006
 - Keyword Alternatives: two, thousand, six, 2000, 21st, twenty, first, Departed

23. Key Phrase: The movie (“The Departed”) was a critically successful Oscar winner for Best Picture.

- Included Keyword: movie
 - Keyword Alternatives: Departed, film, narrativ, flick, featur, show, tale, story, stories, Martin, Scorsese
- Included Keyword: Oscar
 - Keyword Alternatives: Best, picture, award, success, recogn, prais, accla, accolad, trophy, honor, distinct, decor, academy

24. Key Phrase: The text message is more than a cultural fad.

- Included Keyword: fad
 - Keyword Alternatives: trend, phrase, craze, vogue, mania, hype, fashion, catch, thing, obsess, phenom, happen, sensation, chic, hit, whim, fascinat, pass, transient, phase, temp, long, last, endur, die, dying, stop, continu, ceas, fizzle, expir, Persist, Persever, Withstand, Bear, Remain, Abid, laps, declin, forever, contin, dura, long, last, mortal, end, time, year, span, length, exist, ever, serv, sustain, through, keep, hold, futur, surviv, stay, etern, standing, perm, soon, disappear, leav, gone, vanish, fade, fading, perish, dwindl, wan, waning, dissolv, evaporat, dethron, stabl, perpe, perennial, dissipat
- Included Keyword: cultur
 - Keyword Alternatives: soci, habit, life, live, custom, tradition, routin, practic, pattern, convention, day, daily, usual, standard, regular, typical, norm, general, familiar, cur, schedul, environment, using, time, period, circumstance, situation, condition, context, use, agenda, commun, manner, behavior, plan, program, contemporary, present, modern, groov, cycl, scen, trend, activit, look, aspect, dimension, fashion, styl, affair, business, work, person, people, public, popul, back, shap, status, trait, stag, featur, surround, system, world, univers, home, talk, friend, convers, memor, collect, concious, mind, land, influen

25. Key Phrase: Text messages offer permanence.

- Included Keyword: text
 - Keyword Alternatives: short, service, message, chat, communicat, SMS
- Included Keyword: perm
 - Keyword Alternatives: contin, dura, long, last, mortal, end, etern, time, year, span, length, exist, ever, serv, pass, transien, temp, long, last, endur, die, dying, stop, ceas, fizzle, expir, persist, surviv, sustain, perserver, withstand, bear, remain, abid, laps, declin, stay, forever, standing, soon, last, disappear, leav, vanish, fade, fading, wan, waning, dethron, perpe, perennial, dissolv, dissipat, evaporat, gone, sav, preserv, conserv, keep, kept, protect, rescu, safe, guard, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, hold, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulat, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, hidden, archiv, bank, hous, sock, conceal, lodg, park, plac, stow, chang, fix, stab, constan, variabl, delible, mutable, stead, rupt, perpetual, settl, continu, timing, alter, revers, vary, vari, move, moving, begin, shak, perish, rely, reli, mova, defin, phas

26. Key Phrase: SMS is part of a broader shift in the way we connect with one another.

- Included Keyword: sms
 - Keyword Alternatives: short, service, text, message, chat, communicat, phon
- Included Keyword: shift
 - Keyword Alternatives: chang, direction, move, trans, metamorph, evol, advanc, turn, segue, switch, advance, forward, prog, alter, pivot, allow, new, facilit, possib, moving, adjust, modif, conver, adapt, vary, vari, sway, progress, substitut, mutat, replac, displac, migrat, shuffl, position, config, align, swing, revis, vision, amend
- Included Keyword: connect
 - Keyword Alternatives: communicat, chat, interact, talk, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, reach, respon, liais, associat, rapport, exchang, convey, confer, shar, coordinat, play, social, dialog, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend

27. Key Phrase: Speaking on an actual telephone is basically defunct in 2013.

- Included Keyword: phon
 - Keyword Alternatives: call, ring, speak, talk, contact, dial, buzz, line
- Included Keyword: defunct
 - Keyword Alternatives: dead, dat, not, done, obsolete, old, away, antiqu, past, from, histor, bur, check, off, trash, crash, abandon, use, using, used, date, style, contin, dura, mortal, end, time, year, span, length, exist, serv, pass, transien, phase, temp, long, persist, surviv, sustain, bear, remain, laps, declin, last, die, dying, stop, ceas, fizzl, expir, persist, surviv, remain, laps, declin, stay, soon, disappear, leav, vanish, wan, dethron, stabl, perpe, perennial, dissolve, dissipate, evaporate, gone, thousand, 2013, fad

28. Key Phrase: Speaking on an actual telephone is basically defunct (partly) because of the economic reason that “time is money.”

- Included Keyword: phon
 - Keyword Alternatives: call, ring, speak, talk, contact, dial, buzz, line, text, short, service, SMS, message, chat, communicat
- Included Keyword: defunct
 - Keyword Alternatives: dead, dat, not, done, obsolete, old, away, antiqu, past, from, histor, bur, check, off, trash, crash, abandon, use, using, date, style, contin, dura, mortal, end, year, span, length, exist, serv, pass, transien, phase, temp, long, persist, surviv, sustain, bear, remain, laps, declin, last, die, dying, stop, ceas, fizzl, expir, persist, surviv, remain, laps, declin, stay, soon, disappear, leav, vanish, wan, dethron, stabl, perpe, perennial, dissolve, dissipate, evaporate, gone, thousand, 2013, fad
- Included Keyword: time
 - Keyword Alternatives: age, hour, moment, month, point, present, second, space, term, turn, week, while, year, clock, instance, instant, juncture, life
- Included Keyword: money
 - Keyword Alternatives: econom, spend, cash, currency, finance, income, decision, dough, bread, choice, option, capital, expen, pa, fund, wealth, fortun, sum, budget, invest, buck, source, rich, business, market, commer, fiscal, indust, pecuniary, product, mercantile, profit, remunerat, sale, sell, good, merch, service, suppl, bill, salar, wage

- Included Keyword: reason
 - Keyword Alternatives: caus, expla, justif, ration, driv, drov, ground, bas, motiv, incentive, influence, fect, led, lead, impact, brought, consequen, aftermath, result, follow, argu, case, excuse, idea, proof, defend, favor, support, clear, contend, answer, advocat, repercuss

29. Key Phrase: Speaking on an actual telephone is basically defunct (partly) because a text is quicker than a call.

- Included Keyword: defunct
 - Keyword Alternatives: dead, dat, not, done, obsolete, old, away, antiqu, past, from, histor, bur, check, off, trash, crash, abandon, use, using, date, style, contin, dura, mortal, end, year, span, length, exist, serv, pass, transien, phase, temp, long, persist, surviv, sustain, bear, remain, laps, declin, last, die, dying, stop, ceas, fizzle, expir, persist, surviv, remain, laps, declin, stay, soon, disappear, leav, vanish, wan, dethron, stabl, perpe, perennial, dissolve, dissipate, evaporate, gone, thousand, 2013, fad
- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communication, phone, call, ring, line, speak, talk, contact, dial, buzz
- Included Keyword: quick
 - Keyword Alternatives: fast, speed, slow, hast, rapid, pac, swift, lag, dawdl, sloth, prompt, snap, optimiz, energ, effect, complet, proficien, agil, electric, accelerat, dash, flash, sonic, brisk, fleet, expedit, hurr, rush, nipp, immediate, zip, breakneck, whiz, nimbl, light, instant, sudden, pop, spik, stab, velocit, slouch, slug, snail, languid, jiff, celerit, sav, maintain, preserv, conserv, manag, spar, conven, bene, optimi, pratical, access, friend, effort, servic, feas, efficien, conduc, handy, handi

30. Key Phrase: Speaking on an actual telephone is basically defunct (partly) because of a much older desire (in all of us) for permanence.

- Included Keyword: perm
 - Keyword Alternatives: contin, dura, long, last, mortal, end, etern, time, year, span, length, exist, ever, serv, pass, transien, temp, long, last, endur, die, dying, stop, ceas, fizzle, expir, persist, surviv, sustain, perserver, withstand, bear, remain, abid,

laps, declin, stay, forever, standing, soon, last, disappear, leav, vanish, fade, fading, wan, waning, dethron, perpe, perennial, dissolv, dissipat, evaporat, gone, sav, preserv, conserv, keep, kept, protect, rescu, safe, guard, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, hold, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulat, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, hidden, archiv, bank, hous, sock, conceal, lodg, park, plac, stow, chang, fix, stab, constan, variabl, delible, mutable, stead, rupt, perpetual, settl, continu, timing, alter, revers, vary, vari, move, moving, begin, shak, perish, rely, reli, mova, defin, phas

- Included Keyword: phon
 - Keyword Alternatives: call, ring, landline, speak, talk, contact, dial, buzz, text, short, service, SMS, message, chat, communication
- Included Keyword: defunct
 - Keyword Alternatives: dead, out, dat, expir, done, obsolete, old, away, antiqu, past, from, histor, bur, check, trash, crash, abandon, ceas, exist, perm, contin, dura, mortal, end, etern, time, year, span, length, exist, serv, pass, transien, phase, temp, long, last, forever, die, dying, stop, ceas, fizzle, expir, persist, surviv, sustain, perserver, withstand, bear, remain, abid, laps, declin, stay, standing, soon, last, disappear, leav, vanish, fade, fading, wan, waning, dethron, stabl, perpe, perennial, dissolve, dissipate, evaporate, gone, use, using, date, style, thousand, 2013

31. Key Phrase: Text messages provide a record of all our communications.

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communication
- Included Keyword: comm
 - Keyword Alternatives: log, data, sen, info, input, talk, discuss, address, assign, trans, forward, direct, move, rec, chang, converse, chat, account, detail, dialog, act, say, contact, receipt
- Included Keyword: record
 - Keyword Alternatives: perm, contin, dura, long, last, mortal, end, time, year, span, length, exist, ever, serv, sustain, stand, main, through, keep, hold, futur, surviv,

stay, Document, File, Log, Entry, Note, Report, Account, Data, Chronicle, Memoir, Catalog, writ, evidenc, summar, info, proof, prov, transcript, verif, regist, journal, manuscript, etern, entri, diar, archiv, histor, inventor, sav, preserv, conserv, kept, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulatur, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, bank, sock, plac, stow, stab, constan, variabl, delible, mutable, stead, filing

32. Key Phrase: (Even the shortest) Text messages require more pre-thought than a verbalized remark. (We may have to think about the text messages we send)

- Included Keyword: thought
 - Keyword Alternatives: think, consider, cogn, aware, plan, intent, act, reason, focus, reflect, mental, deliberat, judg, spect, sight, perce, prepar, assess, deduc, atent, ration, ruminat, ponder, meditat, contemplat, calculat, brain, repercuss, mus, cogitat, cerebrat, analy, regard, requi, need, necess, must, involve, ask, demand, entail, warrant, compris, rel, tak, took, call, inclus, manda, dictat, pre, have, pay, enabl, could, can, mind

33. Key Phrase: Texts live on our phones for as long as we choose to keep them there.

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat
- Included Keyword: liv
 - Keyword Alternatives: perm, contin, dura, long, last, mortal, end, etern, time, year, span, length, exist, ever, serv, pass, transien, temp, long, last, endur, die, dying, stop, ceas, fizzl, expir, persist, surviv, sustain, perserver, withstand, bear, remain, abid, laps, declin, stay, forever, standing, soon, last, disappear, leav, vanish, fade, fading, wan, waning, dethron, perpe, perennial, dissolv, dissipat, evaporat, gone, sav, preserv, conserv, keep, kept, protect, rescu, safe, guard, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, hold, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulatur, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, hidden, archiv, bank, hous, sock, conceal, lodg, park, plac, stow, chang, fix, stab, constan, variabl, delible, mutable, stead, rupt, perpetual, settl, continu, timing, alter, revers, vary, vari, move, moving, begin, shak, perish, rely, reli, mova, defin, phas

- Included Keyword: choos
 - Keyword Alternatives: deci, choice, will, allow, want, let, wish, permit, authorize, grant, sanction, prefer, inten, ordain, decree, inclin, compel, interest, care, need, necess, important, relevan, use, giv, using, desir, dictat, caring, urg, resolv, opt, settl, determ

34. Key Phrase: The text message has made even our most fleeting conversations permanent.

- Included Keyword: perm
 - Keyword Alternatives: contin, dura, long, last, mortal, end, etern, time, year, span, length, exist, ever, serv, pass, transien, temp, long, last, endur, die, dying, stop, ceas, fizzle, expir, persist, surviv, sustain, perserver, withstand, bear, remain, abid, laps, declin, stay, forever, standing, soon, last, disappear, leav, vanish, fade, fading, wan, waning, dethron, perpe, perennial, dissolv, dissipat, evaporat, gone, sav, preserv, conserv, keep, kept, protect, rescu, safe, guard, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, hold, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulat, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, hidden, archiv, bank, hous, sock, conceal, lodg, park, plac, stow, chang, fix, stab, constan, variabl, delible, mutable, stead, rupt, perpetual, settl, continu, timing, alter, revers, vary, vari, move, moving, begin, shak, perish, rely, reli, mova, defin, phas

- Included Keyword: fleet
 - Keyword Alternatives: ephem, short, live, brief, pass, moment, evanesce, temp, fugitiv, term, transit, quick, flash, gone, rapid, swift, superficial, abrupt, distan, obscur, remot, far, off, faint, dim, hazy, vague, collect, murk, forgot, fuzz, rememb, blur, clear, access, long, ago, time, hazi, ephemeral, brisk, evanescent, vanish, instan, perish

- Included Keyword: convers
 - Keyword Alternatives: talk, connect, chat, interact, engag, mingl, communicat, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter

35. Key Phrase: The letter is one of the earliest modes of communication (even before the telephone).

- Included Keyword: letter
 - Keyword Alternatives: writ, missive, note, mail, memo, post, report, epist
- Included Keyword: earl
 - Keyword Alternatives: old, date, historic, obsolete, ancient, past, former, bygone, relic, immemorial, classic, origin, prior, antique, prece, precur, head, anterior, previous, front, fore, prepar, anteceden, exist, preliminar
- Included Keyword: communicat
 - Keyword Alternatives: talk, connect, chat, interact, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter

36. Key Phrase: Text message is similar to the letter in the context of permanence (By making fleeting conversations permanent, the text harkens back to one of the earliest modes of communication, the letter).

- Included Keyword: perm
 - Keyword Alternatives: contin, dura, long, last, mortal, end, etern, time, year, span, length, exist, ever, serv, pass, transien, temp, long, last, endur, die, dying, stop, ceas, fizzle, expir, persist, surviv, sustain, perserver, withstand, bear, remain, abid, laps, declin, stay, forever, standing, soon, last, disappear, leav, vanish, fade, fading, wan, waning, dethron, perpe, perennial, dissolv, dissipat, evaporat, gone, sav, preserv, conserv, keep, kept, protect, rescu, safe, guard, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, hold, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulat, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, hidden, archiv, bank, hous, sock, conceal, lodg, park, plac, stow, chang, fix, stab, constan, variabl, delible, mutable, stead, rupt, perpetual, settl, continu, timing, alter, revers, vary, vari, move, moving, begin, shak, perish, rely, reli, mova, defin, phas

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat
- Included Keyword: letter
 - Keyword Alternatives: writ, missive, note, mail, memo, post, report, epist

37. Key Phrase: America was a sprawling, disparate place even before the War for Independence.

- Included Keyword: America
 - Keyword Alternatives: u.s, us, states
- Included Keyword: sprawl
 - Keyword Alternatives: diff, dis, diver, var, similar, separat, like, identi, spread, stretch, exten, expan, cover, spill, straggl, extend, diverg, scatter, radiat, contra, like, vast, rambl, dispers, open, wide, proliferat, crowd, dissipat, spac, ampl, diffus, multi, abundan, seminat, roll, broad, scal, haphazard, control, organi, tidy, tidi, system, strag, wander, disparat, divers, vary, vari, distinct, relat, heterogen, equal, differ, discrepan, match, oppos, dissonan, rang, congru, discord
- Included Keyword: war
 - Keyword Alternatives: independ, july, revolution, fight, free, battl, liber, fought, combat, conflict, struggl, clash, strif, campaign, disput, autonom, democra, emancipa, sovereign, self

38. Key Phrase: The War for Independence was in the 1770s.

- Included Keyword: war
 - Keyword Alternatives: independ, july, revolution, fight, free, battl, liber, fought, combat, conflict, struggl, clash, strif, campaign, disput, autonom, democra, emancipa, sovereign, self
- Included Keyword: 177
 - Keyword Alternatives: seven

39. Key Phrase: American residents (in the 1770s) always felt the need to communicate with those farther and farther away.

- Included Keyword: America
 - Keyword Alternatives: u.s, us, states
- Included Keyword: communicat
 - Keyword Alternatives: talk, connect, chat, interact, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter
- Included Keyword: far
 - Keyword Alternatives: way, distan, remot, out, further, clos, near, apart, abroad, oversea, where, reach, beyond, yonder, seclud

40. Key Phrase: Ships carried people back and forth across the Atlantic Ocean.

- Included Keyword: people
 - Keyword Alternatives: traveler, group, person, individual, American, European, colonist, slave, foreign
- Included Keyword: cross
 - Keyword Alternatives: over, from, to, transit, between, carr, convey, transfer, shift, bring, fetch, send, deliver, bear, conduct, haul, lug, cart, run, ship, tak, mov, brought, sent, transmit, transport, freight, travers, portag, dispatch, transplant, displac
- Included Keyword: Atlantic
 - Keyword Alternatives: ocean, America, Europe, Africa, Caribbean, sea

41. Key Phrase: Ships carried correspondence across the Atlantic Ocean.

- Included Keyword: correspondence
 - Keyword Alternatives: letter, mail, message, note, missive, writ, memo, post, report, document, communi, transcript, record, epist
- Included Keyword: cross

- Keyword Alternatives: over, from, to, transit, between, carr, convey, transfer, shift, bring, fetch, send, deliver, bear, conduct, haul, cart, run, ship, tak, mov, brought, sent, transmit, transport, freight, travers, portag, dispatch, transplant, displac, log
 - Included Keyword: Atlantic
 - Keyword Alternatives: ocean, America, Europe, Africa, Caribbean, sea
42. Key Phrase: The US nation was founded on these written communiqués (correspondence).
- Included Keyword: America
 - Keyword Alternatives: u.s, us, states
 - Included Keyword: found
 - Keyword Alternatives: start, initia, form, creat, built, construct, bas, rose, establish, set, start, begin, form, bring, launch, float, develop, endow, institut, brought, originat, inaugurat, constitut, erect, commenc, pioneer, began, begun
 - Included Keyword: communi
 - Keyword Alternatives: correspondence, letter, mail, message, note, missive, writ, memo, post, report, document, transcript, record
43. Key Phrase: Much of what we know about the era (War for Independence) comes from these letters.
- Included Keyword: know
 - Keyword Alternatives: understand, learn, aware, account, histor, info, record, cognizant, conscious, savvy, privy, teach, taught, view, perceiv, realiz, receiv, recog, notic
 - Included Keyword: era
 - Keyword Alternatives: independence, period, point, colon, revolution, time, histor, earl, 17, seventeen, eighteen, 18, war
 - Included Keyword: letter
 - Keyword Alternatives: correspondence, mail, message, note, missive, writ, memo, post, report, document, communi, record, source, evidence, transcript, epist

44. Key Phrase: (One day) Text messages may provide a similar record (akin to letters) of our own moment.

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat
- Included Keyword: similar
 - Keyword Alternatives: like, kin, close, near, compar, correspon, relat, resembl, equiv, analogous, counter, match, parallel, synonym
- Included Keyword: record
 - Keyword Alternatives: correspondence, mail, message, note, missive, writ, memo, post, report, document, communi, source, evidence, transcript, epist, perm, continu, dura, long, last, mortal, end, time, year, span, length, exist, ever, serv, sustain, stand, main, through, keep, hold, futur, surviv, stay, document, file, log, entry, note, report, account, data, chronicle, memoir, catelog, writ, evidenc, summar, info, proof, prov, transcript, verif, regist, journal, manuscript, etern, histor, entri, inventor, diar, archiv, sav, preserv, conserv, kept, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulat, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, bank, sock, plac, stow, stab, constan, variabl, delible, mutable, stead, filing

45. Key Phrase: There are concerns about communication technologies.

- Included Keyword: concern
 - Keyword Alternatives: issue, problem, worry, nega, complicat, anxi, stress, bother, perturb, consider, uneas, opinion, dis, misgiving, doubt, thought, demur, troubl, reserv, reluct, inclin, apprehen, trepidat, quiet, ease, scrupl, compunct, hesit, controvers, critic, danger, fret, tens, agitat, nerv, occup, secur, angst, fear, disturb, strain, easi, easy, alarm, sceptic, skeptic
- Included Keyword: tech
 - Keyword Alternatives: phon, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron

46. Key Phrase: These quick notes (text messages) are not the same as the voluminous correspondence of ages past (i.e. Letters).

- Included Keyword: text
 - Keyword Alternatives: short, service, text, message, chat, communicat, SMS
- Included Keyword: volum
 - Keyword Alternatives: large, lot, big, great, fat, massive, size, tower, consider, tremendous, colossal, vast, extensive, prodigious, immense, giant, gigant, mon, bulk, whopp, hefty, inordinate, infinit, titan, stupend, colo, over
- Included Keyword: correspondence
 - Keyword Alternatives: letter, mail, message, note, missive, writ, memo, post, report, document, communi, record, source, evidence, transcript, epist

47. Key Phrase: “Write Me a Letter” is a monograph by Kari Fields.

- Included Keyword: Write Me a Letter
 - Keyword Alternatives: Kari, Fields, monograph

48. Key Phrase: We may have been “dumbed down” by our technologies. (Warned by Fields)

- Included Keyword: dumb
 - Keyword Alternatives: spoil, down, trivial, simp, diminish, strip, think, mind, cognit, understand, reason, attenti, abilit, competen, profici, need, necess, know, require, lower, reduce, less, streamline, prun, decreas, intelligen, mental, reduc, capab, acuit, potential, function, cogni, capacit, declin, negativ, impact, advers
- Included Keyword: tech
 - Keyword Alternatives: phon, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron

49. Key Phrase: Kari Fields wonders if the sophisticated concentration of that historical correspondence (letters) is even available to us anymore.

- Included Keyword: correspondence
 - Keyword Alternatives: letter, mail, message, note, missive, writ, memo, post, report, document, communi, transcript, record, epist
- Included Keyword: concentrat

- Keyword Alternatives: thought, emotion, sens, idea, reflect, logic, event, mem, atten, content, aware, perce, cogni, consider, contemplat, mediatat, deliberat, think, understand, intuit, impress, assum, speculat, imagin, mood, vib, react, feel, attitude, think, focus, mind, observ, regard, notic, care, caring, scrutin, heed, stud, diligen, examin, vigilan, absor, contemp, effort, spect, interest, engag, alert, involv, participat, respon, adher, note, noting, sentimen, passion, atmospher, temper, state, frame, ffect, tender, attach, sentien, heart, position, soul, experienc, center, direct, fix, apply, appli, intens, immers, devot, channel, dwell, collect, narrow, dedicat, compos, homogeni, gather, zero, occup, commit, engross, cluster, compress, consolidat, hone, honing, stead, point
 - Included Keyword: availab
 - Keyword Alternatives: access, obtain, ready, readi, attain, hand, reach, offer, presen, vacan, open, use, using, usable, dispos, stock, absen, suppl, limit, scarc, grasp, circulat, acquir, miss, grab, feasib, exist, restrict, withdraw
50. Key Phrase: “The content of our communication with each other (‘I’ll be late to work today’; ‘I’ll be home at 10’; or even, ‘I love you’) may ultimately be the same.” (Conceded by Fields)
- Included Keyword: content
 - Keyword Alternatives: material, substance, text, thing, matter, subject, mean, purpose, idea, gist, medium, concept, notion, message, essence, implication, thought, sentiment, picture
 - Included Keyword: communicat
 - Keyword Alternatives: talk, connect, chat, interact, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter
 - Included Keyword: same
 - Keyword Alternatives: similar, like, close, equal, compar, equiv, analogous, resembl, match, akin, identi, congru, equa, indentical, parallel, distinguish, correspond, uniform, even, balanc, proportion, symmetr, homogen, par, kind, line, congruen, consist, homolog, duplicat, near, relat

51. Key Phrase: “Real communication lives in the form - the tone, the unsteady hand on a particular word, the hasty erasures.” (Conceded by Fields)

- Included Keyword: communicat
 - Keyword Alternatives: talk, connect, chat, interact, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, liaison, discours, conferenc, session, repl
- Included Keyword: tone
 - Keyword Alternatives: intonat, express, flect, pitch, modul, accen

52. Key Phrase: Perhaps Fields is missing the point that everything (technologies) has compromised the way we think and understand.

- Included Keyword: Fields
 - Keyword Alternatives: Kari, character
- Included Keyword: everything
 - Keyword Alternatives: phon, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron, tech
- Included Keyword: compromis
 - Keyword Alternatives: harm, offset, cancel, annul, undo, balanc, restrict, curb, check, diminish, inhibit, bridl, bound, confin, impact, influenc, negat, crippl, sabotag, destro, ravag, wast, ruin, blight, declin, take, injur, undermin, chang, threat, danger, risk, weak, jeopard, imp, mar, damag, hurt, dis, hazard, detriment, depriv, wors, down, fell, under, peril, counter, null, valid, strain, debilitat, regula, circum

53. Key Phrase: Naysayers (critics) have said that new technologies have compromised the way we think and understand.

- Included Keyword: critic
 - Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch, several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic,

pessimist, believ, contrar, negativ, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scourn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter

- Included Keyword: compromis

- Keyword Alternatives: chang, take, jeopard, threat, imp, risk, weak, mar, hurt, dis, hazard, depriv, down, fell, under, detriment, injur, harm, danger, peril, counter, offset, cancel, null, annul, undo, valid, balanc, restrict, curb, check, diminish, strain, inhibit, debilitat, bridl, regula, circum, bound, confin, impact, influen, negat, cripl, sabotag, destro, ravag, wast, wors, ruin, blight, declin, damag

- Included Keyword: tech

- Keyword Alternatives: phone, cell, device, computer, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron

- Included Keyword: think

- Keyword Alternatives: thought, consider, cogn, aware, contemplate, calculate, mind, reason, reflect, mental, deliberate, judge, spect, sight, perce, under, know, reali, compre, accept, figur, find, grasp, catch, fathom, see, infer, learn, be, come, make, get, take

54. Key Phrase: New technologies that naysayers have criticized include the printing press.

- Included Keyword: critic

- Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch, several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic, pessimist, believ, contrar, negativ, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scourn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter

- Included Keyword: print

- Keyword Alternatives: press, paper, ink, writ, post, typograph, contrivan, publication, script, text, document, report, record, book, magazine, journal, letter, copy, copi, produc, scrib, lithograph, etch, circulat, replicat, engrav, issue, brochure, leaflet, pamphlet, illustrat

55. Key Phrase: New technologies that naysayers have criticized include the radio.

- Included Keyword: critic
 - Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch, several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic, pessimist, believ, contrar, negativ, opponen, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scourn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter
- Included Keyword: radio
 - Keyword Alternatives: signal, wave, tele, communic, cast, broad, transmi, wire, spectrum, transceiv, walkie, talkie, frequenc

56. Key Phrase: New technologies that naysayers have criticized include the movie screen.

- Included Keyword: critic
 - Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch, several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic, pessimist, believ, contrar, negativ, opponen, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scourn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter
- Included Keyword: screen
 - Keyword Alternatives: movie, film, house, cine, multiplex, theatre, theater, venue, hall, auditor, present, view, watch, observ, big, project, palace, silver, display, panel, monitor, video, television, tv, t.v, vision, visual, flick, motion, featur, pictur, celluloid, reel

57. Key Phrase: New technologies that naysayers have criticized include Google.

- Included Keyword: critic
 - Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch, several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic, pessimist, believ, contrar, negativ, opponen, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scourn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter
- Included Keyword: Google
 - Keyword Alternatives:

58. Key Phrase: The medium of the communication technology (by boat, Pony Express, post, or email) makes no difference (is not the message).

- Included Keyword: medium
 - Keyword Alternatives: means, tech, phon, cell, device, comput, app, tool, gadget, equipment, machine, mech, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, communicat, text, talk, mail, method, approach, mode, way, technique, channel, vehicle, system, process, avenue, platform, outlet, practic, proceed, proced, measur, agency, course, protocol, path, strat, schem, boat, Pony, Express, post, form, carri, carry, contain, conduit, vessel, deliver, present
- Included Keyword: diff
 - Keyword Alternatives: significan, immaterial, appl, relat, extraneous, essential, importan, point, less, none, mean, nonsens, consequen, connect, correlat, consider, bother, little, equal, distinct, discrepant, dispar, diverg, vari, vary, contrast, similar, divers, semblanc, like, liking, agree, simil, deviat, heterogen, congru, depart, consist, contra, junct, opposit, defin, determin, sign, info, control, constrain, essen, idea, inten, capsulat, captur, shap, dictat, separat, imply, impli, interpret, essenc, valu, context, content, ffect, influen, result, outcom, impress, power, weight, forc, ramif, mark, percuss, cloutbear, emphasi, authori, clout, matter, relevan, amount, burden, magnitude, circumstan, interest, focus, issu, concern, depend, actual, core, basis

59. Key Phrase: The time it takes to get a message (a month, two weeks, a few days, or a few seconds) makes no difference (is not the message).

- Included Keyword: time
 - Keyword Alternatives: period, duri, duration, chance, bilit, instan, point, avail, length, span, stretch, space, occasion, moment, circumstance, weeks, day, month, year, sec, yr, use, plan, calendar, travel, signal, pass
- Included Keyword: diff
 - Keyword Alternatives: signifikan, immaterial, appl, relat, extraneous, essential, importan, point, less, none, mean, nonsens, consequen, connect, correlat, consider, bother, little, value, equal

60. Key Phrase: Fields is (already) aware of the way new technologies compromise the way we think and understand.

- Included Keyword: Fields
 - Keyword Alternatives: Kari, character
- Included Keyword: compromis
 - Keyword Alternatives: chang, take, jeopard, threat, imp, risk, weak, mar, hurt, dis, hazard, depriv, down, fell, under, detriment, injur, harm, jeopardiz, danger, peril, counter, offset, cancel, null, annul, undo, valid, balanc, restrict, curb, check, diminish, strain, inhibit, debilitat, bridl, regula, circum, bound, confin, impact, influen, negat, crippl, sabotag, destro, ravag, wast, wors, ruin, blight, declin, damag
- Included Keyword: tech
 - Keyword Alternatives: phon, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron, radio, Google, movie, print, press, TV, tele, Internet, creation, AI, artificial, intelligen, info, virtual, VR, blockchain, AR, data, robotic, cyber, 3D, auto, network, commerce, mobile, digital, quantum, screen

61. Key Phrase: Fields is a sophisticated historian of communication media.

- Included Keyword: sophisticat

- Keyword Alternatives: elegant, refine, cultivate, polish, class, fancy, graceful, worldly, chic, fashion, style, taste, distinct, finesse, poise, cultured, mature, charm, suave, panache, flair, art, polite, urban, dignified, smooth, written, letter, mail, parchment, paper, pen, ink, quill, note, memo, report, epistle, SMS, short, service, Kari, Fields, historical, social, world, teach, profess, job, occupation, field, special, intellect, educate, know, inform, develop, complex, advanced, exquisite, perceive, enlighten, expert, scholar, research, archival, academic, analyze, document, chronicle, invest, antique, interpret, record, keep
 - Included Keyword: media
 - Keyword Alternatives: letter, mail, post, Pony Express, pen, ink, text, talk, call, chat, message, parchment, paper, quill, means, method, device, tech, mech, process, social, world, country, nation, state, network, interact, engage, mingle, converse, communicate, connect, interact, contact, meet, relate, respond, speak, touch, bond, discuss, link, bridge, dialog, exchange, liaison, discourse, conference, session
62. Key Phrase: New technologies (computers, phones, text messaging, internet) forced us to spread our limited attention spans too thin.
- Included Keyword: new
 - Keyword Alternatives: modern, current, present, recent, latest, novel, date, fresh, release, art, contemporary, future, hot, trend, original, innovative, unique, edge, break, pioneer, revolution, creative, advance
 - Included Keyword: tech
 - Keyword Alternatives: phone, cell, device, computer, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron, radio, Google, movie, print, press, TV, tele, Internet, creation, AI, artificial, intelligent, info, virtual, VR, blockchain, AR, data, robotic, cyber, 3D, auto, network, commerce, mobile, digital, quantum, net, web
 - Included Keyword: limit
 - Keyword Alternatives: thin, reduce, lower, diminish, less, restrict, constrain, inhibit, cap, hinder, narrow, press, impede, hamper, hold, quash, quell, damp, obstruct, dwindle, cripple, decrease, weak, cut, short, truncate, trim, under, worsen, prune, confine, detract, bridle

- Included Keyword: attention
 - Keyword Alternatives: aware, notice, observ, heed, regard, scrutin, mind, recog, focus, fix, thought, think, engage, immers, mental, cog, perc, reali, alert, concentrat, engross, absor, vigil, applica, attentiv
63. Key Phrase: Text messages and the Internet have isolated us from one another (by placing us alone at our computers or on our phones).
- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat, net, tech, phon, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron, internet, web
 - Included Keyword: isolat
 - Keyword Alternatives: cut, separat, part, block, off, cloister, segregat, dis, confin, divid, cordon, split, exclu, sever, sequest, alien, rift, gap, detach, seclud, quarantin, insulat, fractur, spac
64. Key Phrase: We typically send text messages while doing other activities.
- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat, correspond, note, send, receiv, see, mail, post, mak, typ, writ, get
 - Included Keyword: act
 - Keyword Alternatives: interest, hobb, endeavo, task, work, pursuit, tim, deed, thing, engagement, labor, exercis, errand, commission, job, dut, responsibilit, commit, assignment, obligation, chore, event, affair, bus, recreation, mission, vocation, occup, profession, gig, routine, ventur, practic, project, exercis
65. Key Phrase: Other activities (while texting) include browsing on the web.
- Included Keyword: web
 - Keyword Alternatives: net, world, wide, online, cyber, space, informat, superhighway, virtual, digit, data, connect, wifi, computer, tech, device, mobile, PC, laptop, mouse, keyboard, type, typi, search, engine, surf, explor, google, bing, firefox, yahoo, navigat

66. Key Phrase: Other activities (while texting) include listening to music or podcasts.

- Included Keyword: listen

- Keyword Alternatives: activit, task, music, podcast, record, hear, enjoy, tune, attend, take, absorb, attent, appreciat, focus, groove, sound, engross, captivat, entranc, fascinat, hook, spellbound, enthrall, voic, voca, speak, spoke, harmon, rhythm, composition, melod, song, track, album, broad, cast, radio, digital, sens, listen, perce, rece, register, notic, pick, chorus, score, arrangement, piece, verse, chord, stream, audio, series, show, program, content

67. Key Phrase: Other activities (while texting) include sending messages to someone else.

- Included Keyword: some

- Keyword Alternatives: else, chat, respond, receiv, send, other, person, people, many, alternat, group, back, forth, multi, messag, different, human, friend, acquaintance, best, family, ather, grand, relative, cousin, aunt, uncle, nephew, niece, great, sister, adult, kid, child, adolescence, parent, guardian, fellow, entit, member, individual, being, participant, soul, spirit, character, mortal, subject, man, dude, sapien, identit

68. Key Phrase: Our communications are getting shorter and shorter.

- Included Keyword: communicat

- Keyword Alternatives: talk, connect, chat, interact, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter

- Included Keyword: short

- Keyword Alternatives: small, tin, little, less, mini, compact, petite, brief, succinct, condense, reduce, shrunk, shrank, shrink, concise, crop, cut, down, compress, abrupt, limit, fast, quick, time, hast, hurr, speed, rapid, swift, prompt, snap, second, thin, decreas, truncat, abbreviat

69. Key Phrase: The time we have for real interactions has shrunk.

- Included Keyword: time
 - Keyword Alternatives: period, dur, chance, bilit, instan, occasion, moment, circumstance, situation, condition, context, use, length, long, span, schedule, space, room, plan, calendar, agenda, arrangement, point, avail
- Included Keyword: interact
 - Keyword Alternatives: communicat, talk, connect, chat, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter
- Included Keyword: shrunk
 - Keyword Alternatives: short, small, tin, little, less, mini, compact, petite, brief, succinct, shrank, shrink, concise, crop, cut, down, compress, abrupt, limit, fast, quick, time, hast, hurr, speed, rapid, swift, prompt, snap, second, truncat, reduc, thin, condens, abbreviat, decreas

70. Key Phrase: All of these new devices are supposed to be time-savers.

- Included Keyword: time
 - Keyword Alternatives: conven, bene, quick, fast, optimiz, speed, brisk, energ, efficient, swift, prompt, snap, slow, hast, rapid, pac, lag, dawdl, sloth, well, effect, complet, proficien, sav, exped, productiv, streamlin, manag, accelerat
- Included Keyword: device
 - Keyword Alternatives: short, service, SMS, message, chat, communicat, net, tech, phon, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron, text, web

71. Key Phrase: In reality we spend more time using these new devices.

- Included Keyword: device

- Keyword Alternatives: short, service, SMS, message, chat, communicat, net, tech, phon, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contraption, invention, instrument, gizmo, widget, gear, material, accessor, agent, paraphernalia, electron, text, using, use, web
- Included Keyword: more
 - Keyword Alternatives: over, beyond, high, exceed, larg, great, extra, add, long, extend, further, increas
- Included Keyword: time
 - Keyword Alternatives: period, dur, chance, bilit, instan, occasion, moment, circumstance, situation, condition, length, long, span, schedule, space, room, plan, calendar, agenda, arrangement, point

72. Key Phrase: A year without seeing a dear friend seems less daunting than a few hours without the phone.

- Included Keyword: daunt
 - Keyword Alternatives: alarm, awful, fright, horri, terri, petri, dis, depress, dread, scar, fear, stress, mourn, sad, deject, bleak, bad, grim, inferior, timid, pleas, not, bother, worr, aggravat, annoy, difficult, severe, burden, consequen, signi, off, atrocious, suck, less, short, small, lower, little, limit, mini, compact, petite, brief, diminish, condense, reduce, shrunk, shrink, hamper, crop, cut, down, compress, abbreviate, decreas, restr, constrain, inhibit, cap, hinder, narrow, confine, short, favor, shrank, hard, challeng, tough, demand, strain, rigor, stenu, ardu, labor, intens, gruel, tax, Hercule, formid, try, hectic, tire, tiring, complicat, involv, complex, rough, sever, exhaust, harsh, yield, effort, break, test, uphill, battl, drenu, heav, handl, problem, sap, intimidat, terrif, startl, appall, dismay, courag, nerv, cow, heart, whelm, petrif, shak, faze, fazing, spirit, repel, bull, torment, moral, awe, panic, upset, beat, shock, rattl, fluster, bash, agitat, stun, suppress, wild, horror, suad, shadow, threat, consternat, spook, interven, subdu, concert, concern, matter, dilemma, question, topic, subject, them, controvers, disput, content, affair, inciden, circumstanc, event, case, point, occur, phenom, occasion, instanc, factor, aspect, situat, detail, element, influen, ffect, result, outcom, impress, signif, importan, weigh, bear, mark, ramif, reverberat, footprint, aftermath, valid, poten, forc, punch, strength, power, reach, clout, exten, percuss, efficac, impetus, resona, collateral, parallel, align, touch

- Included Keyword: phon
 - Keyword Alternatives: short, service, SMS, message, chat, communicat, net, tech, cell, device, comput, app, tool, gadget, equipment, machine, mechanism, contrap-tion, invention, instrument, gizmo, widget, gear, material, accessor, agent, para-phernalia, electron, text, web
- Included Keyword: friend
 - Keyword Alternatives: companion, pal, buddy, chum, amigo, cohort, associate, sidekick, partner, comrade, acquaintance, colleague, confidante, familiar, bestie, BFF, brother, sister, soul, cohort, wingman, helper, pal, buddy, fellow, mate, helper, advocate, fan, backer, compadre, neighbor, consort, confidant, ally, al-ter, ego, familiar, amigo, cron, amiga, allies, boon, homie, homeboy, homegirl, intimate, paisan, bosum, spar, cully, support, bezzie, mucker, butty, bruv

73. Key Phrase: Text messages bring us together.

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat
- Included Keyword: together
 - Keyword Alternatives: along, partner, pair, close, collect, join, masse, side, with, uni, link, bond, connect, collect, collaborat, cooperat, group, stick, bring, brought, combin, merg, consolidat, integrat, assembl, mesh, affiliat, blend, reach, touch, bridg, collab, coop, tandem, concert, harmon, whole, cohesi, sync, mutual, amal-gamat, simultaneous, concurrent, fuse, fusing, one, once, entire, complet, ally, alli

74. Key Phrase: Text messages may be our last, best surrogate for the intimacy of “real” communication.

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat
- Included Keyword: surrogat
 - Keyword Alternatives: sub, replac, proxy, alternat, backup, resort, source, doubl, serv, swap, switch, cover, support, locum, accomodat, counterpart, assist, stand, fill, understud, remed

- Included Keyword: communicat
 - Keyword Alternatives: talk, connect, chat, interact, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter, intima, close, warm, affect, near, proxim, familiar, camarad, comrade, companion, tender, emotion, attach, relation, confiden, understand, love, loving, sens, vulnerab, friend, vicinit, ties, together, trust, depth, affinit, tight, care, caring, involv, sincer, confidant, kinship, cordial, heart, devot

75. Key Phrase: ‘(Despite the new limitations) People are interacting on a day-to-day basis with more people than their ancestors might have met in a lifetime.’ (Observed by Chacon)

- Included Keyword: interact
 - Keyword Alternatives: communicat, talk, connect, chat, engag, mingl, convers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gossip, chit, repl, natter, interfac
- Included Keyword: ancestor
 - Keyword Alternatives: grand, relat, age, old, hag, elder, crone, senior, ancient, predecessor, fore, ante, geniter

76. Key Phrase: Herberth Chacon authored “I Like You...on Facebook.”

- Included Keyword: Herberth
 - Keyword Alternatives: Chacon
- Included Keyword: I Like You
 - Keyword Alternatives: Facebook

77. Key Phrase: Text messages have gained such currency despite all their flaws.

- Included Keyword: currenc

- Keyword Alternatives: fame, popular, world, wide, renown, repute, prominent, stature, recognize, acclaim, esteem, favor, respect, value, likeability, standing, important, worth, merit, distinct, relevant, useful, impact, essence, validity, meaning, weight, contribute, effect, notoriety, utilize, admire, influence, venerate, signify, reputation, glory, presence, exist, appear, real, attend, occur, manifest, subsist, accompany, incarnate, habit, dwell, reside, incorporate, incumbent, abide, present, occupy, embody, figure, notice, evolve, command, demand, want, desire, ask, sought, seek, covet, commodity, request, need, favour, prefer, single, value, die, vogue, look, long, asset, fought, fight, compete, contend, vie, rage, thing, trend, sensation, hit, talk, hype, catch, hot, priority, visible, notable, famous, stand, stood, status, wish, attract, hotcake, market, sell, buzz, high, list, dying, prize, hyping, receive, hip, crazy, happen, prevalent, prestige
- Included Keyword: flaw
 - Keyword Alternatives: naysay, detract, disparage, complain, doubt, dispute, nitpick, fault, whine, cry, crie, fuss, wuss, people, person, some, one, other, oppose, comment, judge, pundit, review, analyze, annotate, interpret, many, few, couple, bunch, several, countless, lot, arbitrate, assess, examine, oppose, disparage, evaluate, skeptic, cynic, pessimist, believe, contrast, negative, opponent, dissent, object, scoff, anthropomorphize, question, trust, conform, defect, support, deny, denigrate, nihilist, optimist, downer, sour, poop, sceptic, Cassandra, scorn, observe, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibble, repine, grumble, niggle, cavil, mutter, perfect, blemish, weak, short, error, frail, problem, accurate, glitch, fail, deficient, drawback, limit, advantage, issue, vulnerable, Achilles, heel, pitfall, taint, bug, aberrate, prop

78. Key Phrase: The words “I love you” flashing up impersonally on a screen may have been stripped of all tone and affection.

- Included Keyword: I love you
 - Keyword Alternatives: ily
- Included Keyword: screen
 - Keyword Alternatives: picture, display, show, scene, ipod, ipad, computer, laptop, cinema, show, entertain, program, t.v, tele, phone, paraphernalia, electronic, widget, device, tool, app, gadget, equipment, machine, gizmo, monitor, tv
- Included Keyword: tone

- Keyword Alternatives: affect, lik, fond, approach, attitude, car, manner, spirit, express, mood, quality, feel, styl, voic, warm, tender, passion, desir, close, devot, heart, endear, attach, soft, admir, ador, emot, emot, excit, endear, affin, attract, senti

79. Key Phrase: The words “I love you” are nice to hear nonetheless (as SMS).

- Included Keyword: I love you
 - Keyword Alternatives: ily
- Included Keyword: nice
 - Keyword Alternatives: enjoy, welcom, friend, pleas, delight, grat, lov, good, great, awesom, nifty, peach, swell, delight, charm, genial, merry, admir, approval, attract, wonder, satisfy, marvel, dandy, com, consider, grac, thought, respect, lik, positiv, kind, generous, caring, polite, gentle, sweet, amiable, affable, courteous, tender, benevolent, sincere, altruistic, patient, radiant, genuine, help, path, support, charit, understand, cheer, uplift, joy, polish, heart, optimis, enthusi, affect

80. Key Phrase: Text messages have redefined what friendship means. (Even if our new definition of “friends” may not square with the old definition)

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat
- Included Keyword: defin
 - Keyword Alternatives: chang, modif, trans, alter, morph, adjust, shape, mend, mutat, develop, progress, board, extend, wide, stretch, expand, out, large, swell, grow, bolst, interpret, delimit, pinpoint, mark, establish, detail, explain, design, decipher, highlight, label, portray, present, reveal, express, grasp, understand, unveil, unfold, expound, character, determin, specif, identif, class, describ, clarif, demarcat, categoriz, constitut, settl, delineat, lin, exemplif, elucidat, enumerat, formulat, narrat, stat, recogniz, signif, manif, showcas, enunciat, cultivat, increas, comprehen
- Included Keyword: friend
 - Keyword Alternatives: camaras, con, mate, associ, acquaint, hom, partner, ami, boon, companion, intimate, confidant, ally, comrade, sister, pal, bosom, chum, spar, sidekick, cully, crony, bezzie, mate, mucker, butty, bruv, compadre, paisan, bro, homeboy, homie, homegirl, play, bud, amrr, allies, famil, amigo

81. Key Phrase: We can't go back to our recorded calls.

- Included Keyword: record
 - Keyword Alternatives: communi, perm, continu, keep, hold, futur, surviv, stay, file, archive, log, entry, note, report, account, data, chronicle, catalog, inventory, info, speak, spoken, oral, speech, call, convers, Utter, Say, Voice, Chime, Chat, Dialogue, Discuss, express, Exclaim, Tell, Respond, Talk, Interact, voice, Convey, vocal, articulat, verbal, enunciat, declar, pronounc, stat, recit, narrat, announc, lectur, orat, engag, hear, document, filing, entri, noting, memoir, writ, evidenc, summar, proof, prov, transcri, verif, regist, journal, manuscri, diar, archiv, histor, inventor, sav, preserv, conserv, kept, spar, retain, store, storing, hoard, maintain, shield, secur, watch, defen, held, redeem, cover, assur, shelter, salvag, stash, gather, accumulat, mass, collect, reserv, stock, pile, piling, cach, deposit, shelv, bank, sock, plac, stow, stab, constan, variab, delible, mutable, stead

82. Key Phrase: We may cast text messages off quickly (casually).

- Included Keyword: text
 - Keyword Alternatives: short, service, SMS, message, chat, communicat
- Included Keyword: quick
 - Keyword Alternatives: conven, bene, fast, speed, brisk, energ, efficient, swift, hast, rapid, well, effect, complet, exped, period, dur, instan, occasion, moment, circumstance, situation, condition, timing, optimal, forget, forgot, neglect, overlook, lose, short, remember, memor, recall, recollect, perm, etern, time, span, length, exist, serv, pass, transien, phase, temp, long, last, die, dying, stop, ceas, fizzle, expir, persist, surviv, sustain, bear, remain, abid, laps, declin, stay, last, perserver, withstand, remain, laps, declin, stay, forever, soon, disappear, leav, vanish, fade, fading, wan, waning, perpe, perennial, dissolv, dissipat, evaporat, gone, cast, trash, cast, dismiss, discard, dispos, preserv, maintain, throw, toss, junk, dump, ditch, scrap, shed, rid, chuck, expel, abandon, reject, forsak, easy, easi, ease, effort, simpl, complicat, straight, forward, challeng, problem, ignor, brush, atten, emphasis, thought, think, consider, cogn, aware, contemplat, meditat, plan, calculat, reason, focus, reflect, mental, deliberat, spect, prepar, side, away, distan, casual, concern, loos, formal

83. Key Phrase: We may have lost one of the essential elements of the human experience. (Suggested by Fields)

- Included Keyword: experienc
 - Keyword Alternatives: human, person, people, folks, men, dude, woman, women, man, individual, encount, event, adventur, journey, particip, exposur, involv, pas-sage, happen, engag, communicat, talk, connect, chat, interact, engag, mingl, con-vers, contact, network, meet, relat, respond, speak, touch, bond, socia, discuss, link, bridg, messag, dialog, exchang, discours, conferenc, session, reach, respon, liais, associat, convey, confer, shar, coordinat, social, catch, base, collab, unit, unif, integrat, mesh, affiliat, blend, rapport, interlocut, banter, palaver, parley, gos-sip, chit, repl, natter, intima, close, warm, affect, near, proxim, familiar, camarad, comrade, companion, tender, emotion, attach, relation, confiden, understand, love, loving, sens, vulnerab, friend, vicinit, ties, together, trust, depth, affinit, tight, care, caring, involv, sincer, confidant, kinship, cordial, heart, devot, occur
- Included Keyword: lost
 - Keyword Alternatives: los, depriv, forfeit, surrender, relinquish, yield, sacrific, renounc, abandon, waiv, forgo, disclaim, abdicat, desert, leav, jettison, dump, drop, ditch, discharg, eject, rid, shed, remov, eliminat, obliterat, wip, extinguish, quash, end, stop, terminat, eradicat, destr, annihilat, stamp, abolish
- Included Keyword: element
 - Keyword Alternatives: factor, aspect, compon, featur, attribut, constituent, portion, segment, piece, facet, part, bit, ingredient, strand, detail, point, unit, module, item, essential, necess

84. Key Phrase: Regardless, it's nice to know there's a world out there that's paying attention to us.

- Included Keyword: world
 - Keyword Alternatives: everyone, everybody, mankind, humankind, humanity, people, community, friend, earth, globe, planet, sphere, society, group, band, fac-tion, gang, bunch, section, company, set, circle, clique, frat, hood, leagu, popul, collective, nation, state, country, realm, land, mate, legion, horde, host, throng, multitude, crowd, drove, mass, mob, rabble, swarm, swarm, flock, herd, pack, score, army, abundan
- Included Keyword: attention

- Keyword Alternatives: aware, notice, observ, heed, regard, scrutin, mind, recog, focus, fix, thought, think, immers, mental, cog, perc, reali, attentiveness, alert, concentrat, engross, absor, vigil, applica, engag

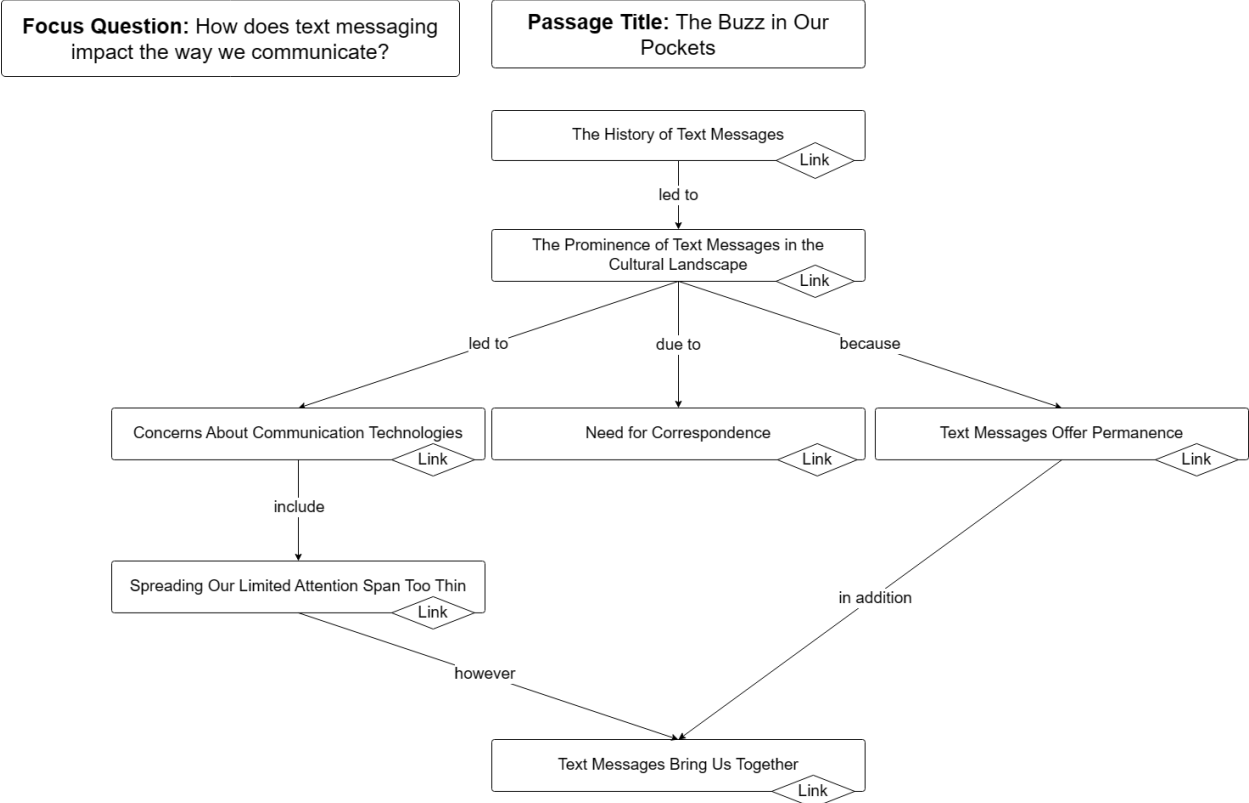


Figure B.20: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - Master-map

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Focus Question: What is the history of text messages?

Paragraph Title: The History of Text Messages

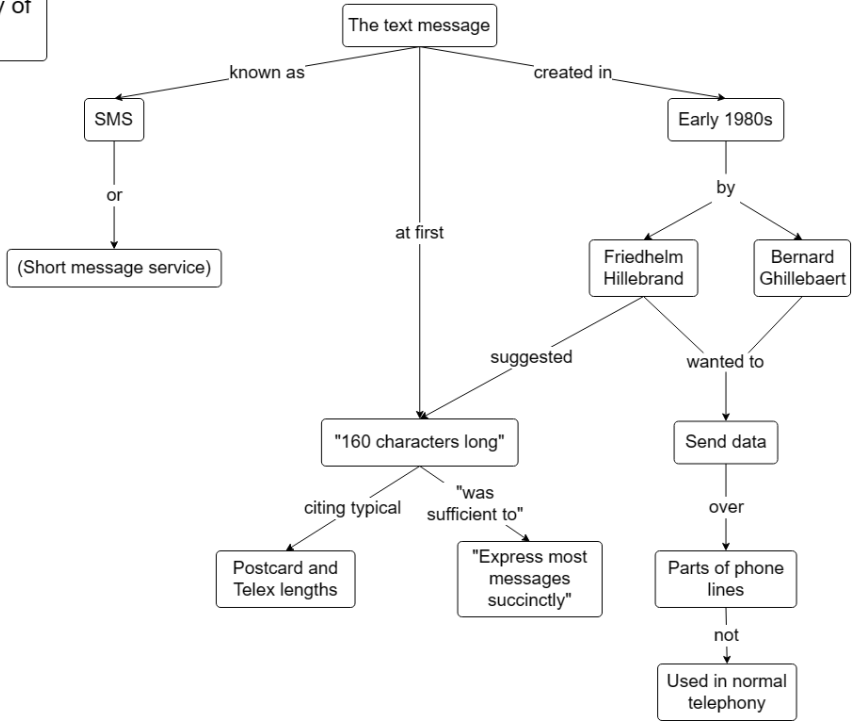


Figure B.21: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - mini-map1

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Paragraph Title: The Prominence of Text Messages in the Cultural Landscape

Focus Question: How is text messaging prominent in the cultural landscape?

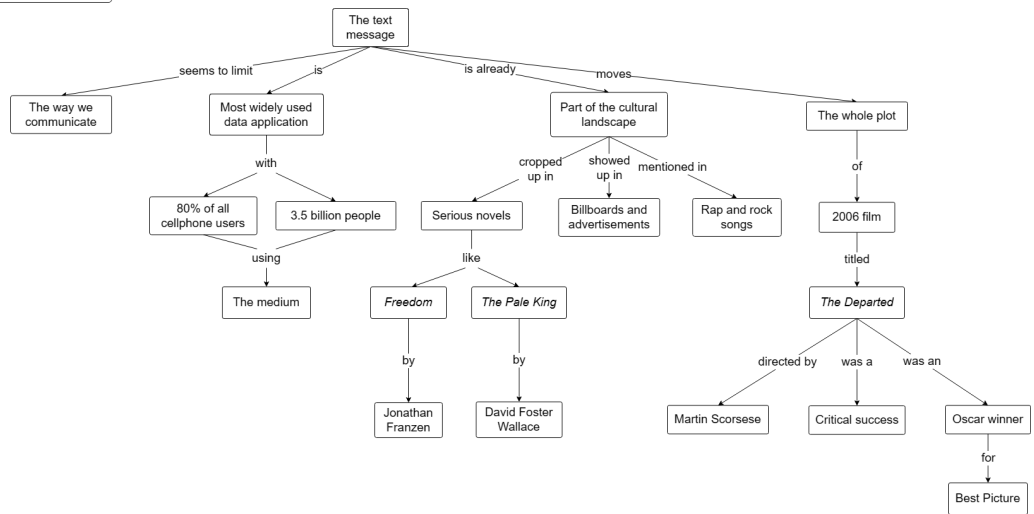


Figure B.22: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - mini-map2

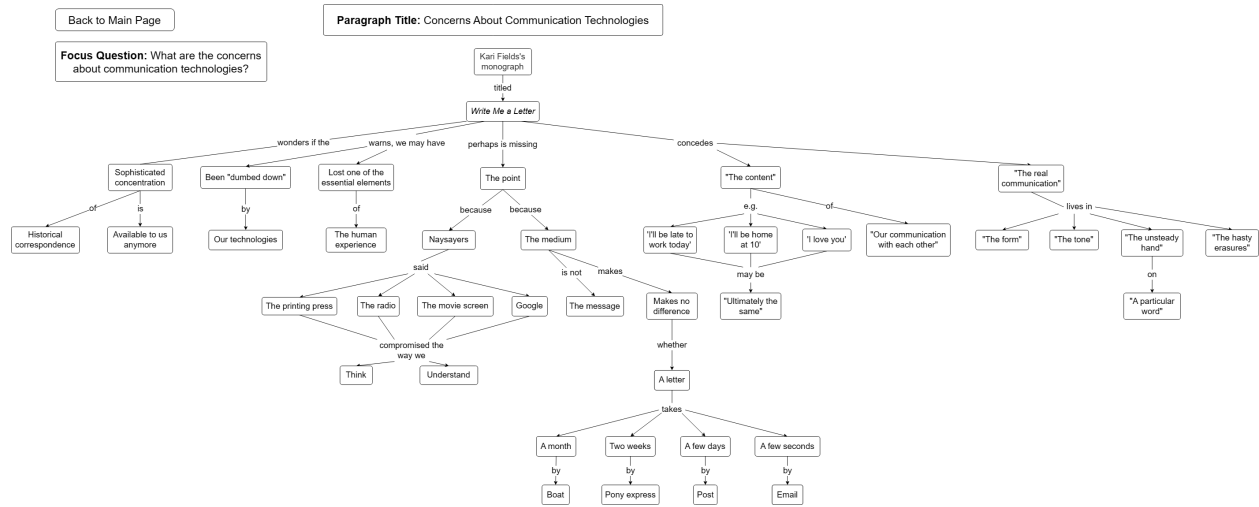


Figure B.23: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - mini-map3

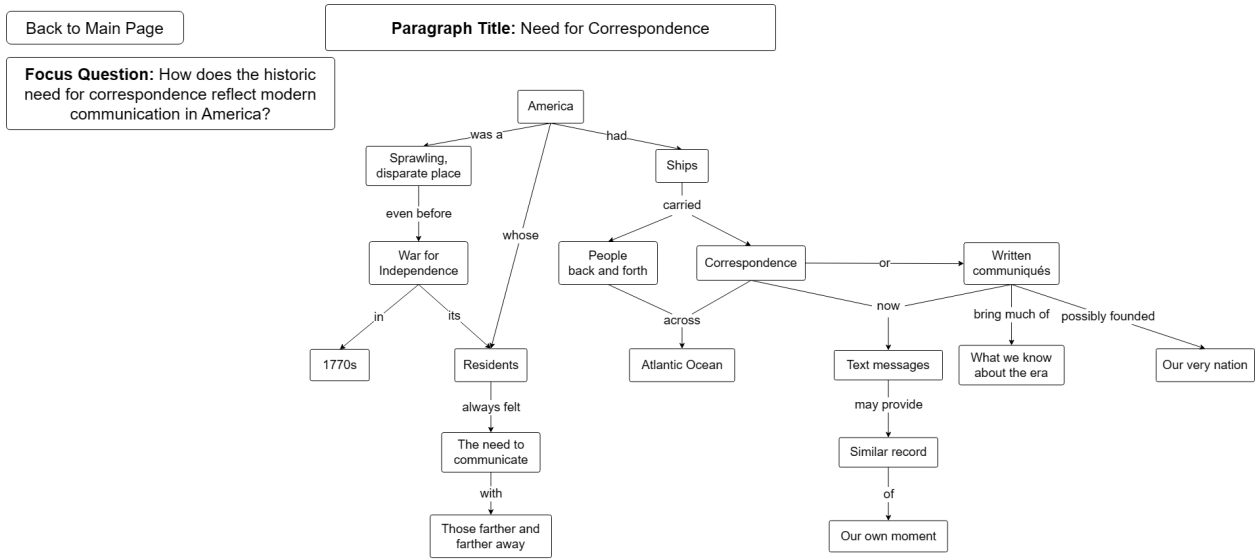


Figure B.24: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - mini-map4

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Paragraph Title: Text Messages Offer Permanence

Focus Question: How does the permanence of text messages separate it from other modes of communication?

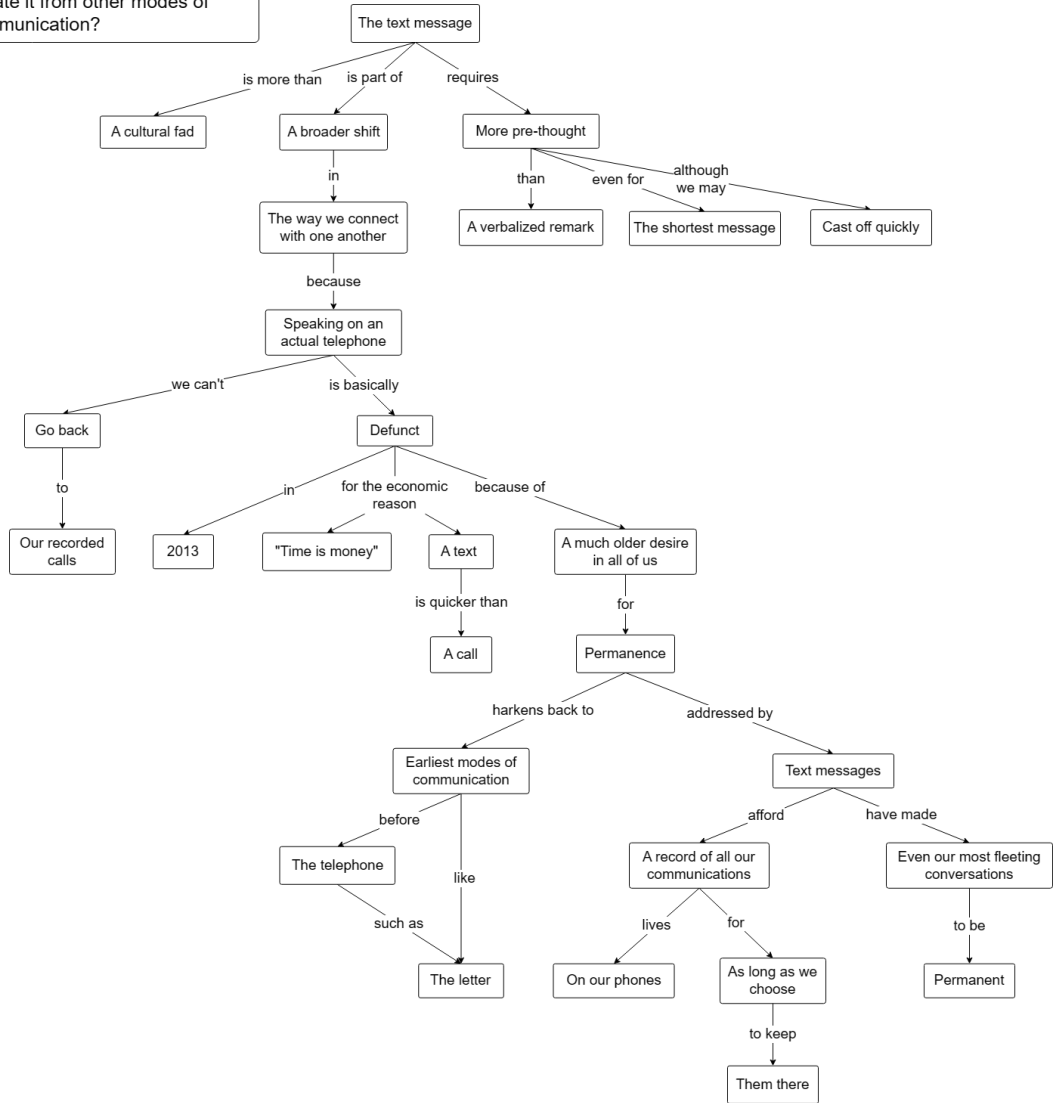


Figure B.25: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - mini-map5

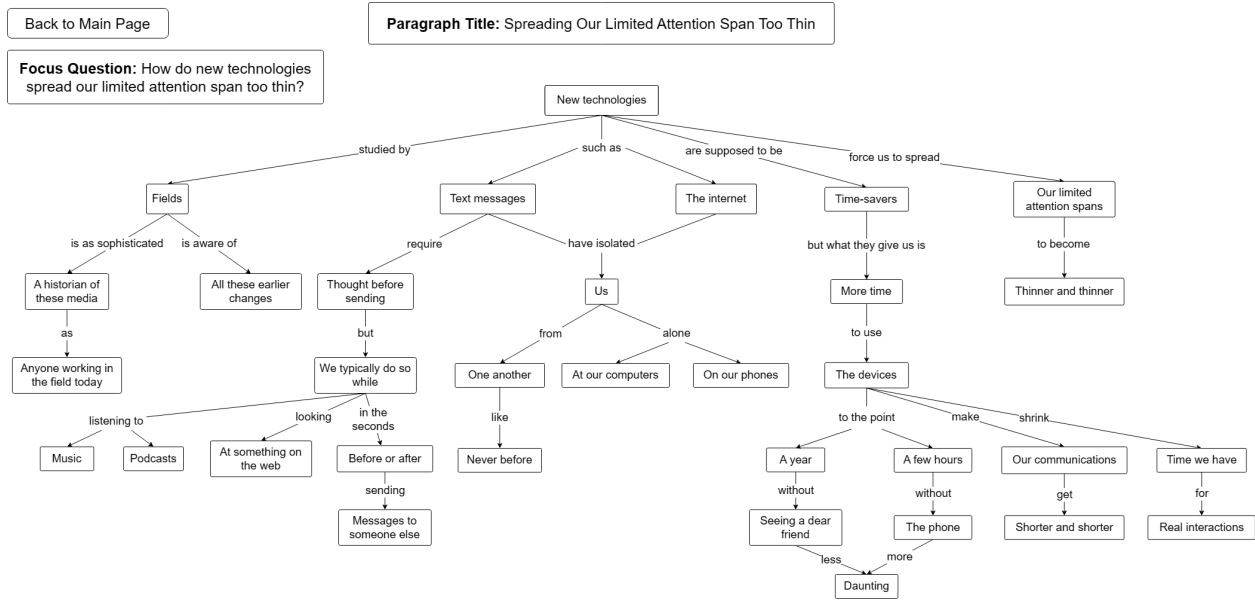


Figure B.26: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - mini-map6

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Paragraph Title: Text Messages Bring Us Together

Focus Question: How do text messages bring us together?

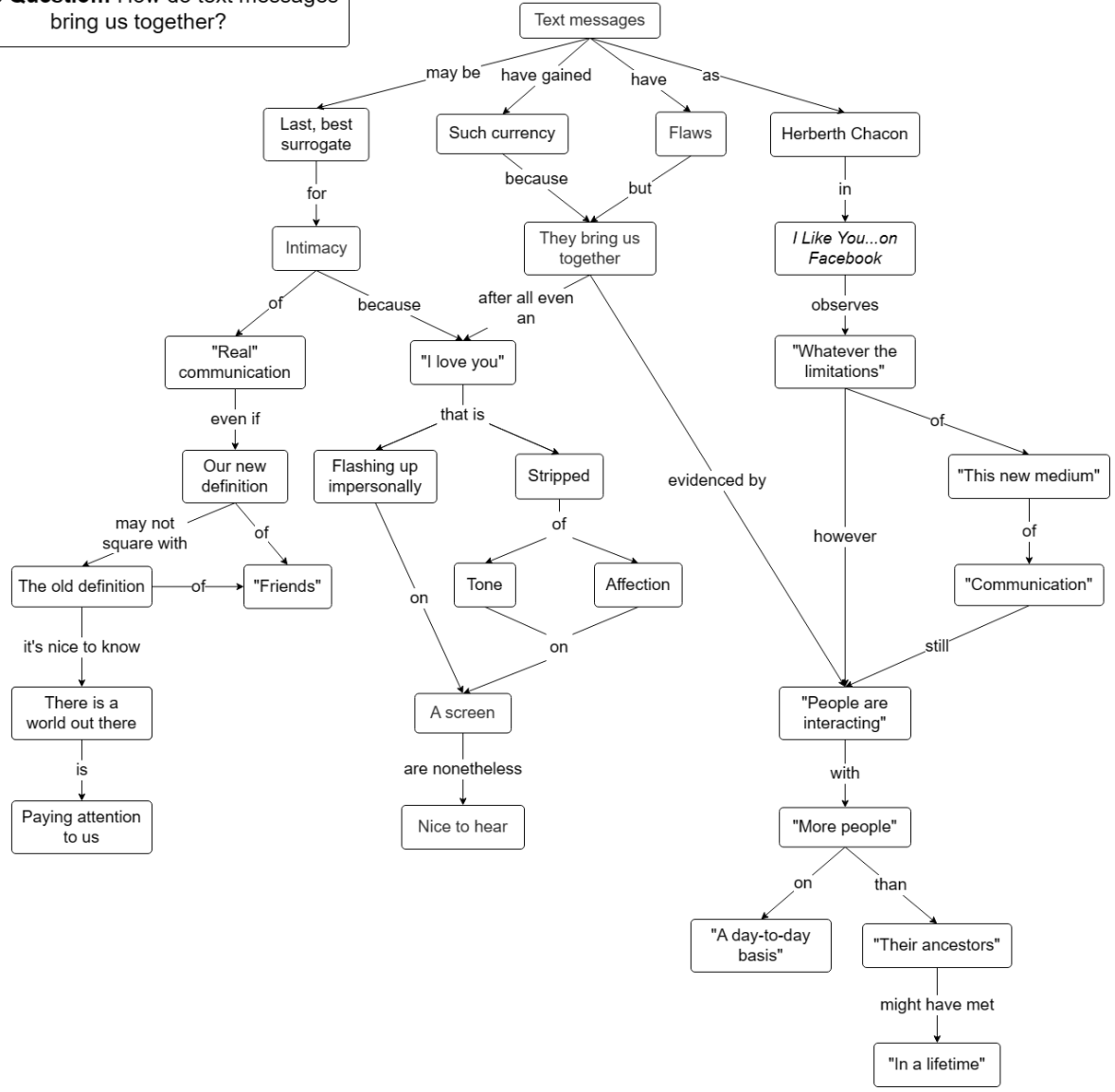


Figure B.27: Passage 3: The Buzz in Our Pockets in Novakian Knowledge Model (K) condition - mini-map7

B.2.4 Passage 4: Prima Ballerina

The modified multiple-choice questions used for this passage are as follows:

1. The point of view from which the passage is told is best described as that of:
 - (a) a son who understands his mother's thoughts.
 - (b) a narrator who relates events from the perspective of Alejandro.
 - (c) a school girl seeing classical ballet for the first time.
 - (d) an impartial narrator who understands what the characters are thinking.

Question Type: Inferential

2. The passage establishes all of the following about Isabel EXCEPT that she:
 - (a) had wanted to be a dancer when she was a child.
 - (b) could identify with some of the issues that Cinderella faced.
 - (c) felt that Swan Lake accurately portrayed the process of falling in love.
 - (d) enjoyed performing.

Question Type: Inferential

3. Which of the following statements best characterizes Alejandro's relationship with his mother, as it is presented in the passage?
 - (a) He feels isolated from her.
 - (b) He hopes to become a dancer to please her.
 - (c) He would like his mother to visit him.
 - (d) He is hesitant to spend time with her.

Question Type: Factual

4. In the passage it discusses a school trip on a cold bright day in 1967, where she boarded a rusty, sputtering, bus for a class field trip to the Palace of the Galician Centre to see Alicia Alonso dance. This primarily serves to:
 - (a) suggest that the theater building was more important to Isabel than the ballet performance.

- (b) describe the experience of going to the Cathedral.
- (c) imply that the fear Isabel felt prevented her from enjoying the ballet.
- (d) provide details that show how new and strange an experience was.

Question Type: Inferential

5. Isabel's reaction to the Giselle performance is most clearly reflected in the way Isabel:
- (a) tried to walk quietly
 - (b) couldn't lean back
 - (c) wept for weeks afterwards
 - (d) embraced him warmly

Question Type: Factual

6. The passage indicates that Alejandro ultimately decided to buy the tickets to see Baryshnikov because Alejandro:
- (a) decided to take a chance on an obscure dancer.
 - (b) thought his mother loved Baryshnikov.
 - (c) was unable to get tickets to the Miami Ballet.
 - (d) realized that Baryshnikov was unlikely to perform in Cuba.

Question Type: Inferential

7. The phrase "She tried to walk quietly, but her hard-soled school shoes insisted on asserting their presence on the shiny floor and the immense marble staircase that curved insistently upward, seemingly to heaven". is most likely included in the passage to suggest that Isabel:
- (a) was awed by the grandeur of the theater.
 - (b) believed the staircase led to heaven.
 - (c) became tired climbing the stairs.
 - (d) was afraid of heights.

Question Type: Inferential

8. The statement “Isabel to the joyful and yearning world of peasant girls celebrating the bountiful harvest and young love. She knew those feelings, but had never been” most nearly means that Isabel:

- (a) was ashamed of the poverty of her childhood.
- (b) thought her feelings could only be expressed through ballet.
- (c) believed she would never experience love.
- (d) was deeply moved by ballet performances.

Question Type: Inferential

9. The statement “she hadn’t known such places existed” most directly refers to the fact that Isabel:

- (a) was unaware that there was anything like the Palace of the Galician Center in Cuba.
- (b) had never travelled to the country to celebrate the bounty of the harvest.
- (c) wore only shoes with no heels before she became an adult and started shopping at fancier shoe stores.
- (d) had heard stories about what the interior of the Cathedral looked like but had never visited it herself.

Question Type: Inferential

10. According to the passage, the event that made Isabel feel “as if she was the mechanical doll CopÃ©llia suddenly brought to life” was:

- (a) the time her son called to say he had tickets to see Baryshnikov.
- (b) traveling to Miami to see Baryshnikov dance.
- (c) going to the see Alicia Alonso perform when she was a school girl.
- (d) attending the Miami Ballet’s performance of Giselle.

Question Type: Factual

The following shows the original ACT reading comprehension passage in linear format. This passage was obtained from ACT Advanced: Targeted Prep and Practice for the Hardest ACT (available at [Crack ACT](#)). This passage in Hybrid Map (H) format is shown in Figure B.28. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent

Novakian concept maps (K) are shown in Figure B.29, Figure B.30, Figure B.31, Figure B.33, Figure B.33, Figure B.34 and Figure B.35. The interactive version that the participants studied through is available [here on Draw.io](#).

Prima Ballerina

After the revolution, her life had become different in many ways, but the ballet was the thing that stood out in vivid color among her faded black-and-white memories of early childhood. Going to school was strange enough. Her older sister hadn't gone, because girls didn't, and her brother didn't, because they couldn't afford the fees. Under the new regime, however, not just poor children, but even poor girls went to school.

Nevertheless, school was at least something she had known about. That cold, bright day in January of 1967, when she boarded a rusty, sputtering bus for a class field trip to the Palace of the Galician Centre to see Alicia Alonso dance *Giselle*, felt like a rebirth to her, as if she were emerging from her cocoon into a new and bigger world. She couldn't believe she was going to actually walk into such a stately building, and was half-afraid that the marble statues keeping watch over the entrance would come to life and forbid her to enter. Enter she did though, and the grandness of the interior forced her into a hush, as if she were in the Cathedral, not a theater. She tried to walk quietly, but her hard-soled school shoes insisted on asserting their presence on the shiny floor and the immense marble staircase that curved insistently upward, seemingly to heaven.

Years later, Isabel Moreno would go to that theater many times, confidently clicking her high-heeled shoes on the same staircase, but that day as a schoolgirl, she hadn't known such places existed. She sat gingerly on the edge of her seat, afraid to lean back into the luxurious plush red upholstery. Then, when the music started and the dancers appeared, she couldn't lean back because she was so mesmerized by what was happening on stage. The elegance of the ballerinas in their pointe shoes was unlike anything she had seen; the dancers' movements, impeccably controlled and flawlessly in time with the music, transported Isabel to the joyful and yearning world of peasant girls celebrating the bountiful harvest and young love. She knew those feelings, but had never been able to imagine or express them as perfectly as the dancers did.

After the performance, Isabel had begged her mother to let her try out for the ballet school—she felt as though her life would never have meaning unless she could be one of those dancers on stage. She wasn't accepted, and wept for weeks afterwards. Even as an adult, every time she went to the ballet she felt that overwhelming sadness again that became so powerful it felt strangely joyful. The pas de deux of Siegfried and Odette in Act 2 of *Swan Lake* seemed to her a more truthful presentation of the

awakening of love than anything she would experience in real life. When Cinderella had to leave the ball at the end of Act 2 for fear of being discovered as her dress turned back to rags, Isabel felt keenly the anxiety of living a relatively comfortable life, so far removed from the poverty of her childhood.

Isabel's son, Alejandro, had been trying to get her to come visit Miami for years, but she had never accepted, claiming that the paperwork was too complicated, that she couldn't take the time off from the hospital. Alejandro had tried to entice his mother with visits to the Miami Ballet, but Isabel wasn't interested. The dancers in Miami weren't as good as the Cuban dancers, she'd say. Eventually, Alejandro realized he had to tempt her with something she couldn't see in Havana. When he called Isabel to say he had purchased tickets to see Mikhail Baryshnikov in Miami, it was as if she were the mechanical doll Coppélia suddenly brought to life. She needed to see the legendary Russian dancer who had defected from the Soviet Union and abandoned classical ballet for modern dance with a fierceness that overcame her hesitations about paperwork and vacation time.

The program started with a short solo dance by Baryshnikov, and he was a marvel of unassuming, fluid grace. Isabel had often thought that male dancers were too assertively athletic, that the ballerinas were the real stars of the show. But that evening, in that short, simple dance, Isabel understood that the classical Cuban ballet she so loved was only one small part of the expressive possibility of dance. She was transported back to that first day at the ballet when she was a schoolgirl, and she felt that same sense of wonder that she hadn't known about this heartbreakingly beautiful art form before. When the first dance ended, she was too stunned to clap. Alejandro touched her arm lightly, worried that Isabel hadn't liked it. After a moment, Isabel turned to her son, tears now leaking out of the corners of her eyes, and embraced him warmly. "Gracias, mi hijo," she whispered, "thank you, my son."

B.2.4.1 Key Phrases and their Boolean Expressions for Prima Ballerina

1. Key Phrase: The (Cuban) revolution affected Isabel's early life in many ways.

- Included Keyword: revol
 - Keyword Alternatives: rebel, insur, coup, riot, chang, reform, resist, trans, radic, upris, upheaval, mutiny, coup, resistance, overthrow, Cuba, gov, regim, Havana, Habana
- Included Keyword: earl

- Keyword Alternatives: child, you, kid, adolesc, life, live, time, period, year, decade, prepubesc, back, day, juv, puberty, little, small
 - Included Keyword: affect
 - Keyword Alternatives: effect, influenc, impact, alter, chang, modif, shap, transform, sway, determin, control, manipul, disturb, perturb, govern, regulat, revamp, redefin, restructur
2. Key Phrase: Memories of ballet during Isabel’s early childhood were remembered in vivid color.
- Included Keyword: mem
 - Keyword Alternatives: remin, recall, recollect, retrospect, recap, back, reliv, reflect, nostalg, thought, think, reflect, forget, mind, event, encod, retriev, experienc, tim, ruminat, still, dwell, ponder, contemplat, mus, came, com, brood, mull, delib-erat, evo, over, vis, consid, anamnesis, impression, retain
 - Included Keyword: balle
 - Keyword Alternatives: danc, choreo
3. Key Phrase: Some black-and-white memories of Isabel’s early childhood were faded.
- Included Keyword: mem
 - Keyword Alternatives: remin, recall, recollect, retrospect, recap, back, reliv, reflect, nostalg, thought, think, reflect, forget, mind, event, encod, retriev, experienc, tim, ruminat, still, dwell, ponder, contemplat, mus, came, com, brood, mull, delib-erat, evo, over, vis, consid, anamnesis, impression, retain
 - Included Keyword: black
 - Keyword Alternatives: white, fade, fading, diminish, declin, wane, waning, ebb, dwindl, weak, subsid, dull, fizzle, disappear, vanish, dissipat, evanesc, reced, abat, bleach, pale, blur, languish, taper, deteriorat, faint, die, dying, peter, lose, losing, strength, strong, flag, slack, subdu, decreas, evaporat, falter, grayscal, dark, light, ebony, ivory, ink, chrom, shadow
4. Key Phrase: Going to school (in Cuba) was strange.
- Included Keyword: school

- Keyword Alternatives: institut, academ, educat, learn
- Included Keyword: strange
 - Keyword Alternatives: Peculiar, Odd, Curious, Bizarre, Quirky, Weird, Uncanny, Eccentric, Alien, Outlandish, Enigmatic, Offbeat, Queer, common, myster, real, familiar, ordinary, regular, Typical, Standard, Average, Usual, Everyday, convent, tradition, expect, norm, standard, rule, custom, convention, protocol, principle, average, expectation, precedent, usual, ruling, practic
5. Key Phrase: Previously many children didn't attend school including Isabel's (her) older sister because girls didn't.
- Included Keyword: attend
 - Keyword Alternatives: school, institut, academ, stud, participat, regist, enroll, went, enlist, class, pupil, join, engag, learn
 - Included Keyword: girl
 - Keyword Alternatives: sister, lad, female, wom, lass, gal, miss, daught, niec, dam, gal, broad, dude, you, chick
6. Key Phrase: Previously many children didn't attend school including Isabel's (her) older brother because they couldn't afford fees.
- Included Keyword: attend
 - Keyword Alternatives: school, institut, academ, stud, participat, regist, enroll, went, enlist, class, pupil, join, engag, learn, educat
 - Included Keyword: fee
 - Keyword Alternatives: poor, pover, low, need, bad, worse, under, broke, less, indig, destit, necess, pauper, penurious, beggar, pecunious, due, charge, tuition, price, cost, afford, money, financ, income, cash, dough, bread, salar, wage, make, earn, get, fund, wealth, rich, well, prosper, fortun, profit, amount, expen, budget, spend, pay, paid
 - Included Keyword: bro
 - Keyword Alternatives: boy, lad, male, man, mis, son, neph, gent, chap, bloke, joe, hombre, dude, guy, you

7. Key Phrase: School under the new regime (in Cuba) was attended by poor children, including girls.

- Included Keyword: school
 - Keyword Alternatives: institut, academ, educat, learn, attend
- Included Keyword: poor
 - Keyword Alternatives: fee, pover, low, need, bad, worse, under, broke, less, indig, destit, necess, pauper, penurious, beggar, pecunious, due, charge, tuition, price, cost, afford, money, financ, income, cash, dough, bread, salar, wage, make, earn, get, fund, wealth, rich, well, prosper, fortun, profit, amount, expen, budget, spend, pay, paid
- Included Keyword: regim
 - Keyword Alternatives: rebel, insur, coup, riot, chang, reform, resist, trans, radic, upris, revol, upheaval, mutiny, coup, resistance, overthrow, Cuba, gov, Havana, law, Habana

8. Key Phrase: School was at least something Isabel (she) had known about.

- Included Keyword: school
 - Keyword Alternatives: institut, academ, educat, learn
- Included Keyword: know
 - Keyword Alternatives: recogni, seen, heard, perce, observ, heed, remark, awar, knowledg, aquaint, consider, gloss, look, atten, regard, stock, idea, found, find, info, detail, learn, cognizant, conscious, vers, date, familiar, privy, knew, clue, ed- ucat, rais, enlight, taught, teach, experien, understand, understood, ground, expos, sight, went, go, encount, live, subject, intro, mind, comprehen, tun, acquaint, con- vers, speed, stranger, oblivious, ignor, naiv, dark, loop, party, involv, invest, alert, sens, grasp, catch, notic

9. Key Phrase: Isabel had a class field trip in January of 1967.

- Included Keyword: school
 - Keyword Alternatives: class, field, trip, excursion, out, broad, day, jaunt, expe- dition, ride, journ, academ, institut, stroll, tour, travel, explor, junket, ventur, es- capad, odyssey, visit

- Included Keyword: Jan
 - Keyword Alternatives: 1967, nine, sixty, seven

10. Key Phrase: Isabel had a class field trip on a cold, bright day.

- Included Keyword: class
 - Keyword Alternatives: school, field, trip, excursion, out, broad, day, jaunt, expedition, ride, journ, stroll, tour, travel, explor, junket, ventur, escapad, odyssey, visit, academ, institut
- Included Keyword: cold
 - Keyword Alternatives: bright, chill, frigid, freez, icy, icicle, frost, glac, polar, nipp, cool, bitter, arctic, wint, gelid, frozen, numb, shiver, zero, raw, brisk, ice, lumin, radian, dazzl, shin, gleam, sparkl, glow, beam, vivid, shimmer, scintillat, resplend, glist, glim, twinkl, luster, lustrous, incandescen, effulg, glint, sun

11. Key Phrase: Isabel boarded a rusty, sputtering bus.

- Included Keyword: bus
 - Keyword Alternatives: rust, coach, vehicle, ricket, old, ratt, ragg, corrod, oxidi, tarnish, decay, deteriorat, weather, erod, crumbl, degrad, worn, fade, fading, aged, aging, antique, ancient, patinat, vintag, dilapidat, crust, rugg, down, dull, pitt, fuzz, lack, wither, spit, stammer, falter, hesistat, babbl, tripp, flounder, fumbl, struggl, hiccup, chok, chatter, gurgl, coher, jibber, jabber, prat, garbl, quaver, titter, quiver, sizzl, tumbl, stall, break, squeak, splat, cough, jerk, spasm, pulsat, trembl, stead, bumbl, utter, stumbl, crackl, fizzl, hiss, gush, prattl, splash, bubbl, burbl, stifl

12. Key Phrase: Isabel's class field trip was to the Palace of the Galician Center.

- Included Keyword: Galician Center
 - Keyword Alternatives: palace, galician, center, auditorium, hall, building, venue, theat
- Included Keyword: class
 - Keyword Alternatives: school, field, trip, excursion, out, broad, day, jaunt, expedition, ride, journ, stroll, tour, travel, explor, junket, ventur, escapad, odyssey, visit, academ, institut

13. Key Phrase: Isabel's class field trip was to see Alicia Alonso dance "Giselle".

- Included Keyword: class
 - Keyword Alternatives: school, field, trip, excursion, out, broad, day, jaunt, expedition, ride, journ, stroll, tour, travel, explor, junket, ventur, escapad, odyssey, visit, academ, institut
- Included Keyword: Alicia
 - Keyword Alternatives: Alonso, Giselle
- Included Keyword: Isabel
 - Keyword Alternatives: kid, child, girl, lad, female, wom, lass, gal, mis, dam, broad, adolesc, pubesc, chap, bloke, joe, hombre, juv, educat, learn, attend, Moreno, chick, you, character, protagonoist, heroine, pupil, student

14. Key Phrase: Watching "Giselle" felt like a rebirth to Isabel.

- Included Keyword: birth
 - Keyword Alternatives: born, new, transform, inspir, morph, incarnat, awak, enlight, juvenat, form, chang, reviv, renaissance, renascence, dawn, com, start, begin, restor, surg, clear, fresh, discover, find, found, rich, open, see, view, observ, shap, evolv, alter, emerg, brought, bring, fold, creat, foster, nurtur, rais, begat, begot, acquir, obtain, gain, affect, effect, spark, touch, trigger, shift, transit, motiv, brand, invent, chanc, cast, differ, work, haul, made, mak, build, built, vigor, cocoon, live, living, rise, rising, experienc, influen
- Included Keyword: Alicia
 - Keyword Alternatives: Alonso, Giselle, balle, choreo, danc
- Included Keyword: Isabel
 - Keyword Alternatives: kid, child, girl, lad, female, wom, lass, gal, mis, dam, broad, adolesc, pubesc, chap, bloke, joe, hombre, juv, educat, learn, attend, Moreno, chick, you, character, protagonoist, heroine, pupil, student

15. Key Phrase: Isabel's rebirth felt as if she were emerging from her cocoon into a new and bigger world.

- Included Keyword: birth

- Keyword Alternatives: born, new, transform, inspir, morph, incarnat, awak, enlight, juvenat, form, chang, reviv, renaissance, renascence, dawn, com, start, begin, restor, surg, clear, fresh, discover, find, found, rich, open, see, view, observ, shap, evolv, alter, emerg, brought, bring, fold, creat, foster, nurtur, rais, begat, begot, acquir, obtain, gain, affect, effect, influence, spark, touch, trigger, shift, transit, motiv, brand, invent, chanc, cast, differ, work, haul, made, mak, build, built, vigor, cocoon, live, living, rise, rising, experienc, influen
- Included Keyword: new
 - Keyword Alternatives: modern, current, present, recent, latest, novel, date, fresh, releas, art, contemporary, futur, hot, trend, original, innovat, unique, edge, break, pioneer, revolution, big, large, great, high, expand, superior, grand, immense, monumental, substantial, enhanc, increas, extensive, huge, vast, transition, emerg, unfold, develop, rise, rising
- Included Keyword: Isabel
 - Keyword Alternatives: kid, child, girl, lad, female, wom, lass, gal, mis, dam, broad, adolesc, pubesc, chap, bloke, joe, hombre, juv, educat, learn, attend, Moreno, chick, you, character, protagonoist, heroine, pupil, student

16. Key Phrase: “The Palace of the Galician Center” was a stately building which Isabel couldn’t believe she had walked into.

- Included Keyword: Galacian Center
 - Keyword Alternatives: Galacian, palace, center, theat, auditorium, hall, building, venue
- Included Keyword: state
 - Keyword Alternatives: presence, digni, majes, court, ceremon, imp, awe, solemn, grand, regal, elegant, splend, luxur, mass, strik, stagger, stun, stand, remark, formid, prominem, significan, conspicuous, distinct, resplend, notab, extra, salien, incredible, defined, distin, establish, unmistakable, recognizable, conspicuous, remarkable, salien, striking, pronounced, respect, mistak, asto, phenom, opulen, rich, royal, lus, ornate, ostentatious, flash, sumptuous, deluxe, posh, class, haught, rad, exuber, character, magnif, exquisit, breath, loft, eye, famous, fame, amaz, captivat, belie, beaut, shock, mesmeriz, fancy

- Included Keyword: walk
 - Keyword Alternatives: shoe, tread, mov, step, hik, pac, stroll, feet, foot, sole, ambl, go, mill, roam, wander, meander, shuffl, strut, mosey, idle, idling, strid, trod, trek, trudg, went, tour, advanc, cross, way, path, proceed, trave, ambulat, journ, leg, pass, explor, plod, navigat, cut, cover, led, guid, follow, route, course, trail, sneak, boot, heel, trainer, tramp, saunter, cruiss, gait, creep, toe, slip, skulk, edg, glid, hurr, inch, slid, worm, slither, eas, ooz, roll, skitter, scuff, lumber, laddl, stagger, thud, totter, teeter, stray, rang, coast, loiter, loung, wind, wiggl, snak, fit, flit, scamper, scurr, rove
- Included Keyword: believ
 - Keyword Alternatives: trust, faith, rely, reli, accept, consider, convinc, credit, buy, bought, confiden, regard, sure, suring, count, doubt, hunch, reason, true, truth, assum, deem, hold, presum, certain, swear, think, suppos, opin, affirm, conclud, conceiv, feel, imagin, perce, suspect, gather, acknowledg, grant

17. Key Phrase: “The Palace of the Galician Center” housed marble statues.

- Included Keyword: Galician Center
 - Keyword Alternatives: Galacian, palace, center, theat, auditorium, hall, building, venue
- Included Keyword: statue
 - Keyword Alternatives: scuplt, figur, idol, carv, effigy, image, model, bust, represent, art, piece, form, cast, shape, cut, etch, chisel, hew, mar

18. Key Phrase: The marble statues (in the “Palace of the Galician Center”) kept watch over the entrance.

- Included Keyword: statue
 - Keyword Alternatives: scuplt, figur, idol, carv, effigy, image, model, bust, represent, art, piece, form, cast, shape, cut, etch, chisel, hew, mar
- Included Keyword: entr
 - Keyword Alternatives: open, door, ingress, access, gate, mouth, drive, thresh, admi, avenue, way, lobby, pass, facade, front, head, anterior, enter, portal, vestibule, inlet

- Included Keyword: watch
 - Keyword Alternatives: guard, observ, monitor, supervis, patrol, oversaw, oversee, look, eye, survey, surveil, safe, protect, regard, check, examin, control, inspect, atten, secur, regulat, alert, vigil, gaze, gazing, shadow, view, witness, peer, contemplat, stare, staring, scan, track, tabs, defend, shield, preserv, screen, shelter, cover, sentinel, fortif, maint, hold, ward, fend

19. Key Phrase: The marble statues (in the “Palace of the Galician Center”) made Isabel half-afraid that they would come to life.

- Included Keyword: statue
 - Keyword Alternatives: scuplt, figur, idol, carv, effigy, image, model, bust, represent, art, piece, form, cast, shape, cut, etch, chisel, hew, mar
- Included Keyword: life
 - Keyword Alternatives: mov, live, breath, anima, wak, conscious, act, cognizant, walk, aware, alert, repon, sens, mind, perce, see, burst, reviv, living, resurrect, thriv, energ, vital, juvenat, vigor, rous, rise, rising, restor, sentien
- Included Keyword: afraid
 - Keyword Alternatives: scar, fright, apprehen, worr, timid, panic, hesita, dread, fear, intimidat, alarm, startl, easy, easi, cautio, tens, trembl, jitter, spook, shak, dismay, settl, secur, perturb, appall, faint, tremul, timor, aghast, quak, shudder, jump, daunt, horr, trepidat, shiver, chicken, petri, cow, terr, stress, agitat, flinch, anxi, nerv, appre, rattl, stun, grim, troubl, bother, concern, torment, wary, wari

20. Key Phrase: The marble statues (in the “Palace of the Galician Center”) made Isabel half-afraid that they would forbid her to enter.

- Included Keyword: statue
 - Keyword Alternatives: scuplt, figur, idol, carv, effigy, image, model, bust, represent, art, piece, form, cast, shape, cut, etch, chisel, hew, mar
- Included Keyword: forb
 - Keyword Alternatives: open, door, ingress, access, gate, mouth, drive, thresh, admi, avenue, way, lobby, pass, facade, front, head, anterior, stop, bar, enter, entr, portal, vestibule, inlet, ban, outlaw, bar, restrict, block, suppress, deny, interdict, hinder, prevent, deter, restrain, withhold, allow, deni, exclud, preclud, hibit

- Included Keyword: afraid
 - Keyword Alternatives: scar, fright, apprehen, worry, timid, panic, hesita, dread, fear, intimidat, alarm, startl, easy, easi, cautio, tens, trembl, jitter, spook, shak, dismay, settl, secur, perturb, appall, faint, tremul, timor, aghast, quak, shudder, jump, daunt, horr, trepidat, shiver, chicken, petri, cow, terr, stress, agitat, flinch, anxi, nerv, appre, rattl, stun, grim, troubl, bother, concern, torment, wary, wari

21. Key Phrase: The “Palace of the Galician Center” had a grandness of the interior.

- Included Keyword: Galacian Center
 - Keyword Alternatives: Galacian, palace, center, theat, auditorium, hall, building, venue
- Included Keyword: grand
 - Keyword Alternatives: presence, digni, majes, court, ceremon, imp, awe, solemn, state, regal, elegant, splend, luxur, mass, strik, stagger, stun, stand, remark, formid, prominen, significan, conspicuous, distinct, notab, extra, salien, incredible, defined, establish, recognizable, pronounced, respect, mistak, asto, phenom, opulen, rich, royal, lus, ornate, ostentatious, flash, sumptuous, deluxe, posh, class, haught, rad, exuber, character, magnif, exquisit, breath, loft, eye, famous, fame, amaz, captivat, belie, beaut, shock, mesmeriz, fancy, enamour, enamor
- Included Keyword: inter
 - Keyword Alternatives: inside, inner, core, cent, heart, depth, bell, content, innard, intern, inward

22. Key Phrase: The grandness of the interior (of the “Palace of the Galician Center”) forced Isabel into a hush.

- Included Keyword: grand
 - Keyword Alternatives: presence, digni, majes, court, ceremon, imp, awe, solemn, state, regal, elegant, splend, luxur, mass, strik, stagger, stun, stand, remark, formid, prominen, significan, conspicuous, distinct, notab, extra, salien, incredible, defined, establish, recognizable, pronounced, respect, mistak, asto, phenom, opulen, rich, royal, lus, ornate, ostentatious, flash, sumptuous, deluxe, posh, class, haught, rad, exuber, character, magnif, exquisit, breath, loft, eye, famous, fame, amaz, captivat, belie, beaut, shock, mesmeriz, fancy, enamou, enamor

- Included Keyword: inter
 - Keyword Alternatives: inside, inner, core, cent, heart, depth, bell, content, innard, intern, inward
- Included Keyword: hush
 - Keyword Alternatives: silen, quiet, nois, sound, mut, subdu, damp, dead, dull, vocal, ton, soft, cut, suppress, audibl, mellow, dimin, low, smother, mouth, passiv, speak, talk, tongue, breath, reduc, mini, pip, volum, shut, say, said, lip, zip, peep, word, glue, loud, spoke, rowd, boisterous, raucous, uproar, ruckus, rambunct, commotion, racket, unrul, hubbub, din, babel, chat, rattl

23. Key Phrase: The grandness of the interior (of the “Palace of the Galician Center”) made Isabel feel as if she were in the Cathedral, not a theater.

- Included Keyword: grand
 - Keyword Alternatives: presence, digni, majes, court, ceremon, imp, awe, solemn, state, regal, elegant, splend, luxur, mass, strik, stagger, stun, stand, remark, formid, prominen, significan, conspicuous, distinct, notab, extra, salien, incredible, defined, establish, recognizable, pronounced, respect, mistak, asto, phenom, opulen, rich, royal, lus, ornate, ostentatious, flash, sumptuous, deluxe, posh, class, haught, rad, exuber, character, magnif, exquisit, breath, loft, eye, famous, fame, amaz, captivat, belie, beaut, shock, mesmeriz, fancy, enamou, enamor
- Included Keyword: inter
 - Keyword Alternatives: inside, inner, core, cent, heart, depth, bell, content, innard, intern, inward
- Included Keyword: cathedral
 - Keyword Alternatives: chapel, church, basilica, sanct, temple, house, place, tabernacl, shrin, institut, building, synagogue, mosque, abbe, monaster, cloister, convent, friar, nun, palace, center, theat, auditorium, hall, building, venue

24. Key Phrase: Isabel tried to walk quietly (inside the Palace of the Galician Center).

- Included Keyword: Isabel
 - Keyword Alternatives: kid, child, girl, lad, female, wom, lass, gal, mis, dam, broad, adolesc, pubesc, chap, bloke, joe, hombre, juv, educat, learn, attend, Moreno, chick, you, character, protagnoist, heroine, pupil, student

- Included Keyword: walk
 - Keyword Alternatives: shoe, tread, mov, step, hik, pac, stroll, feet, foot, sole, ambl, go, mill, roam, wander, meander, shuffl, strut, mosey, idle, idling, strid, trod, trek, trudg, went, tour, advanc, cross, way, path, proceed, trave, ambulat, journ, leg, pass, explor, plod, navigat, cut, cover, led, guid, follow, route, course, trail, sneak, boot, heel, trainer, tramp, saunter, cruiss, gait, creep, toe, slip, skulk, edg, glid, hurr, inch, slid, worm, slither, eas, ooz, roll, skitter, scuff, lumber, laddl, stagger, thud, totter, teeter, stray, rang, coast, loiter, loung, wind, wiggl, snak, fit, flit, scamper, scurr, rove
- Included Keyword: quiet
 - Keyword Alternatives: soft, gentl, peace, calm, seren, hush, tranquil, nois, obtrusiv, still, subdu, mute, muting, assum, placid, mild, moderat, quiescen, ruffl, meek, ostentat, compos, sound, stealth, muffl, whisper, audi, faint, mellow, notic, breath, murmur, silen, seriatim, stead, reserv, hurr

25. Key Phrase: Isabel’s hard-soled shoes insisted on asserting their presence on the shiny floor (of the Palace of the Galician Center).

- Included Keyword: shoe
 - Keyword Alternatives: footwear, boot, slipper, loafer, oxford, moccasin, clog, heel, pump, flip, flop, espadrille, flat, brogue, derb, stiletto, slingback, wedg, slip, kick, sand, sneak, trainer
- Included Keyword: floor
 - Keyword Alternatives: ground, surfac, deck, pavement, foundation, footing, substrate, tile, tiling, board, platform, parquet, laminat, wood, linoleum, carpet

26. Key Phrase: Isabel’s hard-soled shoes insisted on asserting their presence on the immense marble staircase (of the Palace of the Galician Center).

- Included Keyword: shoe
 - Keyword Alternatives: footwear, boot, slipper, loafer, oxford, moccasin, clog, heel, pump, flip, flop, espadrille, flat, brogue, derb, stiletto, slingback, wedg, slip, kick, sand, sneak, trainer
- Included Keyword: stair

- Keyword Alternatives: step, way, path, route, flight, escalat, ladder, climb, graduat, scend, tread, elevat, scent

27. Key Phrase: The immense marble staircase (of the Palace of the Galician Center) curved insistently upward, seemingly to heaven.

- Included Keyword: stair
 - Keyword Alternatives: step, way, path, route, flight, escalat, ladder, climb, graduat, scend, tread, elevat, scent
- Included Keyword: heaven
 - Keyword Alternatives: land, after, paradise, kingdom, gate, house, home, nirvana, place, beyond, elysium, life, world, garden, green, jannah, shamayim, utopia, Eden, Shangri, dwell, arcadia, city, xanadu, Valhalla, height, glor, etern, known, side, isl, live, living

28. Key Phrase: Years later, Isabel Moreno went to that (“Palace of the Galician Center”) theater many times.

- Included Keyword: theat
 - Keyword Alternatives: Center, venue, build, cathedral, stag, hall, site, chateau, estate, castle, palace, villa, house, Galician, auditorium, building, mansion
- Included Keyword: year
 - Keyword Alternatives: after, shortly, same, following, succeeding, subsequent, decade, then, after, throughout, period, time, you, old, mature, futur, down, adult, grown, continue, age, aging, later

29. Key Phrase: Years later, Isabel Moreno went to that (“Palace of the Galician Center”) theater confidently clicking her high-heeled shoes on the same staircase.

- Included Keyword: theat
 - Keyword Alternatives: Center, venue, build, cathedral, stag, hall, site, chateau, estate, castle, palace, villa, house, Galician, auditorium, building, mansion
- Included Keyword: year

- Keyword Alternatives: after, shortly, same, following, succeeding, subsequent, decade, then, after, throughout, period, time, you, old, mature, futur, down, adult, grown, continue, age, aging, later
 - Included Keyword: shoe
 - Keyword Alternatives: footwear, boot, slipper, loafer, oxford, moccasin, clog, heel, pump, flip, flop, espadrille, flat, brogue, derb, stiletto, slingback, wedg, slip, kick, sand, sneak, trainer
 - Included Keyword: stair
 - Keyword Alternatives: step, way, path, route, flight, escalat, ladder, climb, graduat, scend, tread, elevat, scent
30. Key Phrase: As a schoolgirl, Isabel (she) hadn't known such places ("Palace of the Galician Center") existed.
- Included Keyword: girl
 - Keyword Alternatives: child, lass, kid, little, young, daughter, miss, gal, lady
 - Included Keyword: know
 - Keyword Alternatives: aware, appreciat, learn, notice, perciev, realize, recog, see, appre, cogni, compre, ken, grasp, discern, discrimn, inform, vers, schooled, ac- quaint, identif, experien
 - Included Keyword: place
 - Keyword Alternatives: site, spot, venue, Palace, Galician, Center, Theater
31. Key Phrase: As a schoolgirl, Isabel (she) sat gingerly on the edge of her seat (at the "Palace of the Galician Center").
- Included Keyword: ginger
 - Keyword Alternatives: cautious, care, delicat, safe, light, timid, suspicious, guard, alert, prudent, attentive, conscien, concern, fastidious, war, vigilant, guard, watch, heed, judicious, circums, discreet, chary, leery, dubious, scrup, cautio, caring, pruden, tentativ, nerv, circumspect, vigil, waril, daint, gentl, hesitan, reserv, soft, thoughtful, watchful, mild, precarious, tender, reluct, respect, consider, stealth, grac

- Included Keyword: sat
 - Keyword Alternatives: sit, seat, place, perch, plant, set, park, chair, settle, plop, flump, install, position, plunk, land, occup, rest, station, squat, reclin, lodg, nest
- Included Keyword: Isabel
 - Keyword Alternatives: kid, child, girl, lad, female, wom, lass, gal, mis, dam, broad, adolesc, pubesc, chap, bloke, joe, hombre, juv, educat, learn, attend, Moreno, chick, you, character, protagnoist, heroine, pupil, student

32. Key Phrase: As a schoolgirl, Isabel (she) was afraid to lean back on the luxurious plush red upholstery (at the “Palace of the Galician Center”).

- Included Keyword: girl
 - Keyword Alternatives: kid, child, lass, gal, mis, adolescen, student, juv, junior, dam, prepubesc, little, small, female, broad, dude, you, lad, miss, chick
- Included Keyword: lean
 - Keyword Alternatives: bend, angl, tilt, sway, tip, veer, clin, slant, curv, droop, slope, relax, calm, loose, wind, back, laz, stress, repos, clench, lax, eas, idl, down, tens, feel, home, felt, slack, wound, wind, tak, fidget, still, proper, comfort, aware, conscious, rest, breath, break, tarnish, mess, ruin, wreck, loung, sat, edge, sit, seat, place, perch, plant, set, park, chair, settle, plop, worr, flump
- Included Keyword: upholster
 - Keyword Alternatives: cover, furniture, fabric, drape, cushion, pad, stuff, couch, sofa, pillow, plush, furnish, cas, seat, chair, perch, recliner, settee, velvet

33. Key Phrase: When the music started and the dancers appeared (at the “Palace of the Galician Center”), Isabel couldn’t lean back (due to being mesmerized).

- Included Keyword: ball
 - Keyword Alternatives: danc, coryphee, song, music, piece, tune, melod, track, harmon, perform, show, play, act
- Included Keyword: lean

- Keyword Alternatives: reclin, loll, loung, slouch, reced, retir, withdraw, rest, settl, lie, lying, tilt, ease, easing, fall, subsid, loose, bend, slump, subsiden, slant, sway, sink, wind, drift, recumb, laid, lay, loaf, repos, chill, sprawl, drap, clin, angl, tip, veer, curv, droop, slop, back, laz, clench, lax, easy, easi, idl, down, tens, slack, wound, fidget, prop, break, tarnish, mess, ruin, wreck, edge, plac, perch, plant, park, plop

34. Key Phrase: When the music started and the dancers appeared (at the “Palace of the Galician Center”), Isabel was so mesmerized by what was happening on the stage.

- Included Keyword: mesmer

- Keyword Alternatives: interest, memor, novel, signif, event, impress, mean, moment, monument, forget, last, distinguish, except, extra, great, compel, substan, out, curious, fascinat, gross, rivet, captivat, exciting, appeal, thought, absorb, grip, engag, immers, consum, allur, enthrall, stimulat, thrill, entrance, spell, hypnotize, stupefy, bewitch, beguil, enchant, ensorcell, magnetiz, lost, into, delight, dazzl, hook, drawn, infatuat, move, intrigu, transfix, awe, breath, engross, stun, hypnoti, charisma, inspir, marvel, spec, amaz

- Included Keyword: ball

- Keyword Alternatives: danc, coryphee, song, music, piece, tune, melod, track, harmon, perform, show, play, scene, act

- Included Keyword: stag

- Keyword Alternatives: platform, spac, proscenium, arena, venue, set, podium, dais, stand, rostrum, pedestal, ambo, pulpit, riser, plinth, scaffold, lectern, board, theat, Palace, Center, venue, build, cathedral, stag, hall, site, chateau, estate, castle, villa, house, Galician, auditorium, building, mansion

35. Key Phrase: The ballerinas (at the “Palace of the Galician Center”) were in pointe shoes.

- Included Keyword: pointe

- Keyword Alternatives:

36. Key Phrase: (At the “Palace of the Galician Center”) The ballerinas’ elegance was unlike anything Isabel (she) had seen.

- Included Keyword: ball

- Keyword Alternatives: danc, coryphee
 - Included Keyword: elegan
 - Keyword Alternatives: digni, charm, beaut, tast, grace, refine, magnif, distinguish, styl, court, culture, dash, aesthetic, suave, polish, debonair, sumptuous, brillian, radian, splend, gorgeous, grand, charisma, glamour, class, exquisite, majestic, modish, luxur, lavish, opule, state, sophisticat, fine, chic, glam, pois, panache, distinct, cultur, swank
37. Key Phrase: The dancers (at the “Palace of the Galician Center”) performed movements that were impeccably controlled.
- Included Keyword: ball
 - Keyword Alternatives: danc, coryphee
 - Included Keyword: mov
 - Keyword Alternatives: motion, gesture, maneuver, action, tech, activit, manipulat, direct, style, perform, dance, choreo, ballet, procedu, sequence, process, part, scene, step, foot
 - Included Keyword: control
 - Keyword Alternatives: retain, kept, maintain, held, hung, continu, preserv, conserv, precis, deliber, mean, compos, reserv, regulat, contain, disciplin, order, strict, restrain, structur, accurate, meticulous, distinct, sharp, system, point, collect, coordinat, manag, monitor, handl, orchestrat, master, administer, organi, tame, taming, flaw, perfect, fault, blemish, spot, exemplar, ideal, pristin, immaculat, reproach, pure, puri, seam, impecca, exquisit, except, virtuous, stain, infallible, outstand, excel, adept, adapt, skill, supreme, superb, splendid
38. Key Phrase: The dancers (at the “Palace of the Galician Center”) performed movements that were flawlessly in time with the music.
- Included Keyword: ball
 - Keyword Alternatives: danc, coryphee
 - Included Keyword: mov

- Keyword Alternatives: motion, gesture, maneuver, action, tech, activit, manipulat, direct, style, perform, dance, choreo, ballet, procedu, sequence, process, part, scene, step, foot

- Included Keyword: tim

- Keyword Alternatives: with, along, sync, join, uni, coo, con, choreo, execut, tempo, play, beat, harmon, fit, present, met, act, meet, carr, match, ton, suit, integrat, blend, mesh, link, knit, symph, com, orchest, mix, together, meld, ass, fus, adapt, perform, rang, set, danc, merg, synerg, belong, align, connect, coher, accord, converg, consolidat, incorporat, conform, harmoni, interlock, tuning, tune, rhythm, accura, perfect, signature

39. Key Phrase: (At the “Palace of the Galician Center”) The dancers’ movements transported Isabel to a joyful and yearning world.

- Included Keyword: mov

- Keyword Alternatives: motion, gesture, maneuver, action, tech, activit, manipulat, direct, style, perform, dance, choreo, ballet, procedu, sequence, process, part, scene, step, foot, transport

- Included Keyword: joy

- Keyword Alternatives: yearn, positiv, optimis, hope, zeal, assur, cheer, bright, progress, help, benefit, sun, jovial, pleas, good, friend, amiable, cordial, heart, happ, glee, satisf, up, light, content, jolly, spark, chirp, merry, elat, sweet, agree, genial, affable, gentl, kind, nice, irie, grac, amus, bliss, comf, long, desir, wish, want, interest, need, sought, seek, covet, favor, favour, aspir, dream, vision, fantas, entranc, passion, crav, ardor

40. Key Phrase: (At the “Palace of the Galician Center”) The dancers’ movements transported Isabel to the world of peasant girls who celebrated the bountiful harvest.

- Included Keyword: mov

- Keyword Alternatives: motion, gesture, maneuver, action, tech, activit, manipulat, direct, style, perform, dance, choreo, ballet, procedu, sequence, process, part, scene, step, foot, transport

- Included Keyword: harvest

- Keyword Alternatives: bount, ampl, plent, galor, luxur, copi, genero, exuber, prolif, spar, end, liber, yield, limit, fruit, season, fall, autumn, summer, spring, gather, crop, garner, take, put, result, produc, goods, suppl, grow, blossom, bloom, flower, forag, return, shar, portion, ration, chunk, collect, reap, farm, agriculture, storag, abundan, substantial, volum, large, rich, munificen, galore, magnanimous, prolific, more, big, hefty, massive, siz, vast, field, meadow, ranch, grass, hay, plant, pasture, orchard, prairie

41. Key Phrase: (At the “Palace of the Galician Center”) The dancers’ movements transported Isabel to the world of peasant girls who celebrated young love.

- Included Keyword: mov
 - Keyword Alternatives: motion, gesture, maneuver, action, tech, activit, manipulat, direct, style, perform, dance, choreo, ballet, procedu, sequence, process, part, scene, step, foot, transport
- Included Keyword: lov
 - Keyword Alternatives: welcom, friend, pleas, delight, kind, grat, good, great, awesome, nifty, peach, swell, delight, charm, genial, merry, admir, amiabl, approv, attract, wonder, satisf, marvel, dandy, com, consider, grac, polite, thought, respect, lik, ador, appreciat, devot, emot, pass, fond, infatuat, respect, tender, yearn, adul, allegianc, smit, amity, amo, attach, cherish, devot, enchant, enjoy, fervor, fidel, hanker, sentiment, amour, intimacy, affect, car, warm, endear, desir, roman, feel, dote, doting, passion, intima, enam

42. Key Phrase: Isabel (She) knew those feelings, but had never been able to convey (imagine or express) them as perfectly as dancers (at the “Palace of the Galician Center”) did.

- Included Keyword: mov
 - Keyword Alternatives: motion, gesture, maneuver, action, tech, activit, manipulat, direct, style, perform, dance, choreo, ballet, procedu, sequence, process, part, scene, step, foot
- Included Keyword: express
 - Keyword Alternatives: show, articulat, signif, mean, assert, commuicat, convey, declar, disclos, giv, indicat, put, reveal, say, speak, spoke, said, suggest, tell, voic,

asseverat, broach, connot, couch, denot, depict, desig, divulg, body, envinc, exhibit, form, fram, manifest, phras, utter, verbaliz, word, put, emit, pour, unleash, vent, imag, dream, brain, concept, creat, depict, envis, fabric, fantas, figur, form, fram, harbor, invent, nutur, perceiv, pictur, plan, project, realiz, spark, visual, think, believ, conjectur, understand, gather, ponder, consider, examin, reflect, speculat, weigh, comprehen, gather, hold, sens, project, conceiv, tak, mak, devis

43. Key Phrase: Isabel had begged her mother to let her try out for ballet school.

- Included Keyword: beg
 - Keyword Alternatives: request, ask, beseech, implor, urg, nag, obsecrat, bother, appeal, solicit, annoy, badger, fuss, hound, need, peition, pest, bug, goad, import, nudg, persuad, convinc, influenc, coax, sway, talk, get, learn, attend, plea, entreat, supplicat, petition, importun, impetrat, besieg, adjur, exhort
- Included Keyword: balle
 - Keyword Alternatives: dance, institute, school, educat, academ

44. Key Phrase: Isabel felt her life would never have meaning unless she could be one of the dancers on stage.

- Included Keyword: life
 - Keyword Alternatives: exist, tim, day, liv, presence, world, circum, bio, stor, being, breath, essence, verve, vigor, vital, experienc, journ, entit, realit
- Included Keyword: mean
 - Keyword Alternatives: signifi, spirit, substance, valu, purpos, worth, gravit, magnitude, merit, prestige, relevance, weight, vertu, benefit, credit, influenc, matter, sens, amount, moment, memor, soul, import, essence, idea, content, worth, aim, concept, intent, messag, understand, defin, direct, course, way, path, bearing, trajectory, trend, aim, focus, point, approach, method, procedure, guid, orient, rout, head, instruct, advi, better, superior, optimal, improv, enhanc, upgrad, avanc, ameliorat, elevat, qualit, favor, wors, inferior, deteriorat, declin, degrad, diminish, regress, downgrad, weak, poor, degenerat, fail, standard, defeat, loss, flop, fiasco, debacle, blunder, misstep, botch, FALSE, error, disaster, mess, lack, success, fall, collaps, back, disappoint, down, frustrat, achiev, mistak, washout, deficien, favour
- Included Keyword: ball

- Keyword Alternatives: danc, coryphee, stag, platform, spac, proscenium, arena, venue, set, podium, dais, stand, rostrum, pedestal, ambo, pulpit, riser, plinth, scaffold, lectern, board, theat, Palace, Center, venue, build, cathedral, stag, hall, site, chateau, estate, castle, villa, house, Galician, auditorium, building, mansion

45. Key Phrase: Isabel was not accepted to the ballet school.

- Included Keyword: accept
 - Keyword Alternatives: welcom, admit, receiv, enter, grant, permit, access, let, get, tak, reject, den, refus, down, repel, declin, success, fail, pass, achiev, miss, short, avail, flop, flat, worse, better, good, bad, lack, meet, try, chas, stud, participat, went, attempt, shot, dab, check, tackl, pursu, seek, tak, stab, chanc, crack, shot, opportun, tri, succeed, mak
- Included Keyword: balle
 - Keyword Alternatives: school, institut, academ, educat

46. Key Phrase: Isabel wept for weeks (due to her rejection from the ballet school).

- Included Keyword: wept
 - Keyword Alternatives: weep, cry, tear, down, sob, bawl, wail, cri, chok
- Included Keyword: week
 - Keyword Alternatives: day, month, time

47. Key Phrase: When Isabel attended ballet as an adult, she felt the same overwhelming sadness so powerful that she felt strangely joyful.

- Included Keyword: ball
 - Keyword Alternatives: choreo, danc, perform, show, display, act, gig, recital, play, concert, rendition, present, exhibit, produc, demonstrat, spect, execut, appear, theat, portray
- Included Keyword: sad
 - Keyword Alternatives: joy, positiv, optimis, hope, zeal, assur, cheer, bright, progress, help, benefit, sun, jovial, pleas, good, friend, amiab, cordial, glee, satisf, light, content, jolly, spark, chirp, merry, elat, sweet, agree, genial, affab, gentl,

kind, nice, irie, grac, amus, bliss, comf, bum, dismal, deject, happ, down, drag, upset, low, mop, gloom, depress, stress, bleak, hope, mourn, anguish, grief, heart, melanchol, miser, sorrow, negativ, desolat

- Included Keyword: adult
 - Keyword Alternatives: grow, matur, woman, mother, mam, mom, mum, parent, year, later, shortly, same, following, succeeding, subsequent, decade, then, after, throughout, period, time, old, futur, down, continue, age, aging, Isabel, Moreno, character, protagonist, heroine

48. Key Phrase: Act 2 of “Swan Lake” includes the character Siegfried.

- Included Keyword: Swan
 - Keyword Alternatives: Lake
- Included Keyword: Siegfried
 - Keyword Alternatives:

49. Key Phrase: Act 2 of “Swan Lake” includes the character Odette.

- Included Keyword: Swan
 - Keyword Alternatives: Lake
- Included Keyword: Odette
 - Keyword Alternatives:

50. Key Phrase: Characters (Siegfried and Odette) from Act 2 of “Swan Lake” perform a pas de deux.

- Included Keyword: Swan
 - Keyword Alternatives: Lake, Siegfried, Odette, Siegfried
- Included Keyword: pas de deux
 - Keyword Alternatives: duet, deux, duo, pair, couple, tandem, duad, twain, double, two, partner

51. Key Phrase: The pas de deux (of Swan Lake) to Isabel felt like a truthful presentation of the awakening of love.

- Included Keyword: pas de deux
 - Keyword Alternatives: duet, deux, duo, pair, couple, tandem, duad, twain, double, two, partner, Swan, Lake
- Included Keyword: lov
 - Keyword Alternatives: welcom, friend, pleas, delight, kind, grat, good, great, awe-som, nifty, peach, swell, delight, charm, genial, merry, admir, attract, wonder, satisf, marvel, dandy, com, consider, grac, polite, thought, respect, lik, ador, ap-preciat, emot, pass, fond, infatuat, respect, tender, yearn, adul, allegiance, smit, amity, amo, attach, cherish, devot, enchant, enjoy, fervor, fidel, hanker, affect, car, warm, endear, desir, roman, feel, approv, intima, sentiment, amour, amiab

52. Key Phrase: The pas de deux (of Swan Lake) to Isabel felt like more of a truthful presentation than her experiences in real life.

- Included Keyword: pas de deux
 - Keyword Alternatives: duet, deux, duo, pair, couple, tandem, duad, twain, double, two, partner, Swan, Lake
- Included Keyword: life
 - Keyword Alternatives: exist, tim, day, liv, presence, realit, entit, essence, journ, world, circum, bio, stor, being, breath, verve, vigor, vital, experienc, event, inci-dent, episode, trial, wisdom, insight, knowledg, adventur, memor, perc, observ, aware, understand, learn, expos

53. Key Phrase: When Cinderella had to leave the ball, Isabel felt keenly the anxiety of living a relatively comfortable life, so far removed from the poverty of her childhood.

- Included Keyword: ball
 - Keyword Alternatives: choreo, danc, perform, show, display, act, gig, recital, play, concert, rendition, present, exhibit, product, demonstrat, spect, execut, appear, portray, Cinderella
- Included Keyword: life
 - Keyword Alternatives: exist, tim, day, liv, presence, realit, entit, essence, journ, world, circum, bio, stor, being, breath, verve, vigor, vital, experienc, event, inci-dent, episode, trial, wisdom, insight, knowledg, adventur, memor, perc, observ, aware, understand, learn, expos

- Included Keyword: pover
 - Keyword Alternatives: destiut, need, indigen, penur, sufficien, pecuni, depriv, scarc, lack, want, privat, struggl, advers, fortun, stress, necess, ruin, deficien, mendican, pauper, beg, solv, privileg, paucit, scant, dearth, adequa, penn, income, advantag, bankrupt, bare, meager, limit, down, hard, money, monies, nourish, under
- Included Keyword: Isabel
 - Keyword Alternatives: kid, child, girl, lad, female, wom, lass, gal, mis, dam, broad, adolesc, pubesc, chap, bloke, joe, hombre, juv, educat, learn, attend, Moreno, chick, you, character, protagnoist, heroine, pupil, student

54. Key Phrase: Cinderella had to leave the ball at the end of Act 2 (of the ballet “Cinderella”) for fear of being discovered as her dress turned back to rags.

- Included Keyword: Cinderella
 - Keyword Alternatives:
- Included Keyword: leave
 - Keyword Alternatives: exit, depart, go, escape, flee, fly, away, abscond, retire, quit, split, scam, flit, vacate, vanish, ditch, desert, out, off
- Included Keyword: ball
 - Keyword Alternatives: prom, event, function, dance

55. Key Phrase: Isabel has a son named Alejandro.

- Included Keyword: Alejandro
 - Keyword Alternatives:

56. Key Phrase: Alejandro had been trying to get Isabel (his mom) to come visit Miami for years, but she had never accepted (due to paperwork complications & work).

- Included Keyword: Alejandro
 - Keyword Alternatives: son, hijo, bambino, off, offspring, child, boy, heir, progeny, lad
- Included Keyword: Isabel

- Keyword Alternatives: mother, mam, mom, mum, girl, sister, lad, female, wom, lass, gal, miss, daught, niec, dam, gal, broad, dude, you, chick, character, protagon-ist, heroine, Moreno
 - Included Keyword: Miami
 - Keyword Alternatives: Florida, try, attempt, pursu, seek, chanc, crack, shot, oppor-tun, tri, effort, giv, sway, win, coax, compel, talk, cajole, through, reason, persua, influen, encourag, urg, assur, visit, come, meet, time, stay, travel, stop, coming, ventur, came, gav, sought
57. Key Phrase: Isabel claimed that the paperwork (to visit Miami) was too complicated.
- Included Keyword: work
 - Keyword Alternatives: fil, document, form, paper, record, report, archiv, info, data, page, log
58. Key Phrase: Isabel claimed that she couldn't take the time off from the hospital (work).
- Included Keyword: off
 - Keyword Alternatives: Away, Aside, Out, present, here, leav, Pause, Rest, Inter-mission, Recess, Interval, Hiatus, Lull, Gap, Halt, breath, stop, downtime, fur-lough, sabbatical, vacation, break, busy, Hectic, demand, occup, engag, swamp, engross, press, holiday, rest, recess, respite, repriev, free, leisur, recreat, getaway, relax, absen, recuperat, recoup, hiatus, wind, respit
 - Included Keyword: work
 - Keyword Alternatives: hospital, Labor, Job, Occupation, Duty, Project, Task, Ef-fort, Profession, Vocation, Career, Trade, Craft, Business, Pursuit, employ, assign, responsib, Treatment, Hospice, Sickbay, clinic, Care, Trauma, medic, sanatorium, role, activit, endeavor, operat, duti, nurs, heal, dispensar, infirm
59. Key Phrase: Alejandro had tried to entice his mother with visits to the Miami Ballet, but Isabel wasn't interested.
- Included Keyword: Alejandro
 - Keyword Alternatives: son, hijo, offspring, child, boy, heir, progeny, lad, bambino
 - Included Keyword: Miami

- Keyword Alternatives: ball, choreo, danc, Florida
- Included Keyword: interest
 - Keyword Alternatives: care, want, into, intrigu, desir, wish, need, appeal, absorb, compel, excit, stimulat, engag, grip, attent, concern, gross, hook, sold, entic, gung, impress, lur, bait, move, open, will, amenable, sell, stir, game, feel, partial, convinc, sway, inclin, mind, keen, eager, responsive, fascinat, captivat, atten, enthus, persua, attract, coax, draw, enchant, tempt, appeal, invit, mesmer, win, influen, encourag, urg, prompt, motivat, cajol, reason, negociat, incit, tak

60. Key Phrase: Isabel said the dancers in Miami weren't as good as the Cuban dancers.

- Included Keyword: Miami
 - Keyword Alternatives: Florida
- Included Keyword: Cuba
 - Keyword Alternatives: Havana, Habana
- Included Keyword: balle
 - Keyword Alternatives: danc, coryphee

61. Key Phrase: Alejandro realized he had to tempt Isabel with something (a ballet) she couldn't see in Havana.

- Included Keyword: Alejandro
 - Keyword Alternatives: son, hijo, offspring, child, boy, heir, progeny, lad, bambino
- Included Keyword: tempt
 - Keyword Alternatives: entic, lur, persua, attract, coax, influen, induc, beguil, woo, convinc, charm, enchant, solicit, incit, bait, fascinat, captivat, draw, appeal, encourag, intrig, prompt, sway, tantali, cajol, lead, nudg, manipul, urg, inclin, impel, motivat, reason, advocat, sell, prevail, propos, present, exhort, press, push, pull
- Included Keyword: Havana
 - Keyword Alternatives: Cuba, home, land, country, live, living, local, residen, dwell, abod, domicile, house, address, lodg, establish, quarter, haven, nation, state, territory, realm, domain, region, area, province, soil, habitat, Habana

62. Key Phrase: Alejandro had brought tickets to see the Miami Ballet (featuring Mikhail Baryshnikov).

- Included Keyword: Alejandro
 - Keyword Alternatives: son, hijo, offspring, child, boy, heir, progeny, lad, bambino
- Included Keyword: ticket
 - Keyword Alternatives: paper, pass, admit, voucher, permit, admission, entry, stub, book, Mikhail, Baryshnikov, Miami, balle, choreo, danc, Florida

63. Key Phrase: Isabel (She) reacted like the mechanical doll (Coppélia) suddenly brought to life after Alejandro (her son) bought her the ticket to the Miami Ballet.

- Included Keyword: mech
 - Keyword Alternatives: Rigid, automat, machine, tech, indust, engine, motor, system, flex, emotion, person, Coppélia, Toy, Mannequin, Figurine, doll, Marionette, Coppelia, mechani, procedur, organic, method, manufactur, function, puppet, figur, android, robo, cyborg, gadget
- Included Keyword: life
 - Keyword Alternatives: Being, Essence, Soul, Breath, Presence, exist, liv, vital, animat, birth, born, new, transform, inspir, morph, incarnat, awak, enlight, experience, juvenat, form, chang, reviv, renaissance, renascence, dawn, com, start, begin, restor, surg, clear, fresh, discover, find, found, rich, open, see, view, observ, shap, evolv, alter, emerg, brought, bring, fold, ris, creat, foster, nurtur, rais, begat, begot, acquir, obtain, gain, affect, effect, influence, spark, touch, trigger, shift, transit, motiv, brand, invent, chanc, cast, differ, work, haul, made, mak, build, built, vigor, Coppélia, coppelia, mov, breath, anima, wak, conscious, act, cognizant, walk, aware, alert, repon, sens, mind, sentien, perce, burst, resurrect, thrive, energ, rous, rise, rising

64. Key Phrase: Mikhail Baryshnikov was a legendary Russian dancer.

- Included Keyword: Mikhail
 - Keyword Alternatives: Baryshnikov

65. Key Phrase: Mikhail Baryshnikov had defected from the Soviet Union.

- Included Keyword: Russia
 - Keyword Alternatives: Soviet, USSR, CCCP
66. Key Phrase: Mikhail Baryshnikov abandoned classical ballet.
- Included Keyword: danc
 - Keyword Alternatives: ball, choreo, classic, old, historic, ancient, former, standard, defin, establish
 - Included Keyword: Mikhail
 - Keyword Alternatives: Baryshnikov, Russia, Soviet, USSR, CCCP
67. Key Phrase: Mikhail Baryshnikov performed modern dance.
- Included Keyword: danc
 - Keyword Alternatives: balle, choreo, modern, new, current, recent, latest, contemporary, neoteric
 - Included Keyword: Mikhail
 - Keyword Alternatives: Baryshnikov, Russia, Soviet, USSR, CCCP
68. Key Phrase: Baryshnikov's fierceness inspired Isabel to overcome her hesitations (about paperwork and vacation time).
- Included Keyword: danc
 - Keyword Alternatives: balle, choreo, modern, new, current, recent, latest, contemporary, classic, old, historic, ancient, former, russia, soviet, ussr, cccp, mikhail, baryshnikov
 - Included Keyword: hesita
 - Keyword Alternatives: doubt, dubious, irresolut, certain, decid, convinc, settl, sure, thought, waver, unsure, falter, vacillat, deci, dither, paus, consider, think, evaluat, question, attend, visit, show, guest, present, drop, mak, pop, turn, appear, made, clock, tim, off, leisur, vaca, rest, recreat, holiday, work, fil, document, form, paper, record, report, archiv, info, data, page, log
69. Key Phrase: The dance program started with a short solo dance by Baryshnikov.

- Included Keyword: solo
 - Keyword Alternatives: modern, new, current, recent, latest, contemporary, choreo, program, first, one, perform, show, ballet, individual, alone, own, single, one, sole, self, spotlight, independent, exclusive
- Included Keyword: Mikhail
 - Keyword Alternatives: Baryshnikov, dance, ballerina, choreo, perform, coryphee, Russia, Soviet, USSR, CCCP

70. Key Phrase: Baryshnikov was a marvel of unassuming, fluid grace.

- Included Keyword: Baryshnikov
 - Keyword Alternatives: Mikhail, dance, balle, choreo, perform, coryphee, art, Russia, Soviet, USSR, CCCP

71. Key Phrase: Isabel had often thought that male dancers were too assertively athletic.

- Included Keyword: male
 - Keyword Alternatives: balle, man, men, boy, guy, dance, coryphee, perform, art
- Included Keyword: assert
 - Keyword Alternatives: athletic, confident, decisive, firm, bold, steadfast, assur, determin, resolut, waver, will, empha, possess, yield, shak, daunt, swerv, power, might, vigor, stamina, fortitude, force, brawn, prowess, energ, intens, tough, domina, tenaci, physical, endur, unbend, resilien, relent, persist, mascul, muscul, muscle, vital, fit, active, agile, nimble, strong, robust, fleet, quick, dynamic, lively, mobile, sport, swift, rapid, fast, speed, flexi, dexter, coordinat, skill, soft, delicat, mild, tender, smooth, supple, calm, subtle, gentl, peace, mute, muting, reserv, submissive, passive, meek, humbl, modest, impos, unassum, flashy, showy, discreet, restrain, intricate, fine, fining, fluid, grace, ethereal, light, airy, elegan, sophisticat, poise, finess, charm, beaut, styl, compos, seren, harmon, gracious

72. Key Phrase: Isabel had often thought that the ballerinas were the real stars of the show.

- Included Keyword: ball
 - Keyword Alternatives: choreo, danc
- Included Keyword: star

- Keyword Alternatives: attract, main, lead, head, principal, featur, top, key, center, showstop, primar, central, high, talent, prime, prominen, focal, chief, role, front, fore, first, suprem, major, dominan, outstand, pivot, eminent, essen, initial, one, master, best, better, importan, giant, pro, big, virtu, league, veteran, expert, season, ace, adept, premier, whiz, heav, famous, renown, vip, v.i, distinguish, acclaim, panjandrum, icon, idol, excellen, super

73. Key Phrase: Isabel understood that the classical Cuban ballet she so loved was only one small part of the expressive possibility of dance (during Baryshnikov’s short, simple dance).

- Included Keyword: danc
 - Keyword Alternatives: choreo, style, type, art, balle, possibilit
- Included Keyword: classic
 - Keyword Alternatives: historic, old, ancient, former, modern, new, current, recent, latest, contemporary, home, country, standard, defin, establish, neoteric
- Included Keyword: Cuba
 - Keyword Alternatives: Havana, Habana

74. Key Phrase: (At the Miami Ballet) Isabel (She) was transported back to that first day at the ballet when she was a schoolgirl.

- Included Keyword: danc
 - Keyword Alternatives: balle, choreo, historic, former, classic, perform, show, event, art
- Included Keyword: transport
 - Keyword Alternatives: back, junior, cuba, old, remember, mem, remin, recall, recollect, retrospect, recap, back, reliv, reflect, nostalg, thought, think, reflect, forget, mind, event, encod, retriev, experienc, tim, ruminat, still, dwell, ponder, contemplat, mus, came, com, brood, mull, deliberat, evo, over, vis, consid, anamnesis, impression, retain
- Included Keyword: schoolgirl
 - Keyword Alternatives: school, girl, kid, child, you, adolescen, student, juv, junior, prepubesc, little, old, academ, institut, educat, lass, gal, dam, small, female, broad, attend

75. Key Phrase: (At the Miami Ballet) Isabel felt that same sense of wonder that she hadn't known about this heartbreakingly beautiful art form before.

- Included Keyword: wonder

- Keyword Alternatives: awe, appreciat, fascinat, amaz, admir, curios, dazzl, astonish, shock, surpris, marvel, reveren, spectac, sens, ador, emotion, impress, passion, respect, esteem, regard, vib, react, tingl, excit, thrill, grand, magnif, splend, presence, digni, majes, regal, elegan, splend, luxur, mass, strik, stagger, stun, prominent, significan, distinct, notab, extra, salien, incredibl, striking, asto, opulen, rich, lus, ornate, exuber, exquisit, heart, know

- Included Keyword: art

- Keyword Alternatives: danc, choreo, perform, balle, form, type, produc, activit

76. Key Phrase: (At the Miami Ballet) Isabel was too stunned to clap when the first dance (by Baryshnikov) ended.

- Included Keyword: danc

- Keyword Alternatives: ball, choreo, classic, school, perform, show, event

- Included Keyword: stun

- Keyword Alternatives: wonder, awe, appreciat, fascinat, amaz, admir, dazzl, astonish, shock, surpris, marvel, reveren, spectac, sens, ador, emotion, impress, passion, respect, esteem, regard, vib, react, tingl, excit, thrill, grand, magnif, splend, presence, digni, majes, regal, elegan, splend, luxur, strik, stagger, stun, prominent, significan, distinct, notab, extra, salien, incredibl, striking, asto, opulen, rich, lus, ornate, exuber, exquisit, clap, applau, ovation, cheer

77. Key Phrase: (Alejandro touched her (Isabel's) arm lightly,) Alejandro worried that Isabel hadn't liked the dance.

- Included Keyword: danc

- Keyword Alternatives: ball, choreo, classic, school, perform, show, event

- Included Keyword: worr

- Keyword Alternatives: upset, sick, ill, ease, overwrought, strung, stress, afraid, anxi, disturb, perturb, troubl, bother, concern, fret, worr, uneas, agitat, edg, nerv, fear, frighten, scare, apprehens, panic, distr, anticipat, care, insecur, doubt, angst, misgiving, occup, rest, tens, trepidat, quiet, alarm, jitter, caring

78. Key Phrase: (Turning to her son,) Isabel embraced him (Alejandro).

- Included Keyword: Isabel
 - Keyword Alternatives: mother, mam, mom, mum, girl, sister, lad, female, wom, lass, gal, miss, daught, niec, dam, gal, broad, dude, you, chick, character, protagonist, heroine, Moreno
- Included Keyword: embrac
 - Keyword Alternatives: hug, caress, held, hold, grasp, cradl, cuddl, clasp, squeez, encircl, envelop, grip, cherish, wrap, clench, nestl, cling, snug, clinch, nuzzl, fold, press
- Included Keyword: Alejandro
 - Keyword Alternatives: son, hijo, offspring, child, boy, heir, progeny, lad, bambino

79. Key Phrase: Tears are now leaking out of the corners of Isabel’s (her) eyes (after watching the first dance by Baryshnikov).

- Included Keyword: tear
 - Keyword Alternatives: weep, snivel, whimper, wept, sob, bawl, wail, mewl, cry, crie, water, lament, lachrym, blubber

80. Key Phrase: Isabel whispered “thank you, my son” or “Gracias, mi hijo.”

- Included Keyword: thank
 - Keyword Alternatives: gracias, grati, appreciat, grateful, acknowledg, credit, oblig, bless, cheer, kudo, prop, hail, prais, salut, applaus, admir, debt, recogni, acquiesc
- Included Keyword: Alejandro
 - Keyword Alternatives: son, hijo, offspring, child, boy, heir, progeny, lad, bambino

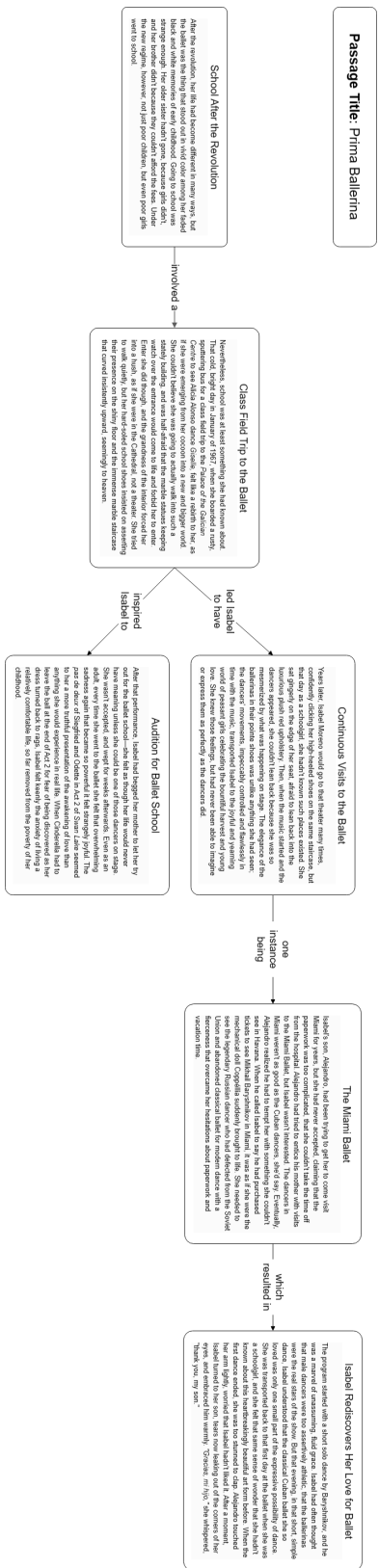


Figure B.28: Passage 4: Prima Ballerina in Hybrid Map (H) condition

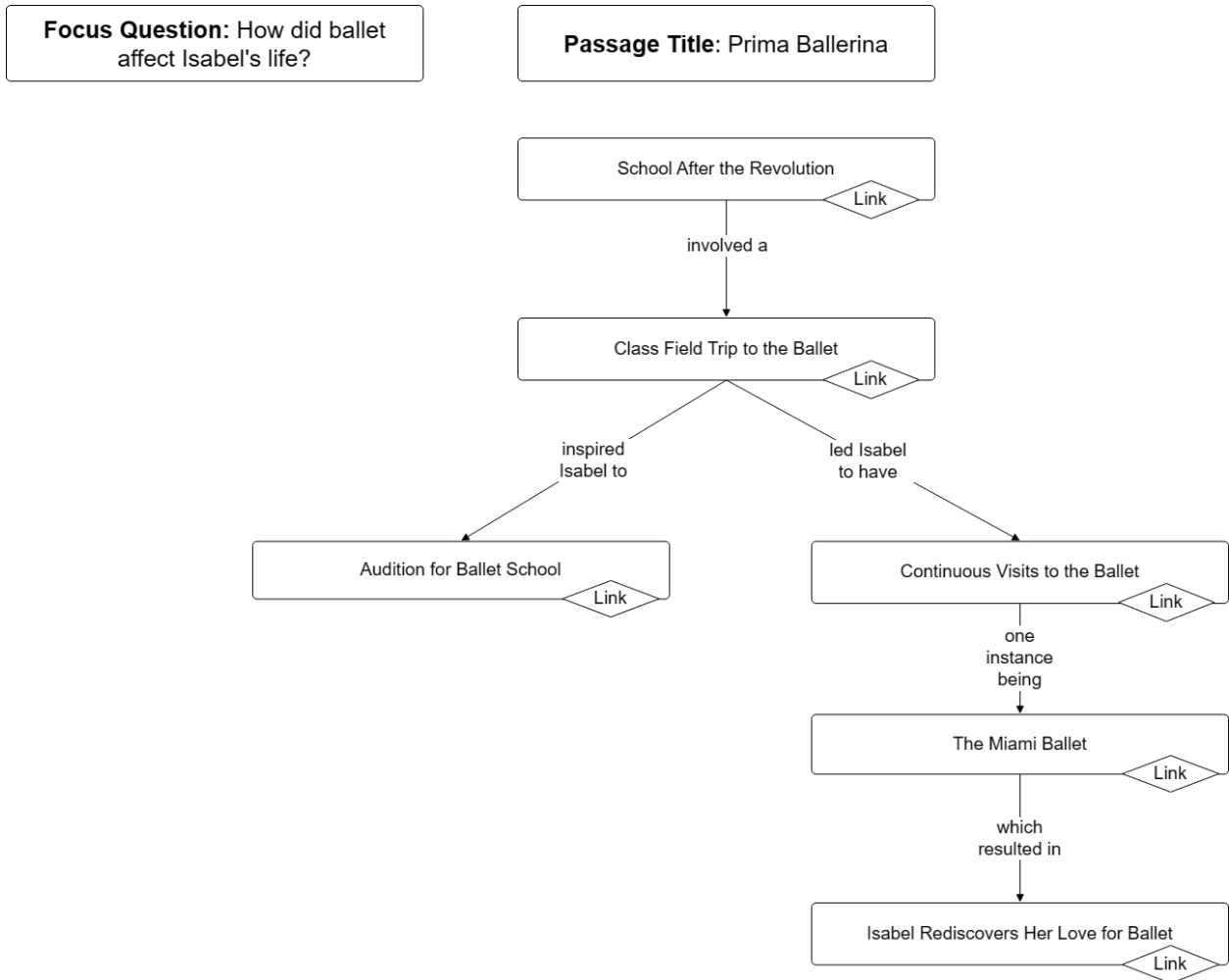


Figure B.29: Passage 4: Prima Ballerina in Novakian Knowledge Model (K) condition - Master-map

Back to Main Page

Paragraph Title: School After the Revolution

Focus Question: How did the revolution affect Isabel?

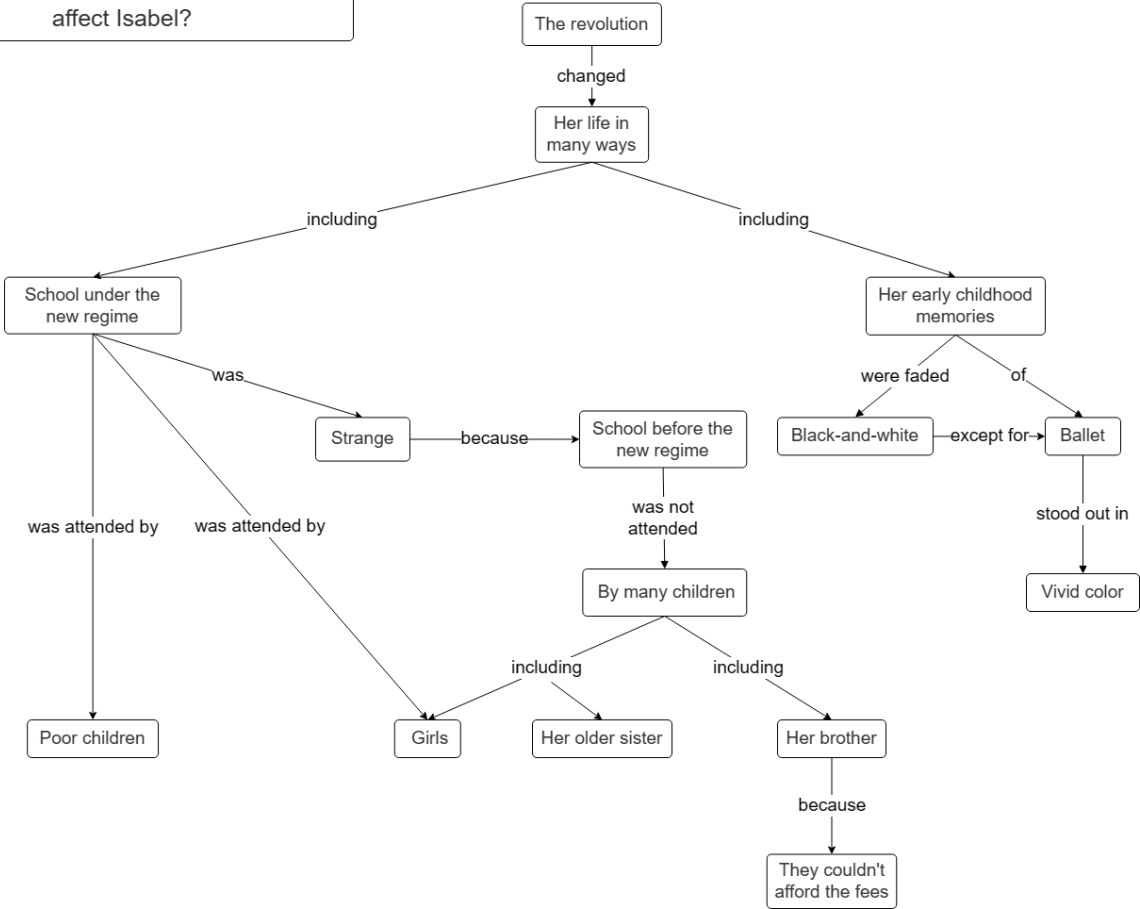


Figure B.30: Passage 4: Prima Ballerina in Novakian Knowledge Model (K) condition - mini-map1

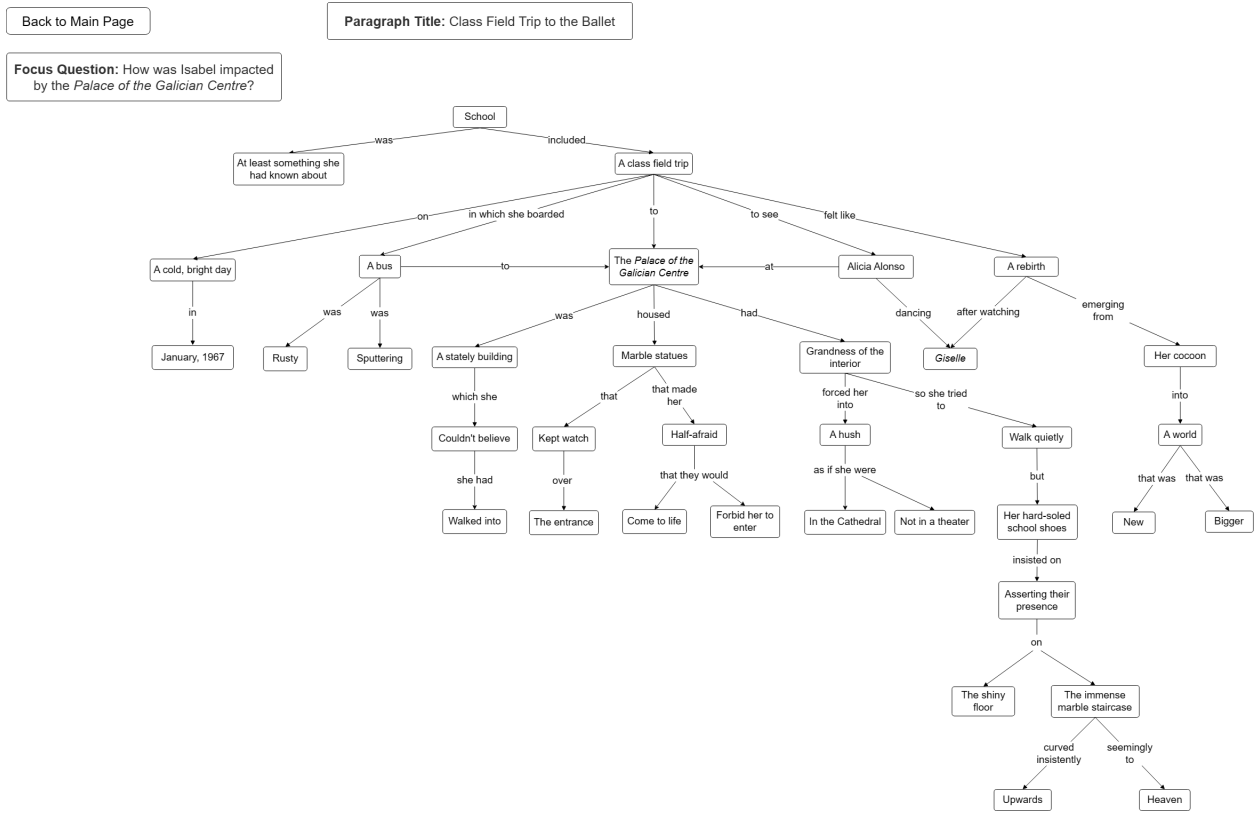


Figure B.31: Passage 4: Prima Ballerina in Novakian Knowledge Model (K) condition - mini-map2

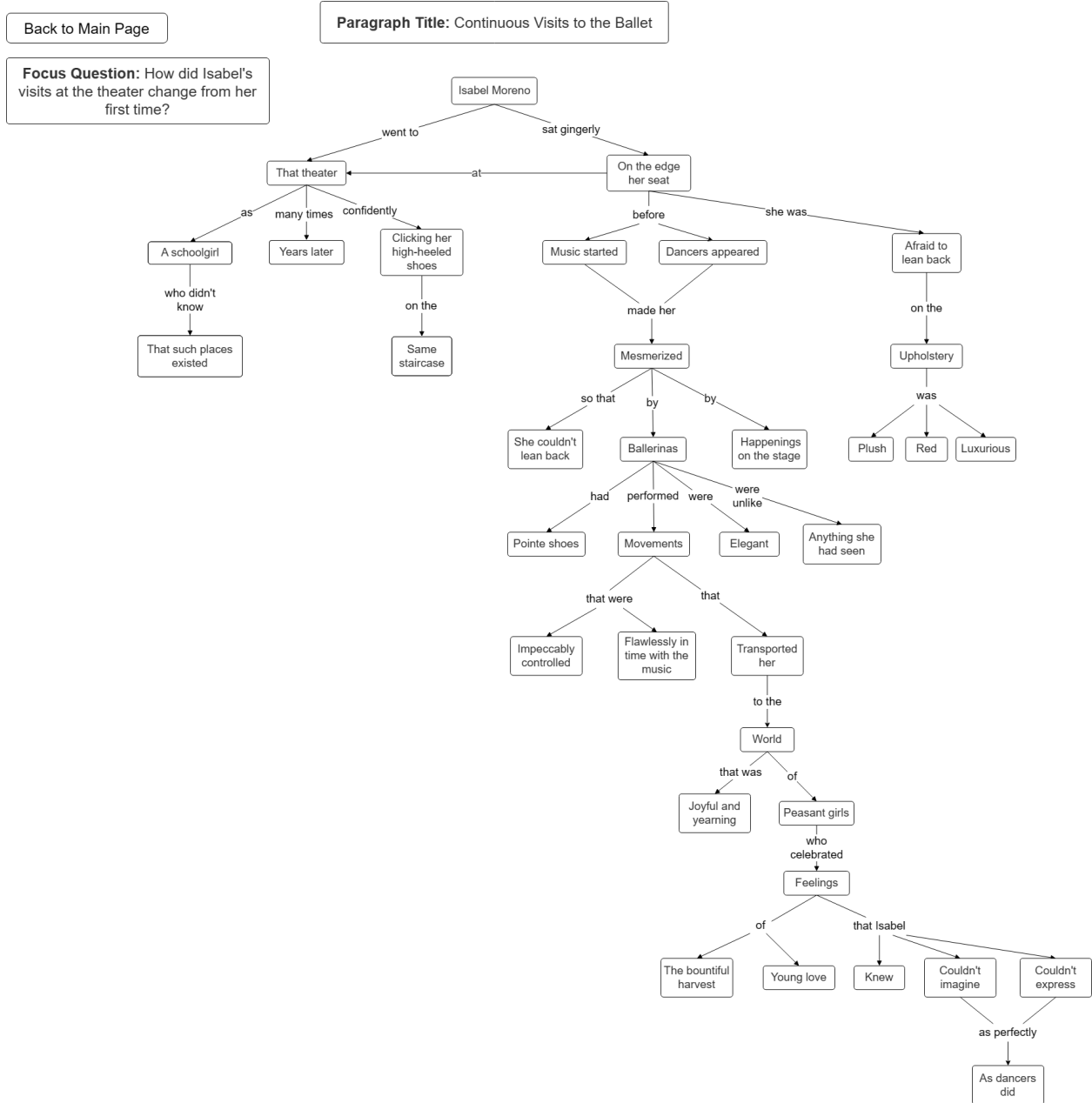


Figure B.32: Passage 4: Prima Ballerina in Novakian Knowledge Model (K) condition - mini-map3

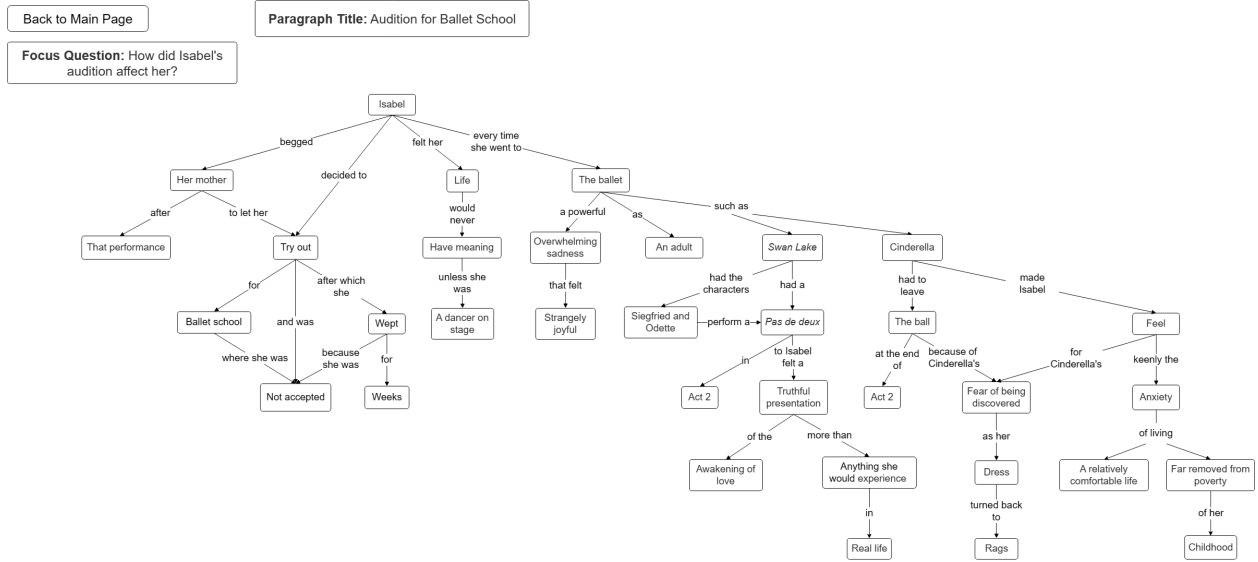


Figure B.33: Passage 4: Prima Ballerina in Novakian Knowledge Model (K) condition - mini-map4

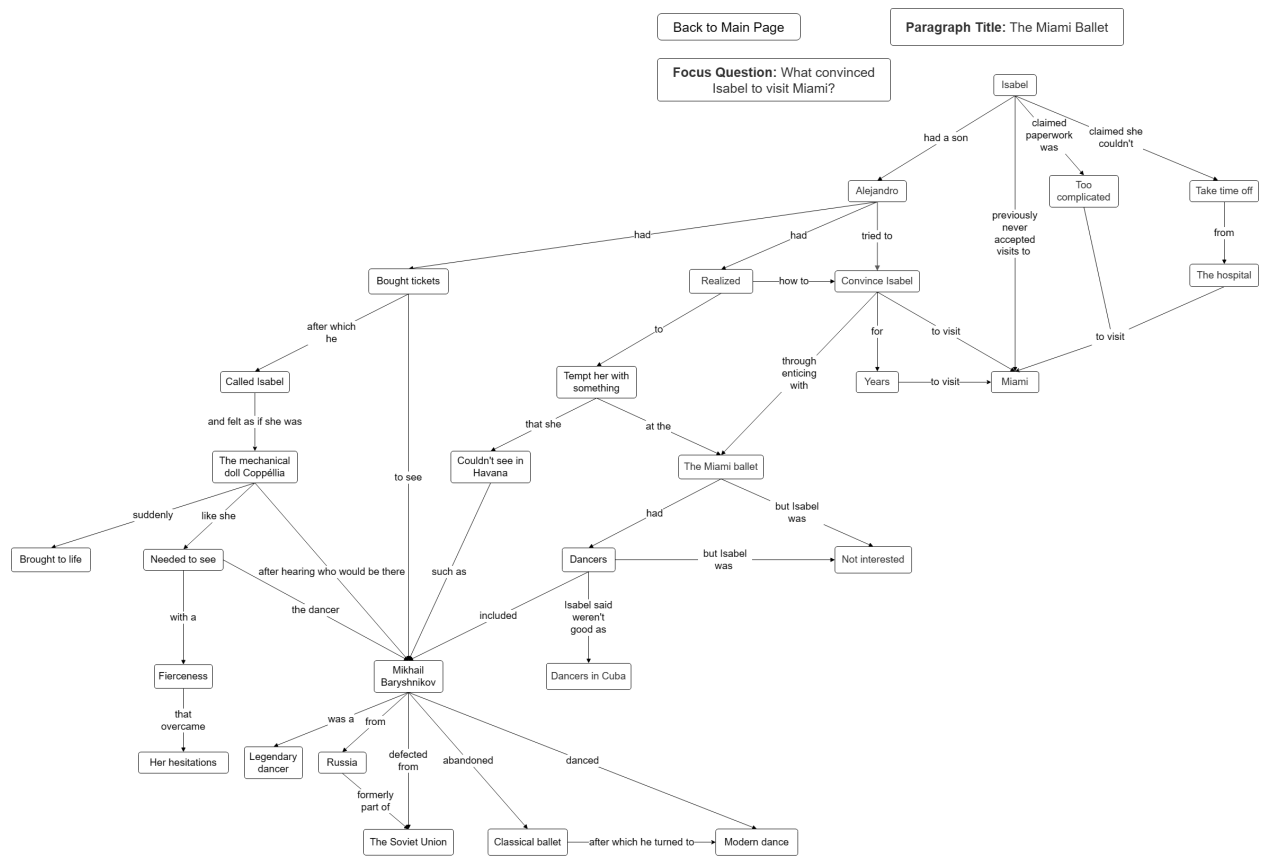


Figure B.34: Passage 4: Prima Ballerina in Novakian Knowledge Model (K) condition - mini-map5

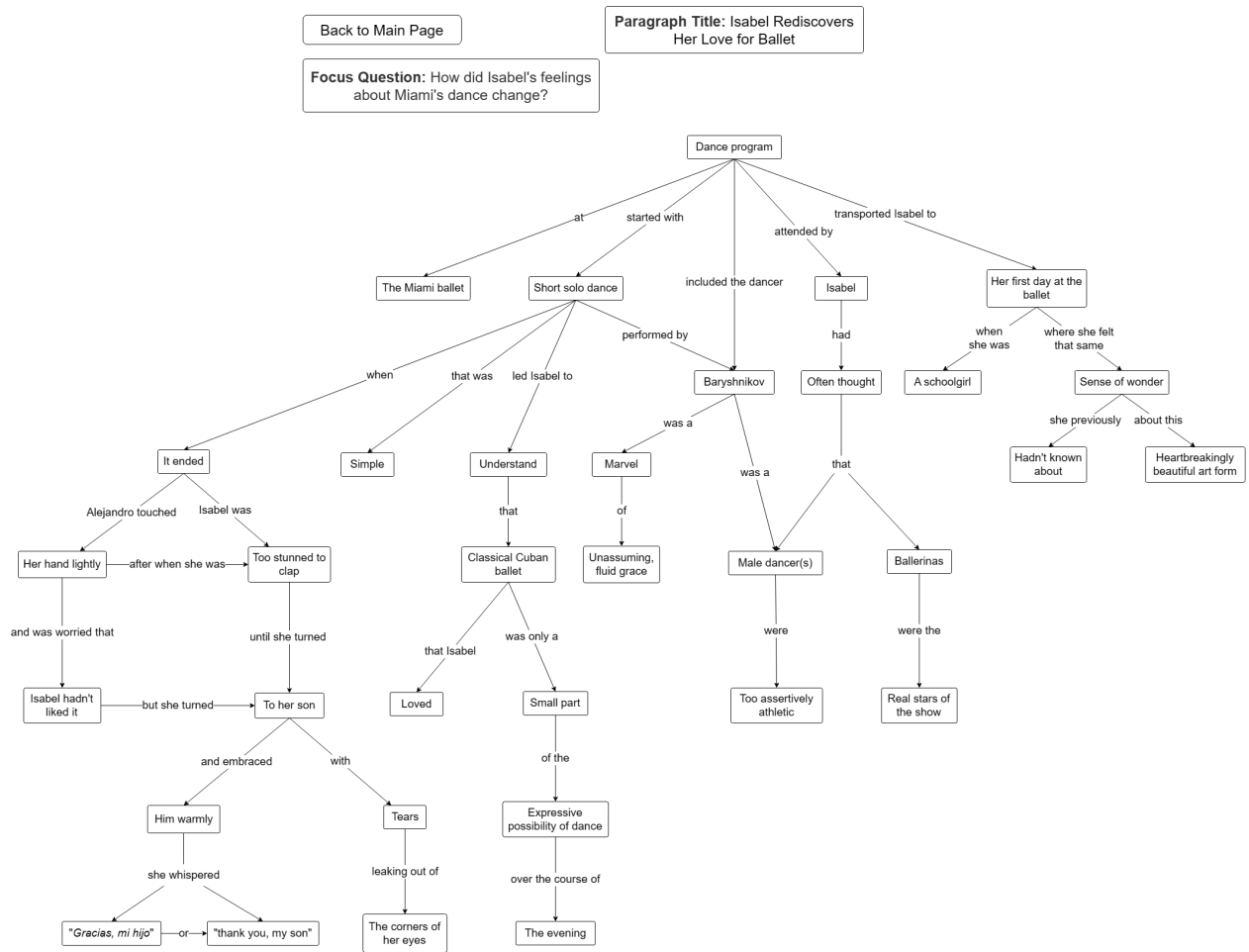


Figure B.35: Passage 4: Prima Ballerina in Novakian Knowledge Model (K) condition - mini-map6

B.2.5 Passage 5: How to Watch Television

The modified multiple-choice questions used for this passage are as follows:

1. The author of this passage can most reasonably be described as:
 - (a) a detective who tries to find evidence proving that a television network is not guilty of misleading the public.
 - (b) a television executive who discusses important factors for a successful news program.
 - (c) a critic who warns his readers about the effects that television has had on the reporting of news.
 - (d) a journalism teacher who wishes to show his students how to write interesting television news stories.

Question Type: Inferential

2. It can reasonably be inferred that the author would most likely agree with which of the following statements?
 - (a) News stories are more interesting when they are presented on live television than when they are recorded.
 - (b) The short amount of time given to news stories on television reduces the value of the facts reported.
 - (c) Television has done a good job of bringing families together by creating programs that the entire family can watch.
 - (d) Television news reports should also write news stories for magazines and newspapers.

Question Type: Inferential

3. The author offers details about Christine Craft in order to:
 - (a) illustrate the importance of the appearance of the newscaster on television.
 - (b) show that television gets its nature from both telegraphy and photography.
 - (c) support a claim about sexism in America.
 - (d) present the story of a friend and her experiences in television journalism.

Question Type: Inferential

4. It can reasonably be inferred that the author believes that:
- (a) well-trained actors are better than newscasters at delivering news on television.
 - (b) television is not well suited to a serious presentation of the news.
 - (c) newspapers will likely disappear in a few years if people continue to get their news from television.
 - (d) the presentation of the news has a not fundamentally changed since ancient times.

Question Type: Inferential

5. According to the passage, television has become a medium whose main goal is:
- (a) to report the facts in an unbiased manner.
 - (b) to help television reporters become famous.
 - (c) to inform the public of important news productions.
 - (d) to entertain viewers.

Question Type: Inferential

6. The author's reference to "talking hairdos" is a reference to:
- (a) people whose faces are pleasing to viewers.
 - (b) the advertising of hair-care products on television.
 - (c) animated cartoon characters.
 - (d) the amount of money spent make television personalities look good.

Question Type: Inferential

7. According to the author, the phrase "Now...this" indicates that the next topic:
- (a) will be more important than the previous topic.
 - (b) will receive less time than the previous topic.
 - (c) will have no connection to the previous topic.
 - (d) will begin a new eight-minute segment of news.

Question Type: Factual

8. According to passage, television viewers' perceptions of whether a story is true or false depends largely on the:
- (a) appearance of the person reporting the news.
 - (b) reputation of the television network.
 - (c) references cited during the news story.
 - (d) commentary provided by those being interviewed.

Question Type: Inferential

9. Which of the following is NOT cited as having an impact on the presentation of television news?
- (a) Airtime is a very valuable commodity for television stations.
 - (b) People are not expected to remain attentive to the television for more than a short period of time.
 - (c) Television relies on images rather than on words to transmit its message.
 - (d) Television sets are relatively expensive, and not everyone can afford them.

Question Type: Inferential

The following shows the original ACT reading comprehension passage in linear format. This passage was obtained from ACT exam 2009 (available at [Crack ACT](#)). This passage in Hybrid Map (H) format is shown in Figure B.36. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent Novakian concept maps (K) are shown in Figure B.37, Figure B.38, Figure B.39, Figure B.40, Figure B.41, Figure B.42 and Figure B.43. The interactive version that the participants studied through is available [here on Draw.io](#).

How to Watch Television

“Now...this” is commonly used on the radio and television newscasts to indicate that what one has just heard or seen has no relevance to what one is about to hear or see, or possibly to anything one is ever likely to hear or see. The phrase is a means of acknowledging that fact that the world as mapped by the speeded-up electronic media has no order or meaning and it is not to be taken seriously. There is no murder so brutal, no earthquake so devastating, no political blunder so costly—for that matter, no ball score so tantalizing or weather report so threatening—that it cannot be erased from our minds by a newscaster saying, “Now...this.” The newscaster means that you have

thought long enough on the previous matter (approximately 45 seconds), that you must not be morbidly preoccupied with it (let us say, for 90 seconds), and that you must now give your attention to another fragment of news or a commercial.

Television did not invent the “Now...this” worldview. As I have tried to show, it is the offspring of the intercourse between telegraphy and photography. But it is through television that it has been nurtured and brought to a perverse maturity. For on television, nearly every half hour is a discrete event, separated in content, context, and emotional texture from what precedes and follows it. In part because television sells its time in seconds and minutes, in part because television must use images rather than words, in part because its audiences can move freely to and from the television set, programs are structured so that almost each eight-minute segment may stand as a complete event in itself. Viewers are rarely required to carry over any thought or feeling from one parcel of time to another.

Of course, in television’s presentation of the “news of the day,” we may see the “Now...this” mode of discourse in its boldest and most embarrassing form. For there, we are presented not only with fragmented news but news without context, without consequences, without value, and therefore without essential seriousness; that is to say, news as pure entertainment.

Consider, for example, how you would proceed if you were given the opportunity to produce a television news show for any station concerned to attract the largest possible audience. You would, first, choose a cast of players, each of whom has a face that is both “likable” and “credible.” Those who apply would, in fact, submit to you their eight-by-ten glossies, from which you would eliminate those whose countenances are not suitable for nightly display. This means that you will exclude women who are not beautiful or who are over the age of 50, men who are bald, all people who are overweight or those whose noses are too long or whose eyes are too close together. You will try, in other words, to assemble a cast of talking hairdos. At the very least, you will want those whose faces would not be unwelcome on a magazine cover.

Christine Craft has just such a face, and so she applied for a co-anchor position on KMBC-TV in Kansas City. According to a lawyer who represented her in a sexism suit she later brought against the station, the management of KMBC-TV “loved Christine’s look.” She was accordingly hired in January 1981. She was fired in August 1981 because research indicated that her appearance “hampered viewer acceptance.” What exactly does “hampered viewer acceptance” mean? And what does it have to do with the news? Hampered viewer acceptance means the same thing for television news

as it does for any television show: Viewers do not like looking at the performer. It also means that viewers do not believe the performer, that she lacks credibility. In the case of a theatrical performance, we have a sense of what that implies: The actor does not persuade the audience that he or she is the character being portrayed. But what does lack of credibility imply in the case of a news show? What character is a co-anchor playing? And how do we decide the performance lacks verisimilitude? Does the audience believe that the newscaster is lying, that what is reported did not in fact happen, that something important is being concealed?

It is frightening to think that this may be so, that the perception of the truth of a report rests heavily on the acceptability of the newscaster. In the ancient world, there was a tradition of banishing or killing the bearer of bad tidings. Does the television news show restore, in a curious form, this tradition?

B.2.5.1 Key Phrases and their Boolean Expressions for How to Watch Television

1. Key Phrase: “Now...this” is commonly used on the radio and television newscasts.
 - Included Keyword: newscast
 - Keyword Alternatives: report, perform, entertain, crew, anchor, part, cast, act, stat, program, announc, headlin, new, show, tele, info, stor, TV, T.V, network, content, messag, broadcast, program, radio
 - Included Keyword: now
 - Keyword Alternatives: phras
 - Included Keyword: this
 - Keyword Alternatives: phras
2. Key Phrase: “Now... this” indicates that what one has just heard or seen has no relevance to what one is about to hear and see.
 - Included Keyword: now
 - Keyword Alternatives: phras
 - Included Keyword: hear

- Keyword Alternatives: listen, catch, detect, attend, heed, absorb, gather, learn, discover, apprehend, understand, told, perciev, reciev, notic, inform, awar, see, spot, detect, view, behold, witness, catch, watch, eye, look, ascertain, discern, survey, observ, glimps, identif, recogniz, visualiz, connect, correlat, relate, relevan
 - Included Keyword: about
 - Keyword Alternatives: going, upcoming, transition, next, time, attention, proceed, preced, previous
 - Included Keyword: this
 - Keyword Alternatives: phras
3. Key Phrase: “Now... this” indicates that what one has just heard or seen has no relevance to anything one is ever likely to hear and see.
- Included Keyword: now
 - Keyword Alternatives: phras
 - Included Keyword: hear
 - Keyword Alternatives: listen, catch, detect, attend, heed, absorb, gather, learn, discover, apprehend, understand, told, perciev, reciev, notic, inform, awar, see, spot, detect, view, behold, witness, catch, watch, eye, look, ascertain, discern, survey, observ, glimps, identif, recogniz, visualiz, connect, correlat, relate, relevan
 - Included Keyword: this
 - Keyword Alternatives: phras
4. Key Phrase: The phrase (“Now ... this”) acknowledges that the world has no order or meaning.
- Included Keyword: now
 - Keyword Alternatives: phras
 - Included Keyword: this
 - Keyword Alternatives: phras
 - Included Keyword: order

- Keyword Alternatives: sort, govern, command, direct, control, arrang, organiz, structur, systematiz, categoriz, class, coordinat, regulat, sequenc, methodiz, harmoniz, standard, mean, tidy, tidiness, worth, value, importanc, significanc, meaning

5. Key Phrase: The phrase (“Now ... this”) acknowledges that the world is not to be taken seriously.

- Included Keyword: now
 - Keyword Alternatives: phras
- Included Keyword: this
 - Keyword Alternatives: phras
- Included Keyword: serious
 - Keyword Alternatives: earnest, somber, sober, profound, deep, critical, solemn, earnest, grav, thought, weight, significan, importan, intens, sever, substant, resolut, determin, focus

6. Key Phrase: The phrase (“Now ... this”) acknowledges the fact that the world is mapped by the speeded-up electronic media.

- Included Keyword: electron
 - Keyword Alternatives: media, tv, phone, computer, lap, devic, tech, equip, speed, fast, quick, rapid, swift, mach, gadget, t.v, prompt, snap, short, time
- Included Keyword: now
 - Keyword Alternatives: phras
- Included Keyword: this
 - Keyword Alternatives: phras

7. Key Phrase: There is no phenomenon that cannot be erased from our minds by a newscaster saying, “Now ... this.” (There is no murder so brutal, no earthquake so devastating, no political blunder so costly, no ball score so tantalizing or weather report so threatening)

- Included Keyword: now

- Keyword Alternatives: phras
 - Included Keyword: this
 - Keyword Alternatives: phras
 - Included Keyword: eras
 - Keyword Alternatives: forg, disregard, neglect, overlook, slight, omit, miss, lose, remember, learn, clear, clean, exit, remain, ignor, delet, remov, wipe, wiping, losing
8. Key Phrase: The newscaster (saying “Now ... this”) means that you have thought long enough on the previous matter.
- Included Keyword: thought
 - Keyword Alternatives: think, consider, cogn, aware, contemplat, meditat, plan, intent, calculat, mindful, brainwork, act, reason, focus, reflect, mental, deliberat, judg, spect, sight, perce, prepar, enough, long, emotion
 - Included Keyword: matter
 - Keyword Alternatives: stor, commercial, subject, event, info, broadcast, message, report, stat, cast, thing, program, content, move, next, proceed, segment, occur, take, place, about, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, annouc, headlin, advanc, eventuat, transpir, aris, ensu, surfac, new, previous
9. Key Phrase: Approximately 45 seconds is long enough to think on the previous matter.
- Included Keyword: 45
 - Keyword Alternatives: forty, fourty, forty-five, fourty-five
 - Included Keyword: second
 - Keyword Alternatives: less, more, about
 - Included Keyword: matter
 - Keyword Alternatives: stor, commercial, subject, event, info, broadcast, message, report, stat, cast, thing, program, content, move, next, proceed, segment, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, annouc, headlin, advanc, eventuat, transpir, aris, ensu, surfac, new, previous

10. Key Phrase: The newscaster (saying “Now ... this”) means that you must not be morbidly preoccupied with the previous matter.

- Included Keyword: occup
 - Keyword Alternatives: busy, focus, gross, tied, engag, take, linger, conce, hook, caught, entic, draw, care, invest, lur, interest, pull, grab, intrigue, worry, bother, burden, immers, glue, consider, absorb, bur, consum, mesmer, bound, deep, wrap, tune, fix, rapt, fascinat, impress, forget, curious, rivet, captivat, grip, immers, enthrall, hold, held, hung, hang, hypno, carr, beguil, tranc, distract, involved, obsessed, lost, losing, move
- Included Keyword: matter
 - Keyword Alternatives: stor, commercial, subject, event, info, broadcast, message, report, stat, cast, thing, program, content, move, next, proceed, segment, occur, take, place, about, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, annouc, headlin, advanc, eventuat, transpir, aris, ensu, surfac, new, previous
- Included Keyword: newscast
 - Keyword Alternatives: phrase, Now, this, anchor, broadcast, journal, report, present, newsread, announc, correspond, anchor, commentat, analy, host, news, newsman, newspaper, newswoman, TV, personalit

11. Key Phrase: 90 seconds is too long to be preoccupied on with it (the previous matter).

- Included Keyword: 90
 - Keyword Alternatives: ninety, minute
- Included Keyword: occup
 - Keyword Alternatives: busy, focus, gross, tied, engag, take, linger, conce, hook, caught, entic, draw, care, invest, lur, interest, pull, grab, intrigu, worry, bother, burden, consider, bur, consum, mesmer, bound, deep, wrap, tune, fix, rapt, fascinat, impress, forget, curious, rivet, captivat, grip, immers, enthrall, held, hung, hang, los, hypno, carr, beguil, tranc, distract, involv, obsess, cling, attach, grip, hold, fasten, bond, affix, glue, cement, cling, stick, clasp, bind, connect, adher, ponder, mull, reflect, linger, stew, chew, dwell, absorb, introspect, think, deeply, engag, contemplat, meditat, perceiv, digest, perception, comprehen, process, move

- Included Keyword: matter
 - Keyword Alternatives: stor, commercial, subject, event, info, broadcast, message, report, stat, cast, thing, program, content, move, next, proceed, segment, occur, place, about, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, advanc, eventuat, transpir, aris, ensu, surfac, news, previous
- Included Keyword: sec
 - Keyword Alternatives: less, more, about

12. Key Phrase: The newscaster (saying “Now ... this”) means you must give your attention to another fragment of news or a commercial.

- Included Keyword: new
 - Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac
- Included Keyword: atten
 - Keyword Alternatives: emotion, sens, idea, reflect, logic, event, mem, thought, content, aware, perce, cogni, consider, contemplat, mediatat, deliberat, think, understand, intuit, impress, assum, speculat, imagin, sentiment, mood, vib, react, effect, feel, attitude, think, focus, concentrat, mind, observ, regard, notic, care, caring, scrutin, heed, stud, diligen, examin, vigilan, absor, contemp, effort, spect, interest, engag, alert, involv, participat, respon, adher, note, noting
- Included Keyword: newscast
 - Keyword Alternatives: phrase, Now, this, anchor, broadcast, journal, report, present, newsread, announc, correspond, anchor, commentat, analy, host, personalit, news, newsman, newsperson, newswoman, TV

13. Key Phrase: Television did not invent the “Now ... This” worldview.

- Included Keyword: tele
 - Keyword Alternatives: tv, new, cinema, show, entertain, program, t.v, broadcast, telly, tube, media

- Included Keyword: invent
 - Keyword Alternatives: creat, innovat, devis, contriv, fashion, fabricat, form, design, develop, produc, forg, construct, establish, make, making, made, conceiv, imagin, author, craft, concoct, manufactur, generat, assembl, shap, compos, begin, start, initiat, come, coming, came, stem, spring, sprung, aris, emerg, deriv, develop, evolv, generat, form, born, proceed, ensu, manifest, appear, result, surfac, birth, dawn, commenc, spark, coin, origin, intro, debut, reveal, unveil, exist, sourc, exclu, depend, result, consequence, date, dating, preced, lead, led, from
14. Key Phrase: “Now... this” worldview is the offspring of the intercourse between (a combination of) telegraphy and photography.
- Included Keyword: telegraph
 - Keyword Alternatives:
 - Included Keyword: photo
 - Keyword Alternatives:
15. Key Phrase: Television has allowed “Now ... This” worldview to flourish. (It is through television that it has been nurtured and brought to a perverse maturity).
- Included Keyword: tele
 - Keyword Alternatives: tv, new, cinema, show, entertain, program, t.v, tube, telly, broadcast
 - Included Keyword: now
 - Keyword Alternatives: phras
 - Included Keyword: this
 - Keyword Alternatives: phras
16. Key Phrase: On television, every half hour is a discrete event.
- Included Keyword: 30
 - Keyword Alternatives: thirty, half, less, more, about
 - Included Keyword: minute

- Keyword Alternatives: hour
- Included Keyword: discrete
 - Keyword Alternatives: separat, distinct, individual, detach, independent, connect, isolat, self, relat, attach, divid, different, specific, exclusive, particular, unique, different, associat, peculiar, depend, alone

17. Key Phrase: A discrete event is separated in context from what precedes and follows it.

- Included Keyword: context
 - Keyword Alternatives: news, info, story, stori, article, report, broad, cover, feature, update, bulletin, breaking, press, release, head, line, edit, opinion, comment, analy, item, material, expos, current, past, future, affair, piece, thing, stuff, person, anecdo, setting, background, circumstance, environent, situation, condition, scenario, scene, frame, surround, event, premise, narrative
- Included Keyword: preced
 - Keyword Alternatives: lead, before, pre, exist, forego, earli, early, ahead, time, herald, introd, way, head, fore, prior, former, previous, first, preliminar, already, avanc, anteced, guid, pav, stag, introduc, antedat, front, start, launch, initat, open, kick, eminen
- Included Keyword: follow
 - Keyword Alternatives: subsequen, next, later, post, succe, ensu, come, comi, consequen, latter, after, posthumous, here, down, trail, pursu, superven

18. Key Phrase: A discrete event is separated in content from what precedes and follows it.

- Included Keyword: content
 - Keyword Alternatives: news, info, story, stori, article, report, broad, cover, feature, update, bulletin, breaking, press, release, head, line, edit, opinion, comment, analy, item, material, expos, current, past, future, affair, piece, thing, stuff, person, anecdo
- Included Keyword: preced

- Keyword Alternatives: lead, before, pre, exist, forego, earli, early, ahead, time, herald, introd, way, head, fore, prior, former, previous, first, preliminar, already, avanc, anteced, guid, pav, stag, introduc, antedat, front, start, launch, initat, open, kick, eminen
 - Included Keyword: follow
 - Keyword Alternatives: subsequen, next, later, post, succe, ensu, come, comi, consequen, latter, after, posthumous, here, down, trail, pursu, superven
19. Key Phrase: A discrete event is separated in emotional texture from what precedes and follows it.
- Included Keyword: emotion
 - Keyword Alternatives: feel, mood, sentimen, state, mind, position, temper, attitude, spirit, outlook, fram, humor, tone, tona, character, natur, ffect, condition, mental, psych, aura, vibe, vibing, sens, tendenc, tenor, complex, demeanor, stanc, essen, heart, core, substan, gestalt, ambian, atmospher
 - Included Keyword: preced
 - Keyword Alternatives: lead, before, pre, exist, forego, earli, early, ahead, time, herald, introd, way, head, fore, prior, former, previous, first, preliminar, already, avanc, anteced, guid, pav, stag, introduc, antedat, front, start, launch, initat, open, kick, eminen
 - Included Keyword: follow
 - Keyword Alternatives: subsequen, next, later, post, succe, ensu, come, comi, consequen, latter, after, posthumous, here, down, trail, pursu, superven
20. Key Phrase: Television programs are structured (designed) to sell its time in minutes and seconds.
- Included Keyword: sell
 - Keyword Alternatives: market, business, money, econom, spend, cash, currency, finance, income, decision, dough, bread, choice, option, capital, expen, fund, wealth, fortun, sum, budget, invest, buck, source, rich, business, market, commer, fiscal, indust, pecuniary, product, mercentile, profit, remunerat, sale, good, merch, service, suppl, bill, salar, wage, pay, paid, vend, exchang, barter, offer, promot, distribut, deal, capital, optimiz, monetiz, dispos, wast, time, efficien

- Included Keyword: tele
 - Keyword Alternatives: tv, new, cinema, show, entertain, program, t.v, broadcast, telly, tube, media

21. Key Phrase: Television programs are structured (designed) to use images rather than words.

- Included Keyword: imag
 - Keyword Alternatives: pictur, photo, visual, illustrat, portrait, snap, depict, view, render, design, sketch, print, graphic, visib, sight, sought, see, vision, expos, reveal, observ, diagram, vivid, lucid, explicit, present, figur, paint, draw, show, look, notic, perce, glimps, spot, scan, examin, regard, gaze, gazing, glanc, peer, survey, witness, watch, scrutin, portray, symbol, icon, scen, shot, cartoon, emblem, detect, beheld, behold, discern, eye, check, peep, scop, contemplat
- Included Keyword: word
 - Keyword Alternatives: term, express, utter, phras, verb, languag, speech, statement, remark, communicat, say, said, articulat, vocal, talk, dialog, discours, line, lining, lexic, lexeme, ling, pronounc, announc, declar, assert, convers, messag, letter, stat, voic, mention, told, tell, reply, repli, answer, spoke, speak, convey, enunciat, report, cite, citing, quot, narrat, comment, address, acknowledg, chat, confer, discuss, banter, palaver, confab, gossip, oral, natter, respon, consult, dict
- Included Keyword: tele
 - Keyword Alternatives: tv, new, show, entertain, program, t.v, broadcast, telly, tube, media

22. Key Phrase: Television programs are structured (designed) with the fact audiences can move freely to and from the television set in mind.

- Included Keyword: tele
 - Keyword Alternatives: tv, new, cinema, show, entertain, program, t.v, broadcast, telly, tube, media
- Included Keyword: move
 - Keyword Alternatives: shift, transfer, transport, alter, adjust, maneuver, switch, progress, travel, flow, proceed, act, displac, chang, migrat, budg, advanc, position, locat, sit, roam, wander, locomot, perch, squat, plant, seat, park, plop, occup,

repos, settl, nestl, ensconc, loung, reclin, situat, plac, stay, remain, linger, persist, stick, halt, stop, rest, sojourn, dwell, hang, around, keep, resid, wait, continu, endur, lodg, tarr, abid, liv, bid, wireless, mobil

23. Key Phrase: Television programs are separated into eight-minute segments.

- Included Keyword: eight
 - Keyword Alternatives: 8, min

24. Key Phrase: Programs are structured so that almost (each eight-minute) segment may stand out as a complete event in itself.

- Included Keyword: complete
 - Keyword Alternatives: discrete, distinct, separate, different, unique, notable, individual, connect, isolate, detach, unit, disjunct, independent, whole, entire, total, full, finish, conclud, consum, accomplish, thorough, absolut, integral, intact, final, exhaust, comprehen, integrat, compass
- Included Keyword: event
 - Keyword Alternatives: matter, stor, commercial, subject, info, stat, cast, thing, program, content, segment, occur, place, manifest, befall, surfac, message, report, material, announc, headlin, eventuat, transpir, aris, new, take, topic, section, part, portion, division, piece, component, element, slice, fraction, bit, module, portion, compartment, block, phase, unit, partition, wedge, sector, fragment, 8, eight, min

25. Key Phrase: Viewers are rarely required to carry over any thought or feeling from one parcel of time to another.

- Included Keyword: thought
 - Keyword Alternatives: emotion, sens, idea, reflect, logic, event, mem, atten, content, aware, perce, cogni, consider, contemplat, mediatat, deliberat, think, understand, intuit, impress, assum, speculat, imagin, mood, vib, react, feel, attitude, think, focus, concentrat, mind, observ, regard, notic, care, caring, scrutin, heed, stud, diligen, examin, vigilan, absor, contemp, effort, spect, interest, engag, alert, involv, participat, respon, adher, note, noting, sentimen, passion, atmospher, temper, state, frame, ffect, tender, attach, sentien, heart, position, soul, experienc

26. Key Phrase: We are presented with news as pure entertainment.

- Included Keyword: entertain
 - Keyword Alternatives: fun, inform, content, pleasur, diver, distract, joy, relax, recreat, good, play, amus, delight, interest, wow, cheer, engross, engag, captivat, fascinat, beguil, exhilarat, gratif, entranc, regal, mesmeriz, rapt, enjoy, leisure, activit, show, spect, theat, movie, comed, perform, hobb, festiv, celebrat, event, extravagan, art, present, anaz

27. Key Phrase: Television presents the “news of the day.”

- Included Keyword: day
 - Keyword Alternatives: current, event, recent, modern, present, dat
- Included Keyword: tele
 - Keyword Alternatives: tv, cinema, show, entertain, program, t.v, broadcast, telly, tube, media
- Included Keyword: new
 - Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac

28. Key Phrase: We may see “Now ... this” mode of discourse in its boldest and most embarrassing form on “news of the day.”

- Included Keyword: new
 - Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac
- Included Keyword: day
 - Keyword Alternatives: current, event, recent, late, modern, present, dat
- Included Keyword: now
 - Keyword Alternatives: phras

- Included Keyword: this
 - Keyword Alternatives: phras

29. Key Phrase: We are presented with fragmented news on TV.

- Included Keyword: fragment
 - Keyword Alternatives: full, whole, half, fraction, shard, bit, portion, section, segment, fraction, part, complet, continu, divid, separat, particle, scrap, remnan, slic, piec, chip, sliver, shred, block, chunk, divis, component, element, ingredient, item, unit, parcel, speck, morsel, crumb, remain, trace, tracing, flake, flaking, lump, residue, vestige, clip, shrapnel, break, broken, ruin, patch, atom, cluster, snip, debris, extract, detritus, excerpt, sampl, token, trial, tast, shatter, unif, assembl, structur, total, entire, coher, split, fuse, fusing, rupt, organi, cohes, intact
- Included Keyword: new
 - Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac

30. Key Phrase: We are presented news without context on TV.

- Included Keyword: new
 - Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac
- Included Keyword: context
 - Keyword Alternatives: back, refer, tru, know, understand, mean, relev, setting, environment, situation, milieu, atmosphere, ambiance, frame, circumstan, condition, scen, surround, referenc, premis, explain, connect, isolat, specif, ambigu, clear, interpret, congru

31. Key Phrase: We are presented news without consequences on TV.

- Included Keyword: new

- Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac

- Included Keyword: consequence

- Keyword Alternatives: after, result, out, ramifi, end, conclu, react, effect, signif, weight, repercuss, impact, implicat, importan, eventuality, reverberat, issue, burden, load

32. Key Phrase: We are presented news without value on TV.

- Included Keyword: new

- Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac

- Included Keyword: valu

- Keyword Alternatives: imp, signif, merit, use, worth, bene, purpos, help, virtue, qualit, utili, appeal, desir, satisf, mean, substance, treasure, weight, influen, apprais

33. Key Phrase: We are presented news without essential seriousness on TV.

- Included Keyword: new

- Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac

- Included Keyword: serious

- Keyword Alternatives: weight, gravi, imp, signif, mean, sinc, thought, griev, intent, load, severe, critic, crucial, substan, resol, focus, commit, solemn, sobriety, sober

34. Key Phrase: (As a thought experiment) The author asks the readers to consider how they would produce a TV news show for any station.

- Included Keyword: consider
 - Keyword Alternatives: think, plan, process, lay, out, ponder, contemplat, suppose, mull, imagin, vision, visag, fantas, pictur, conceiv, brain, assess, analy, play, weigh, evaluat, examin, review, debate, judg, sketch, frame, blue, over, draft, structur, design, schem, propos, strat, map, idea, thought, experiment, speculat, theor, assum, conjec, presum, tentative, postul, fict
- Included Keyword: produc
 - Keyword Alternatives: creat, develop, generat, content, prep, assemb, organiz, compos, fabricat, construc, craft, build, manufactur, compil, arrang, together, script, coordinat, choreograph, curate, direct, forg, form, spawn, cook, cultivat, yield, conceiv, mak, output, offer, concoct
- Included Keyword: new
 - Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac

35. Key Phrase: To attract the largest possible audience, you would, first, choose a cast of players.

- Included Keyword: attract
 - Keyword Alternatives: entic, draw, bring, appeal, lur, interest, hook, pull, grab, intrigue, garner, captivat
- Included Keyword: audience
 - Keyword Alternatives: crowd, viewer, spectator, listener, people, count, number, everyone, population, folk, public, community, nation
- Included Keyword: cast
 - Keyword Alternatives: players, act, performer, troupe, entertainer, part, character, group, lineup, ensemble, company, set, crew, squad, team, roster, member, reporter, anchor, presenter, people, person

36. Key Phrase: A cast of players whose face should be “likable.”

- Included Keyword: player
 - Keyword Alternatives: part, member, cast, act, performer, troupe, entertainer, part, character, group, lineup, ensemble, company, set, crew, squad, team, roster, member, anchor, reporter, presenter, people, person
- Included Keyword: like
 - Keyword Alternatives: amiab, agree, person, civil, warm, pleas, convivial, engag, fetch, appeal, endear, present, friendly, kind, genial, affable, sociable, warm, lovable, winsome, approach, likable, engag, captivat, enjoy, attract, delight, charm, love, lika, attractive, pretty, handsome, gorgeous, allur, enchant, desir, irresistible

37. Key Phrase: A cast of players whose face should be “credible.”

- Included Keyword: player
 - Keyword Alternatives: part, member, cast, act, performer, troupe, entertainer, part, character, group, lineup, ensemble, company, set, crew, squad, team, roster, member, anchor, reporter, presenter, people, person
- Included Keyword: cred
 - Keyword Alternatives: believe, trust, accept, collect, depend, persua, reason, compel, present, convin, plaus, reliable, authentic, reputable, honest, competent, legit, rely, depend, genuin, reput

38. Key Phrase: A cast of players must submit their headshots during application. (Those who apply would, in fact, submit to you their eight-by-ten glossies.)

- Included Keyword: submit
 - Keyword Alternatives: turn, hand, send, receiv, lodg, file, present, offer, deliver, forward, sign, commit, appl, prop, give, serv, mail, shar, sent, provid, transfer, giving
- Included Keyword: shot
 - Keyword Alternatives: head, photo, imag, snap, print, pic, portrait, self, prof, gloss, fanc, design, visual, graphic, face, noggin, countenance

39. Key Phrase: A cast of players whose countenances (faces) are not suitable for nightly display should be eliminated.

- Included Keyword: appear
 - Keyword Alternatives: look, image, presen, visag, face, feat, counten, profile, aspect, hot
- Included Keyword: suit
 - Keyword Alternatives: fit, prop, good, bad, satis, seem, pleas, toler, like, appeal, agree, endear, invit, attract, entic, worthy, deserv, captiv, charm, appropri, befit, worth
- Included Keyword: reject
 - Keyword Alternatives: den, drop, refus, away, exclud, off, pass, shun, decli, disc, elimin, prohibit, banish, fire, decline, dismiss, spurn, turn, aside, rebuff, disown, veto, disregard, snub, overlook, abandon, desert, repudiat, renounc, forsak, out, disapprov

40. Key Phrase: Women who are not beautiful would be excluded (from a cast of players).

- Included Keyword: beaut
 - Keyword Alternatives: attract, fair, good, gorg, stun, hot, cute, eas, chant, charm, sight, ravish, beguil, foxy, material, lovely, pretty, breathtaking, elegant, exquisite, radiant, enchanting, splendid, picturesque, striking, resplendent, glamorous, magnificent, captivat, appeal, allur, enchant, mesmeriz, delight, photogen, strik, glamor, grac, ugly, attractive, repulsive, unsightly, disgusting, grotesque, foul, deform, revolt
- Included Keyword: women
 - Keyword Alternatives: lad, woman, gal, girl, dame, miss, madam, lass, matron, maid, damsel, chick, broad, female, feminine

41. Key Phrase: Women over the age of 50 would be excluded (from a cast of players).

- Included Keyword: 5
 - Keyword Alternatives: fifty, sixty, forty, 4, 6
- Included Keyword: women
 - Keyword Alternatives: female, lad, woman, gal, girl, dame, miss, madam, lass, matron, maid, damsel, chick, broad, female, feminine

42. Key Phrase: Bald men would be excluded (from a cast of players).
- Included Keyword: bald
 - Keyword Alternatives: shav, bare, hair
43. Key Phrase: All people who are overweight would be excluded (from a cast of players).
- Included Keyword: overweight
 - Keyword Alternatives: big, port, chub, stout, rotund, large, flab, bloat, massive, shape, heavy, fat, plump, chunky, stout, bulky, rotund, corpulent, pudgy, ample, paunchy, husky, thick, round, heft, tub, curv, obes
44. Key Phrase: All people whose noses are too long would be excluded (from a cast of players).
- Included Keyword: nose
 - Keyword Alternatives: sniff, snout, nozzle, snoot
 - Included Keyword: long
 - Keyword Alternatives: length, extend, out, pro, big, large, huge, great, massive, tall, beak
45. Key Phrase: All people whose eyes are too close together would be excluded (from a cast of players).
- Included Keyword: eye
 - Keyword Alternatives: Orb, Optic, Visual, Ocular, Pupil, peeper
 - Included Keyword: clos
 - Keyword Alternatives: short, slim, cram, pack, spac, spread, gap, shut, near, adjacent, tight, narrow, outlying, removed, away, yonder, wide, separate, apart, far, distan, diverg
46. Key Phrase: You need to assemble a cast of talking hairdos.
- Included Keyword: hairdo

- Keyword Alternatives: beaut, pretty, fair, good, stun, hot, cute, eas, chant, charm, sight, ravish, beguil, foxy, material, attract, entic, draw, bring, appeal, lur, interest, hook, pull, grab, dazz, doll, man, marion, figure, puppet, model, angel, sweet, dream, strik, bab, stud, prince, meal, feast, snack, dainty, hon, lov, grand, glam, aesthetic, idea, marvel, fine, fascina, radiant, 10, ten, win, catch, prize, treasure, breath, exquis, nice, deli, divin, grace, symm, well, wonder, appeti, invit, form, feat, look, heart, shock, fanta, out, natural, gorg, pulchritud, styl, talk, barbie, mannequin, model, actor, actress, screen, Hollywood, movie, cinema, film, celeb, star, idol, public, person, profile, feature, aspect, intrigu, appear

47. Key Phrase: You will want those (from a cast of players) whose faces would not be unwelcome on a magazine cover.

- Included Keyword: welcom

- Keyword Alternatives: charm, sight, attract, entic, appeal, interest, intrigue, assum, appeti, glam, idea, invit, loss, ugl, fascina, 1, one, gross, horr, monst, symm, hid, awful, gris, grot, appal, bad, beast, form, seem, figure, foul, fright, feat, loath, shape, look, plain, repugnant, puls, revolt, beaut, come, lov, dirt, disgust, tast, mess, nast, shock, sordid, terr, vile, bas, filth, nobl, low, mean, naus, noisome, object, question, odious, offens, scandal, sick, sorry, wick, wretch, abomin, dread, ghastr, grim, grue, weird, detest, morbid, offens, warp, distort, absurd, bizarre, eerie, ludicrous, odd, out, preposterous, ridiculous, strange, aberrant, freak, grod, canny, natural, appearance, profile, feature, aspect, celeb, star, public, person, idol, barbie, mannequin, model, actor, actress, screen, Hollywood, movie, cinema, film

- Included Keyword: face

- Keyword Alternatives: facial, magazine, countenance, visage, cover

48. Key Phrase: Christine Craft had a problematic experience.

- Included Keyword: Christine

- Keyword Alternatives: Craft, she, her

- Included Keyword: problem

- Keyword Alternatives: issue, complicat, dilemma, obstacle, hurdle, troubl, challeng, conundrum, concern, pitfall, nuisance, mishap, experienc, inciden, event,

encount, occur, circum, matter, scen, occas, situat, moment, instan, difficult, controversial, thorny, sticky, knotty, dicey, hairy, tricky, intricate, tough, contentious, debatable, vex, bother, worr, disput, victim, case, instance, episode

49. Key Phrase: Christine Craft has an attractive face.

- Included Keyword: Christine
 - Keyword Alternatives: Craft, she, her
- Included Keyword: problem
 - Keyword Alternatives: issue, complicat, dilemma, obstacle, hurdle, troubl, challeng, conundrum, concern, pitfall, nuisance, mishap, experienc, inciden, event, encount, occur, circum, matter, scen, occas, situat, moment, instan, difficult, controversial, thorny, sticky, knotty, dicey, hairy, tricky, intricate, tough, contentious, debatable, vex, bother, worr, disput, victim, case, instance, episode

50. Key Phrase: Christine Craft applied for a co-anchor position on KMBC-TV.

- Included Keyword: Christine
 - Keyword Alternatives: Craft, she, her
- Included Keyword: anchor
 - Keyword Alternatives: caster, report, present, announc, comment, KMBC

51. Key Phrase: KMBC-TV is in Kansas City.

- Included Keyword: KMBC
 - Keyword Alternatives: TV, tele, network, K.M.B.C, T.V, station
- Included Keyword: Kansas City
 - Keyword Alternatives: K.C, Missouri

52. Key Phrase: Christine Craft filed a sexism lawsuit against the TV station (KMBC-TV).

- Included Keyword: sex
 - Keyword Alternatives: bias, discrimin, misogyn, prejudice, inequit, unfair, favor, chauvin, unjust, injust, immoral, unethic

- Included Keyword: suit
 - Keyword Alternatives: litigation, legal, case, action, trial, law, proceedings, court, dispute, sue, fair, justice, judic, compinsation, damage, bill, claim, prosecution

53. Key Phrase: Christine Craft was hired by the station (KMBC-TV) in January 1981.

- Included Keyword: hir
 - Keyword Alternatives: employ, appoint, recruit, start, enlist, work, join, role, sign, enroll, payroll, commision, job, career, profession, occupation
- Included Keyword: 1981
 - Keyword Alternatives: 81, eight, January, 80s, 80's

54. Key Phrase: Management of KMBC-TV loved Christine's look.

- Included Keyword: Christine
 - Keyword Alternatives: Craft, she, her
- Included Keyword: look
 - Keyword Alternatives: appear, image, air, face, aspect, bearing, presen, semblance, guise, facade, poise, qualit, visage, countenance, feature, aesthetic, appeal, trait, mien, figur, profile

55. Key Phrase: Christine Craft was fired by the station (KMBC-TV) in August 1981.

- Included Keyword: fir
 - Keyword Alternatives: dismiss, off, out, oust, axe, boot, eject, door, rid, sack, remov, discharg, term, let, lay, laid, releas, drop, canned, eliminat, pack, displac
- Included Keyword: 1981
 - Keyword Alternatives: 81, eight, 80s, 80's, after, later, August, shortly, same, year, following, succeeding, subsequent, wake, beyond

56. Key Phrase: Research indicated Christine Craft's appearance "hampered viewer acceptance."

- Included Keyword: hamper

- Keyword Alternatives: impair, affect, hinder, inhibit, obstruct, limit, block, upset, impede, restrict, stall, foil, curb, slow, sabotage, halt, derail, held, thwart, interrupt, prevent, stop, disrupt, encumber, hold, reduc, effect, low
 - Included Keyword: accept
 - Keyword Alternatives: approv, embrace, tolerant, welcome, compli, adopt, enjoy, ok, yes, like, agree, acquires, concur, view, audience, spectat, watch, fan, follow, subscrib, consum, user, patron, customer, support, participa, engag, attend
57. Key Phrase: Christine Craft was fired (from KMBC-TV) because her appearance “hampered viewer acceptance.”
- Included Keyword: fir
 - Keyword Alternatives: dismiss, off, out, oust, axe, boot, eject, door, rid, remov, sack, discharg, term, let, lay, laid, releas, drop, canned, eliminat, pack, displac
 - Included Keyword: accept
 - Keyword Alternatives: approv, embrace, tolerat, welcom, compli, adopt, enjoy, yes, like, agree, acquies, concur, view, audience, spectat, watch, fan, follow, sub-scrib, consum, user, patron, customer, support, participa, engag, attend, okay
58. Key Phrase: “Hampered viewer acceptance” means that the viewers do not like the look of the performer (reporter).
- Included Keyword: hamper
 - Keyword Alternatives: accept, viewer
 - Included Keyword: look
 - Keyword Alternatives: present, featur, appear, presen, image, air, face, aspect, bearing, semblance, guise, facade, poise, qualit, visage, countenance, aesthetic, appeal, trait, mien, figur, profile
59. Key Phrase: “Hampered viewer acceptance” means the same thing for television news as it does for television shows (fictional media).
- Included Keyword: new

- Keyword Alternatives: stor, commercial, matter, subject, event, info, broadcast, messag, report, stat, cast, thing, program, content, segment, next, occur, place, manifest, befall, pass, into, being, happen, unfold, come, forth, crop, material, announc, headlin, eventuat, transpir, aris, ensu, surfac, show, television, channel, fict, narrative, tale, media, fantas, myth, short
- Included Keyword: same
 - Keyword Alternatives: similar, like, close, equal, compar, equiv, analogous, resembl, match, akin, identi, congru, equa, indential, parallel, distinguish, correspond, uniform, even, balanc, proportion, symmetr, homogen, par, kind, line, congruen, consist, homolog, duplicat
60. Key Phrase: “Hampered viewer acceptance” means that viewers do not believe the performer (reporter).
- Included Keyword: hamper
 - Keyword Alternatives: accept, viewer
 - Included Keyword: believ
 - Keyword Alternatives: trust, accept, assume, conclude, take, give, reput, cred, compl, surmize, deduce, dependable, valid, endear, faith, assure, rely, relia, sincer, credi, convinc, plausi, genui
61. Key Phrase: “Hampered viewer acceptance” in theatrical performing means that the actor’s portrayal is not persuasive to the audience.
- Included Keyword: hamper
 - Keyword Alternatives: accept, viewer
 - Included Keyword: act
 - Keyword Alternatives: performer, cast, thespian, artist, player, stager, troupe, entertain, lead, stage, anchor, journalist, reporter, presenter, announcer, commentator, analyst, host, person
 - Included Keyword: persua

- Keyword Alternatives: interest, care, want, into, intrigu, desir, wish, need, appeal, absorb, compel, excit, stimulat, engag, grip, attent, concern, gross, hook, sold, entic, gung, impress, lur, bait, move, open, will, amenable, sell, stir, game, tak, feel, partial, convinc, sway, inclin, mind, keen, eager, responsive, fascinat, captivat, atten, enthus, persua, attract, coax, draw, enchant, incit, tempt, appeal, invit, mesmer, win, influen, encourag, urg, prompt, motivat, cajol, reason, negotiat, incit, induc, beguil, woo, charm, solicit, intrig, tantali, lead, nudg, manipul, impel, advocat, prevail, propos, present, exhort, press, push, pull

62. Key Phrase: We must consider what lack of credibility means in the case of a news show.

- Included Keyword: cred
 - Keyword Alternatives: depend, believe, qual, trust, accept, collect, compel, persua, reason, reliab, trust, accura, plaus, convinc, valid, predict, confiden, correct, honest, dut, rely, authentic, integ, verit, veracit, reputa
- Included Keyword: news
 - Keyword Alternatives: show, tele, info, stor, TV, T.V, report, stat, network, content, messag, broadcast, program, cast, headlin, announc, event, occur, commercial, matter, subject, content, segment, happen, material, transpir, aris, ensu

63. Key Phrase: We must consider what character a co-anchor is playing (in a news show).

- Included Keyword: chara
 - Keyword Alternatives: player, act, performer, troupe, entertainer, part, cast, group, lineup, ensemble, company, set, crew, squad, team, roster, anchor, who, role, person, position, people, member, facade

64. Key Phrase: We must consider how to decide if the performance lacks verisimilitude (in a news show).

- Included Keyword: perform
 - Keyword Alternatives: produc, show, present, act, display, port, ensemb, play, exhibit, enter, demon, execut, conduc, event, behav, scen, exhibit
- Included Keyword: veri

- Keyword Alternatives: tru, real, authent, legit, accept, qual, compel, persua, reason, cred, believ, accura, depend, reliab, plaus, convinc, valid, predict, confid, correct, honest, veracit, genuin

65. Key Phrase: We must consider whether the audience believes the newscaster is lying.

- Included Keyword: audienc
 - Keyword Alternatives: crowd, viewer, spectator, listener, people, count, number, everyone, population, folk, person, public, community, nation, watch, fan, follow, subscrib, consumer, patron, support, participat, attend
- Included Keyword: lying
 - Keyword Alternatives: liar, honest, authent, legit, accept, qual, compel, persua, reason, cred, believ, accura, depend, reliab, plaus, convinc, valid, predict, confid, correct, honest, real, trust, true, fib, sincer, bs, b.s, fak, fals, decei, veri, prevaricat, fabricat, cap, perfid, ruse, duplicit
- Included Keyword: news
 - Keyword Alternatives: report, perform, entertain, crew, anchor, part, cast, act, stat, program, announc, headlin, show, tele, info, stor, TV, network, content, messag, broadcast, program, T.V, happen, material, transpir, aris, ensu

66. Key Phrase: We must consider whether the audience would believe that what is reported did not happen.

- Included Keyword: audienc
 - Keyword Alternatives: crowd, viewer, spectator, listener, people, count, number, everyone, population, folk, person, public, community, nation, watch, fan, follow, subscrib, consumer, patron, support, participat, attend
- Included Keyword: happen
 - Keyword Alternatives: occur, fulfill, done, take, place, bring, realize, attain, complete, begin, execute, achiev, ffect, start, result, arise, develop, trans, proceed, follow, ensue, advanc, continu, get, real
- Included Keyword: report

- Keyword Alternatives: new, report, perform, entertain, cast, act, stat, program, announc, headlin, show, tele, info, stor, TV, network, content, messag, broadcast, program, T.V, material, transpir, communicat, disclos, present, describ, delineat, outlin, claim, chronicl, declar, publiciz, publish, promulgat, investigat, cover

67. Key Phrase: We must consider if something important (on the news) is being concealed.

- Included Keyword: conceal
 - Keyword Alternatives: hid, secret, cover, cloak, disguise, mas, camo, expose, obscure, block, censor, restr, limit, supress, prohibit, ban, remov, keep, left, kept, withh, mask, shroud, veil, mantl, envelop, swath, unseen, conspicuous, notic, visib, tuck, suppress, omit, bury, buried
- Included Keyword: thing
 - Keyword Alternatives: new, show, tele, info, stor, TV, T.V, report, stat, network, content, messag, program, cast, headlin, announc, event, occur, detail

68. Key Phrase: The perception of the truth of a report rests heavily on the acceptability of the newscaster.

- Included Keyword: tru
 - Keyword Alternatives: accur, fact, legit, belie, valid, know, fals, lie, fake, fabricat, dece, hon, real, genuin, authenti, trust, reputa, relia, sincer, depend, respect, good, bad, evil, fraud, interpret, lead, frank, bias, right, wrong, fair, just, precis, correct, valu, exact, reason, cred, solid, opinion, assum, impress, judg, view, feel, think, thought, understand, notion, aware, insight, perce, info, sens, detail, take, discern, conce
- Included Keyword: news
 - Keyword Alternatives: report, perform, entertain, crew, anchor, part, cast, act, stat, program, announc, headlin, show, tele, info, stor, TV, network, content, messag, broadcast, program, T.V, accept

69. Key Phrase: In the ancient world, there was a tradition of banishing or killing the bearer of bad tidings (bad news).

- Included Keyword: tradition

- Keyword Alternatives: ancient, cust, cultur, belief, ceremon, ritual, habit, pattern, convention, folkway, heritage, routin, norm, histor, practic, pratic
- Included Keyword: banish
 - Keyword Alternatives: kill, murder, elim, ostraciz, rid, oust, remov, deport, eject, evict, disc, trans, assassin, slay, terror, liquid, blood, destroy, slaught, mass, butch, expel, excommunicat, exil, exclud, dismiss, extradit, displac, eradicat, shoot, punish, penaliz, castigat, condemn, sentenc, afflict, retribution, disciplin, annihilat, execut, terminat, dispatch, obliterated, neutraliz, ban
- Included Keyword: bad
 - Keyword Alternatives: news, tiding, omen, harbinger, herald, augur, forebod, presage, forewarn, portent, bear, carr, courier, conveyer, messenger, bringer, deliver, transporter, distributor

70. Key Phrase: The television news show may restore this tradition in a curious form.

- Included Keyword: tradition
 - Keyword Alternatives: cust, cultur, belief, ceremon, ritual, habit, pattern, convention, folkway, heritage, routin, norm, histor, practic, pratic
- Included Keyword: tele
 - Keyword Alternatives: show, new, info, stor, TV, T.V, report, stat, network, content, messag, broadcast, program, season, episod, announc
- Included Keyword: restor
 - Keyword Alternatives: conserv, protect, back, improv, renew, recover, regain, return, repair, fix, resurrect, reclaim, rebuild, replenish, reconstruct, regenerate, refresh, remedy, instat, reviv, institut, vitali, invigorat, generat, furbish, establish, rebuilt

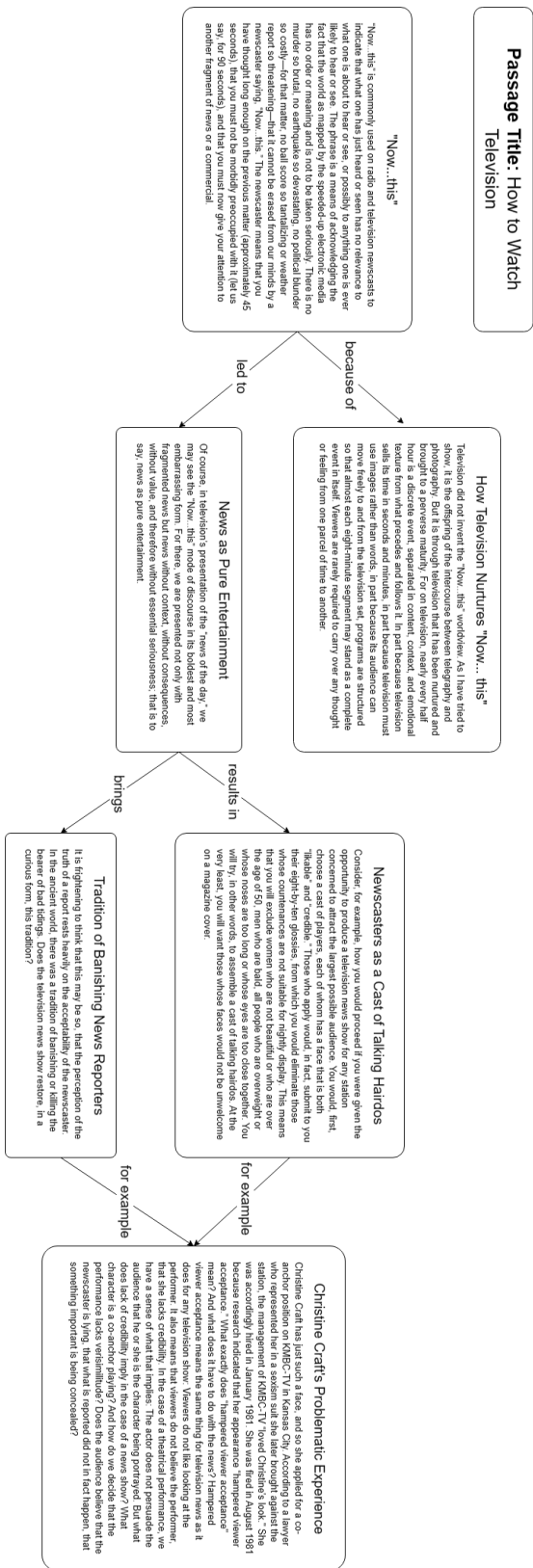


Figure B.36: Passage 5: How to Watch TV in Hybrid Map (H) condition

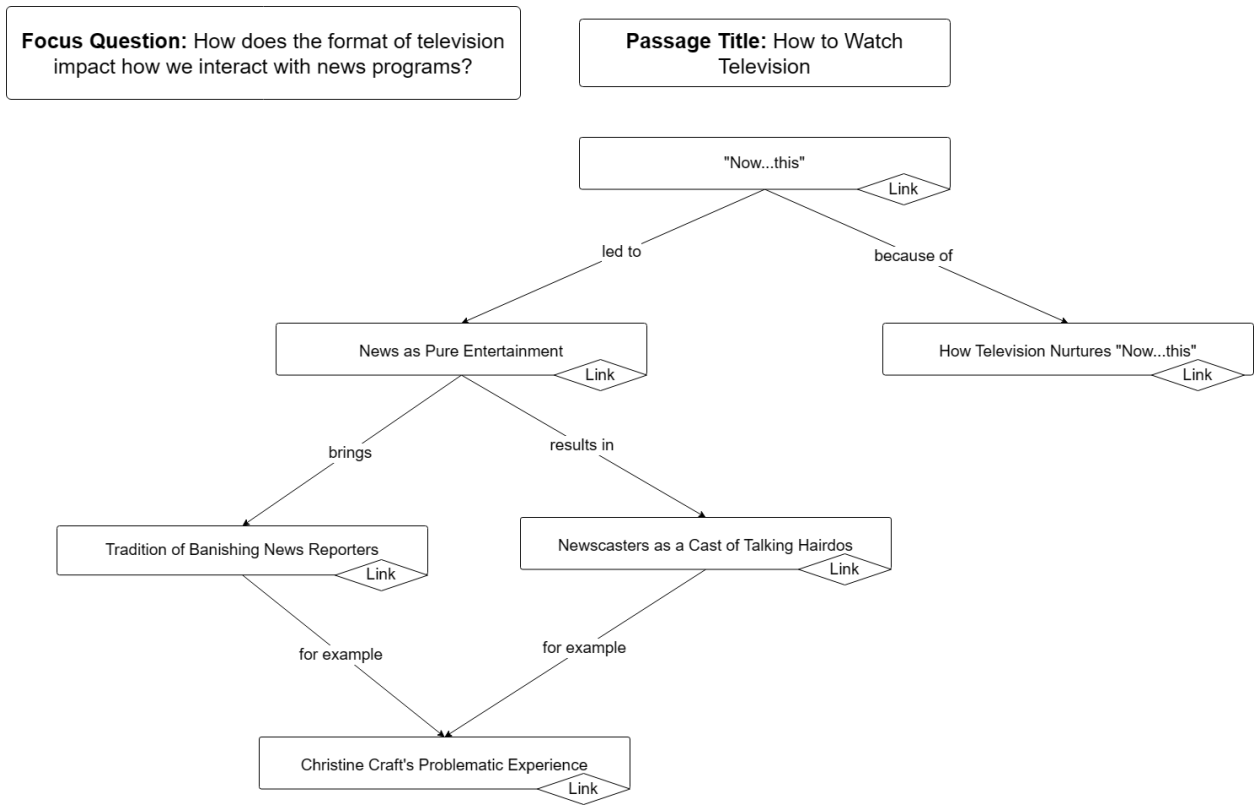


Figure B.37: Passage 5: How to Watch TV in Novakian Knowledge Model (K) condition - Master-map

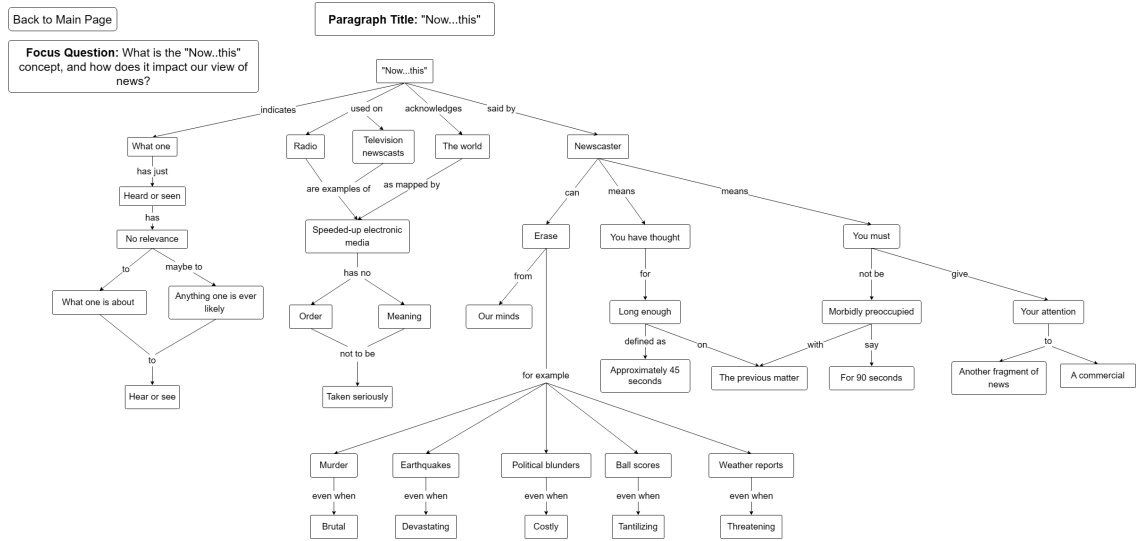


Figure B.38: Passage 5: How to Watch TV in Novakian Knowledge Model (K) condition - mini-map1

Back to Main Page

Paragraph Title: How Television Nurtures "Now...this"

Focus Question: How do the characteristics of television nurture the "Now... this" worldview?

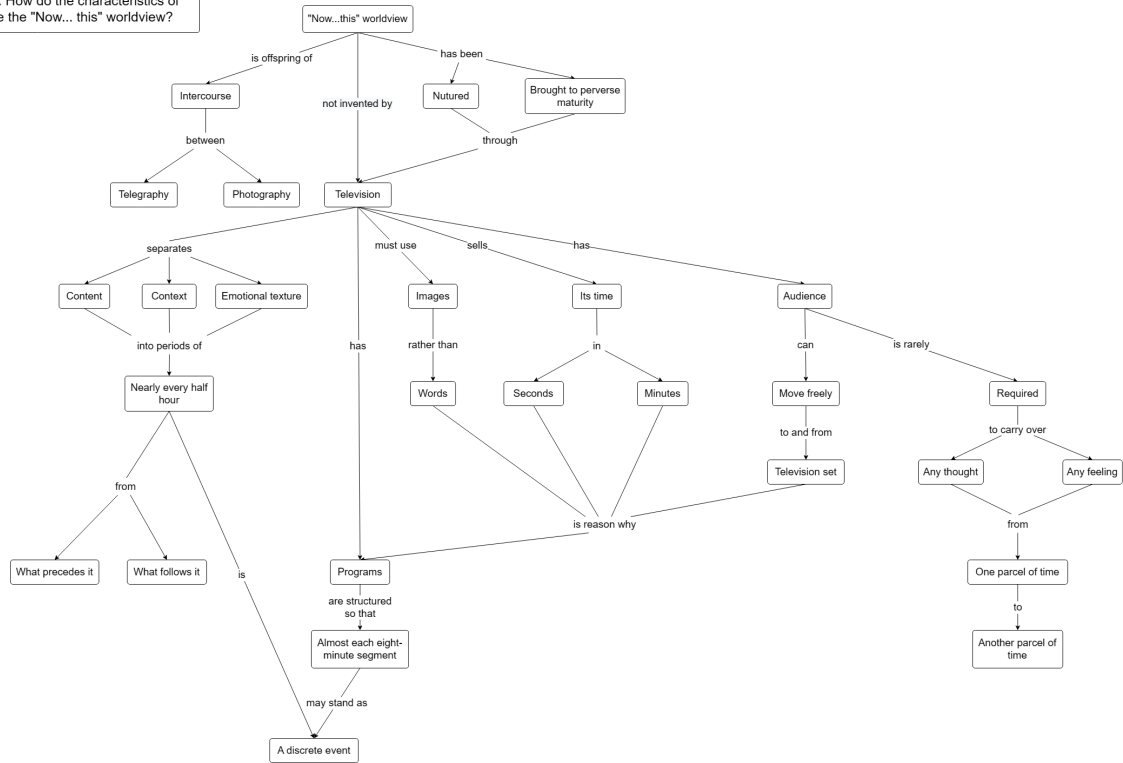


Figure B.39: Passage 5: How to Watch TV in Novakian Knowledge Model (K) condition - mini-map2

Back to Main Page

Paragraph Title: News as Pure Entertainment

Focus Question: How has news become pure entertainment?

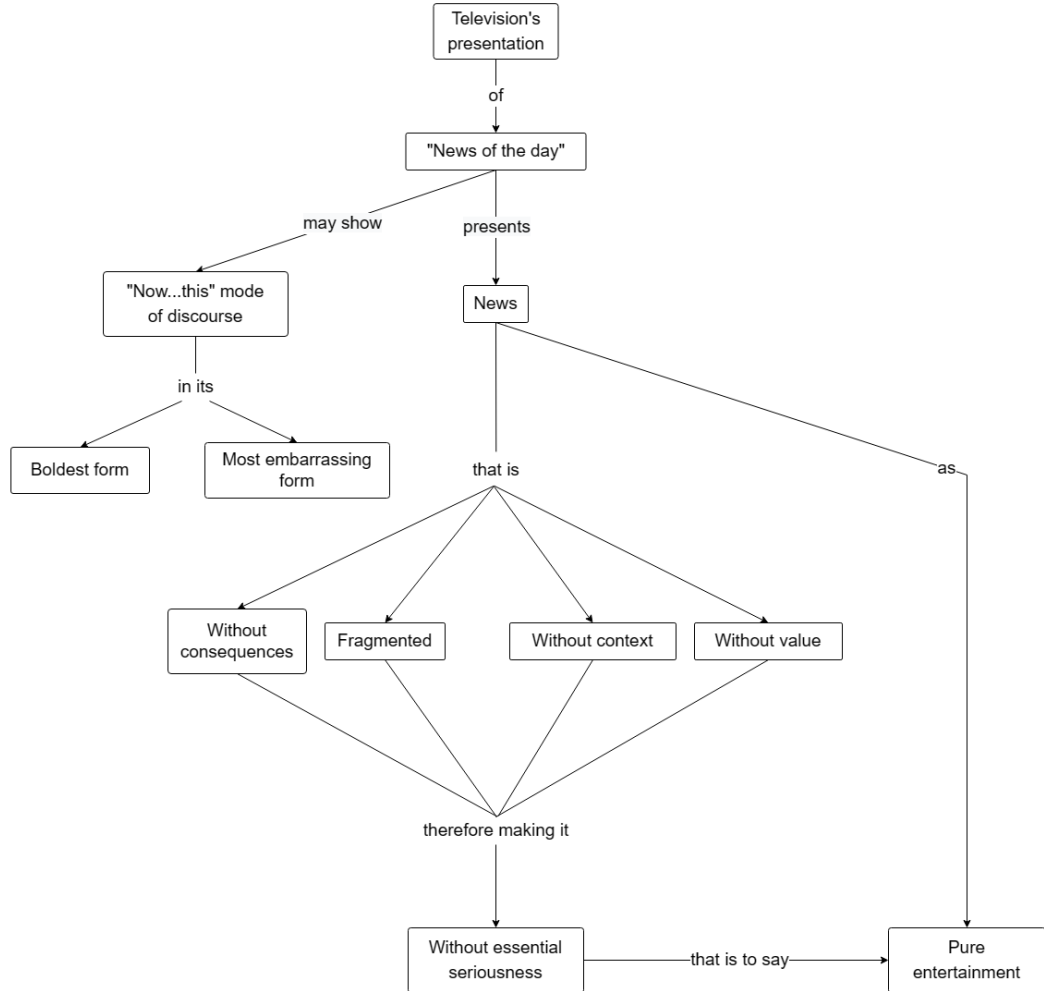


Figure B.40: Passage 5: How to Watch TV in Novakian Knowledge Model (K) condition - mini-map3

Back to Main Page

Paragraph Title: Newscasters as a Cast of Talking Hairdos

Focus Question: What determines how you would choose the newscasters?

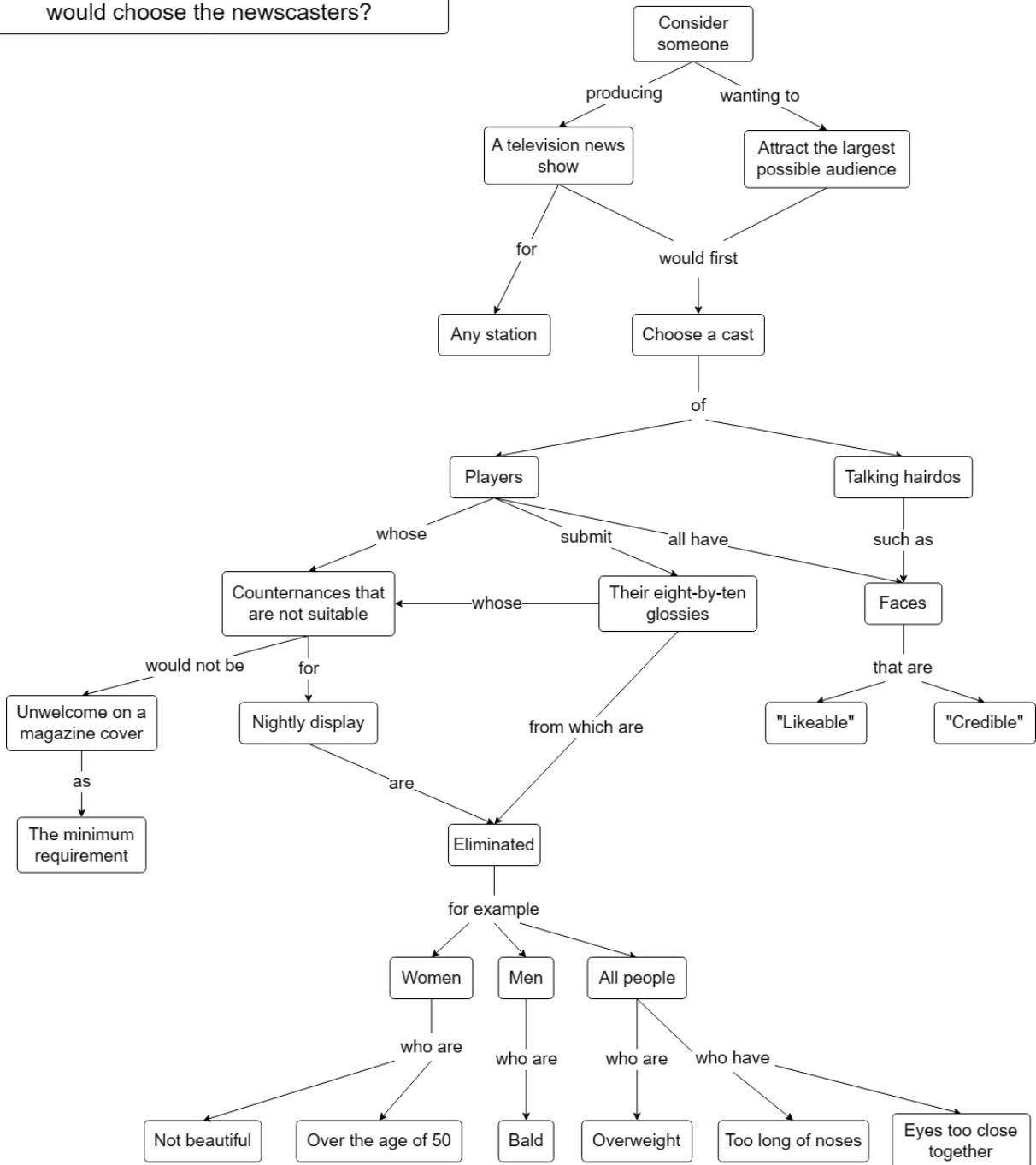


Figure B.41: Passage 5: How to Watch TV in Novakian Knowledge Model (K) condition - mini-map4

Back to Main Page

Paragraph Title: Tradition of Banishing News Reporters

Focus Question: How could the perception of truth be influenced by who the newscaster is and how does it relate back to ancient times?

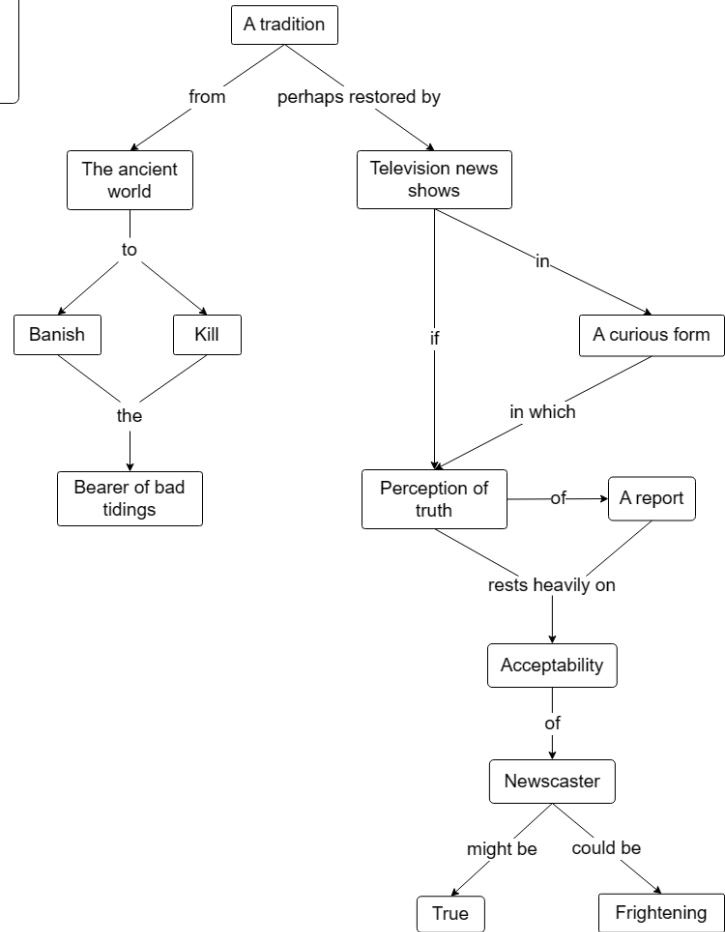


Figure B.42: Passage 5: How to Watch TV in Novakian Knowledge Model (K) condition - mini-map5

Back to Main Page

Paragraph Title: Christine Craft's Problematic Experience

Focus Question: Why did research claim that Christine Craft's appearance hampered viewer acceptance?

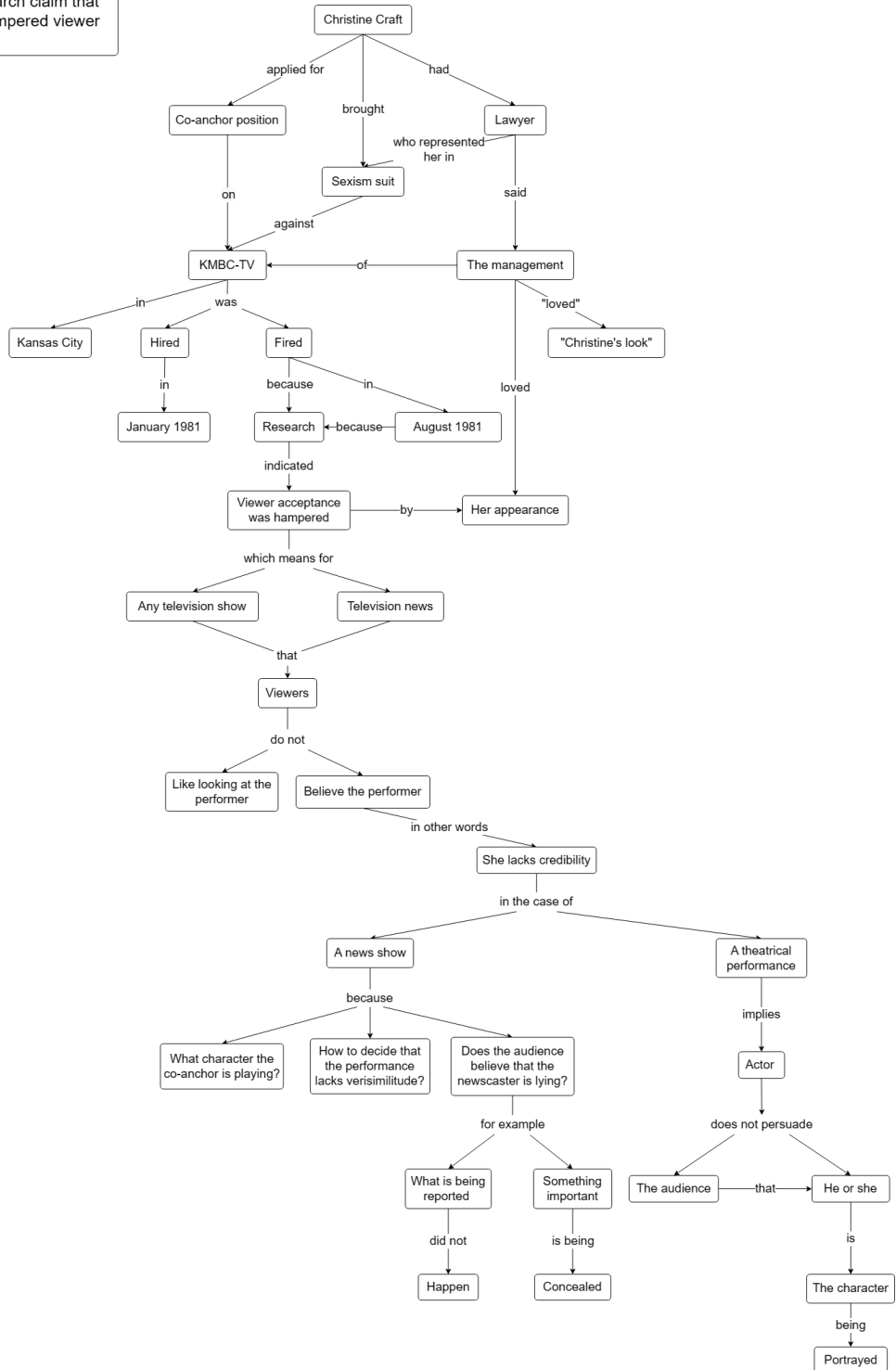


Figure B.43: Passage 5: How to Watch TV in Novakian Knowledge Model (K) condition - mini-map6

B.2.6 Passage 6: Reena

The modified multiple-choice questions used for this passage are as follows:

1. Of the persons mentioned in the passage, which of the following had the greatest positive effect on the narrator as a child?
 - (a) Reena's minister
 - (b) Reena's father
 - (c) Aunt Vi's godmother
 - (d) Aunt Vi

Question Type: Inferential

2. In order to ensure that her family would call her Reena, and not Doreen, Reena would:
 - I. point at them threateningly.
 - II. start crying loudly.
 - III. shout and stamp her feet.
 - IV. stare meaningfully.
 - (a) I and II only
 - (b) I and IV only
 - (c) II and IV only
 - (d) I, II, and IV only

Question Type: Factual

3. It can reasonably be inferred from the passage that Reena's mother, as compared with Reena's father, was a:
 - (a) more strict and much funnier parent.
 - (b) more retiring and less authoritative parent.
 - (c) more forceful and effective parent.
 - (d) less argumentative and more gentle parent.

Question Type: Inferential

4. Reena's talking about which of the following subjects intimidated the narrator?
 - I. Hitler in Poland
 - II. The Civil War in Spain
 - III. The thrall of the Little Minister
 - (a) I only

- (b) II only
- (c) III only
- (d) I and II only

Question Type: Factual

5. The description of Reena's entrance into the church suggests that Reena is a woman who:
- (a) is quite confident.
 - (b) is used to officiating at funerals.
 - (c) is deeply unhappy.
 - (d) has changed remarkably.

Question Type: Inferential

6. Reena apparently had the sort of character that her father found it necessary to:
- (a) discipline her severely.
 - (b) keep her at a distance.
 - (c) praise her constantly.
 - (d) humor her endlessly.

Question Type: Factual

7. The narrator's point of view is that of:
- (a) a child.
 - (b) an adolescent.
 - (c) a psychologist.
 - (d) an adult.

Question Type: Inferential

8. The statement that Reena had a half dozen brothers and sisters yet "behaved like an only child and got away with it" supports the narrator's feeling that Reena:
- (a) was completely and utterly selfish.
 - (b) had been her best friend for years.

- (c) did not like her brothers and sisters.
- (d) could overwhelm just about anyone.

Question Type: Inferential

9. According to the narrator, adolescence is a stage usually characterized by:
- (a) raw edges.
 - (b) abstract principles.
 - (c) dazzling leaps.
 - (d) impatient patronizing.

Question Type: Factual

The following shows the original ACT reading comprehension passage in linear format. This passage in Hybrid Map (H) format is shown in Figure B.44. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent Novakian concept maps (K) are shown in Figure B.45, Figure B.46, Figure B.47, Figure B.48, Figure B.49, Figure B.50, Figure B.51 and Figure B.52. The interactive version that the participants studied through is available [here on Draw.io](#).

Reena

We met—Reena and myself—at the funeral of her aunt who had been my godmother and whom I had also called aunt, Aunt Vi, and loved, for she and her house had been, respectively, a source of understanding and a place of calm for me as a child. Reena entered the church where the funeral service was being held as though she, not the minister, were coming to officiate, sat down among the immediate family up front, and turned to inspect those behind her. I saw her face then.

It was a good copy of the original. The familiar mold was there, that is, and the configuration of bone beneath the skin was the same despite the slight fleshiness I had never seen there before, her features had even retained their distinctive touches: the positive set to her mouth, the assertive lift to her nose, the same insistent, unsettling eyes which when she was angry became as black as her skin—and this was total, unnerving, and very beautiful. Yet something had happened to her face. It was different despite its sameness. Aging even while it remained enviably young. Time had sketched in, very lightly, the evidence of the twenty years.

Her real name had been Doreen, a standard for girls among West Indians (her mother, like my parents, was from Barbados), but she had changed it to Reena on her twelfth birthday—"As a present to myself"—and had enforced the change on her family by refusing to answer to the old name. "Reena. With two e's!" she would say and imprint those e's on your mind with the indelible black of her eyes and a thin threatening finger that was like a quill.

She and I had not been friends through our own choice. Rather, our mothers, who had known each other since childhood, had forced the relationship. And from the beginning, I had been at a disadvantage. For Reena, as early as the age of twelve, had had a quality that was unique, superior, and therefore dangerous. She seemed defined, even then, all of a piece, the raw edges of her adolescence smoothed over; indeed, she seemed to have escaped adolescence altogether and made one dazzling leap from childhood into the very arena of adult life. At thirteen, for instance, she was reading Zola, Hauptmann, Steinbeck, while I was still in the thrall of the Little Minister and Lorna Doone. When I could only barely conceive of the world beyond Brooklyn, she was talking of the Civil War in Spain, lynchings in the South, Hitler in Poland and talking with the outrage and passion of a revolutionary. I would try, I remember, to console myself with the thought that she was really an adult masquerading as a child, which meant that I could not possibly be her match.

For her part, Reena put up with me and was, by turns, patronizing and impatient. I merely served as the audience before whom she rehearsed her ideas and the yardstick by which she measured her worldliness and knowledge.

"Do you realize that this stupid country supplied Japan with the scrap iron to make the weapons she's now using against it?" she had shouted at me once.

I had not known that.

Just as she overwhelmed me, she overwhelmed her family, with the result that despite a half dozen brothers and sisters who consumed quantities of bread and jam whenever they visited us, she behaved like an only child and got away with it. Her father, a gentleman with skin the color of dried tobacco and with the nose Reena had inherited jutting out like a crag from his nondescript face, had come from Georgia and was always making jokes about having married a foreigner—Reena's mother being from the West Indies. When not joking, he seemed slightly bewildered by his large family and so in awe of Reena that he avoided her. Reena's mother, a small, dry, formidably black woman, was less a person to me than the abstract principle of force, power, energy. She was alternately strict and indulgent with Reena and, despite the inconsistency,

surprisingly effective.

B.2.6.1 Key Phrases and their Boolean Expressions for Reena

1. Key Phrase: The narrator (they) met Reena at the funeral of Aunt Vi (Reena's aunt).
 - Included Keyword: funeral
 - Keyword Alternatives: burial, ceremon, entomb, grave, interment, wake, memorial
 - Included Keyword: aunt
 - Keyword Alternatives: vi, god, mother, god-mother, godmother, loved
2. Key Phrase: Aunt Vi (Reena's aunt) was the narrator's (their) godmother.
 - Included Keyword: aunt
 - Keyword Alternatives: vi, loved
 - Included Keyword: godmother
 - Keyword Alternatives: god, mother, god-mother
3. Key Phrase: The narrator (They) called Reena's aunt Aunt Vi.
 - Included Keyword: aunt
 - Keyword Alternatives: vi
 - Included Keyword: Reena
 - Keyword Alternatives:
4. Key Phrase: The narrator (They) loved Aunt Vi.
 - Included Keyword: lov
 - Keyword Alternatives:
 - Included Keyword: aunt
 - Keyword Alternatives: vi
5. Key Phrase: As a child Aunt Vi's (Reena's aunt's) house had been a place of calm for the narrator (me as a child).

- Included Keyword: aunt
 - Keyword Alternatives: vi
 - Included Keyword: house
 - Keyword Alternatives: home, calm, serence, tranquil, peace, quiet, still, relax, collect, cool, undisturb, dusturb, steady
6. Key Phrase: As a child Aunt Vi (Reena’s aunt) had been a source of understanding for the narrator (me as a child).
- Included Keyword: aunt
 - Keyword Alternatives: vi
 - Included Keyword: understand
 - Keyword Alternatives: aware, insight, perc, recogn, concern, sympath, empath, care, caring
7. Key Phrase: Reena (She) entered the church (where the funeral service of Aunt Vi was being held).
- Included Keyword: church
 - Keyword Alternatives: cathedral, chapel, basilica, sanct, temple, house, place, tabernacl, shrin, institut, building, synagogue, mosque, abbe, monaster, cloister, convent, friar, nun
8. Key Phrase: Reena (She) entered the church as if she were coming to officiate (like a minister).
- Included Keyword: officiat
 - Keyword Alternatives: oversee, lead, administer, conduct, direct, run, charg, perform, celebrat, solemnize, confidence, air
9. Key Phrase: Reena (She) sat down among the immediate family up front (at the church).
- Included Keyword: sat
 - Keyword Alternatives: sit, seat, place, perch, plant, set, park, settle, plop, flump
 - Included Keyword: family

- Keyword Alternatives: kin, blood, clan, relatives, folk, people, relat, household
 - Included Keyword: front
 - Keyword Alternatives: fore, head, anterior, lead
10. Key Phrase: The narrator (They) saw Reena when Reena turned to inspect those behind her (at the church).
- Included Keyword: behind
 - Keyword Alternatives: back, rear, posterior
 - Included Keyword: turn
 - Keyword Alternatives: twist, shift, look, around, swivel, pivot, rotate, twirl, spin, spun, volv, inspect, look, view, check, observ, examin, scan, watch, review, analyz, stud, survey, eye, scop, captur, scruti, investigat, monitor, supervis, surv, prob, assess, appraise, vet
11. Key Phrase: Reena’s face (It) was a good copy of the original. (Reena looks similar but older).
- Included Keyword: copy
 - Keyword Alternatives: duplicat, reprint, scan, doppel, facsimil, reproduc, mimic, incarnat, replica, imitation, similar, look, like, parallel, resembl, identical
 - Included Keyword: original
 - Keyword Alternatives: authentic, genuine, actual, prime, real, true, bona, fide, veritable, young, child, kid, teen, adolescen, old, prototyp, archetyp, youth
12. Key Phrase: The familiar mold and the configuration of bone beneath her (Reena’s) face remained the same.
- Included Keyword: same
 - Keyword Alternatives: duplicat, reprint, scan, doppel, facsimil, reproduc, mimic, incarnat, replica, imitation, similar, look, like, parallel, resembl, identical
 - Included Keyword: mold

- Keyword Alternatives: bone, configurat, form, pattern, template, cast, model, frame, skelet, arrang, formation, foundation, design, structure, composition, organization, alignment

13. Key Phrase: There was a slight fleshiness that was never seen before (on Reena’s face).

- Included Keyword: fleshiness
 - Keyword Alternatives: soft, pudg, corpulen, plump, stout, portl, dough, mellow, gentle, mild, round, tender, adiposity, breadth, flab, girth, rotund, heav, heft, bulk

14. Key Phrase: Reena’s (Her) features retained their distinctive touches.

- Included Keyword: featur
 - Keyword Alternatives: character, element, aspect, compon, attribut, qual, prop, trait, detail, fac, touch, specifi
- Included Keyword: retain
 - Keyword Alternatives: kept, held, hung, continu, preserv, conserv, contain, have, maintain, own, possess, grasp, reserve, save, hold, keep, change, recogniz, remain

15. Key Phrase: Reena’s distinctive touches include the positive set to her (Reena’s) mouth.

- Included Keyword: mouth
 - Keyword Alternatives: lip
- Included Keyword: set
 - Keyword Alternatives: positive, touch, unique, unmistakabe, apparent, notable, noticeable, evident, obvious, distinguish, definite, discernible, recogniz, individual, distinct, feature

16. Key Phrase: Reena’s distinctive touches include the assertive lift to her (Reena’s) nose.

- Included Keyword: nose
 - Keyword Alternatives:
- Included Keyword: lift
 - Keyword Alternatives: assertive, touch, unique, unmistakabe, apparent, notable, noticeable, evident, obvious, distinguish, definite, discernible, recogniz, individual, feature

17. Key Phrase: Reena's distinctive touches include her glaring (insistent and unsettling) eyes.

- Included Keyword: eye
 - Keyword Alternatives: optic, orb, peep, glance, stare, gaze, look, sight, observ
- Included Keyword: glar
 - Keyword Alternatives: insistent, unique, unmistakable, apparent, notable, noticeable, evident, obvious, distinguish, definite, discernible, recognize, individual, persist, determine, tenacious, unyielding, resolute, steadfast, unrelent, assertive, firm, force, unwavering, demand

18. Key Phrase: (The narrator observed that) Reena's eyes became as black as her skin when she was angry.

- Included Keyword: eye
 - Keyword Alternatives: optic, orb, peep, glance, stare, gaze, look, sight, observ
- Included Keyword: black
 - Keyword Alternatives: dark, ebony, jet, ink, coal, sable, night, raven, onyx, obsidian, shadow, shad
- Included Keyword: skin
 - Keyword Alternatives: flesh, her

19. Key Phrase: The narrator was captivated by the transformation of her eyes (which is total, unnerving, and very beautiful).

- Included Keyword: transform
 - Keyword Alternatives: unnerv, dark, ebony, jet, ink, coal, sable, night, raven, onyx, obsidian, shadow, shad, black, insistent, unique, unmistakable, apparent, notable, noticeable, evident, obvious, distinguish, definite, discernible, recognize, individual, persist, determine, tenacious, unyielding, resolute, steadfast, unrelent, assertive, firm, force, unwavering, demand, distinct, beautiful, frighten, unse, chill, intimidat, disconcert, perturb, uncomfortable, startl, terrifying, harrowing, creepy, unique, unmistakable, apparent, notable, noticeable, evident, obvious, distinguish, definite, discernible, recognize, individual, attractive, lovely, stun, gorgeous, charm, allure, exquisite, elegant, mesmeriz, grace, ravish, enchant, splendid, pretty, breathtaking, total, chang, shift

- Included Keyword: eye
 - Keyword Alternatives: optic, orb, peep, glance, stare, gaze, look, sight, observ
20. Key Phrase: Yet something had happened to her face (it was different despite its sameness).
- Included Keyword: same
 - Keyword Alternatives: duplicat, reprint, scan, doppel, facsimil, reproduc, mimic, incarnat, replica, imitation, similar, look, like, parallel, resembl, identical
 - Included Keyword: different
 - Keyword Alternatives: chang, contrast, similar, like, alter, modify, transform, shift, vary
21. Key Phrase: Reena (She) aged lightly even after twenty years and her face remained enviably young. (Time had sketched in, very lightly, the evidence of the twenty years.)
- Included Keyword: age
 - Keyword Alternatives: year, decade, then, after, throughout, period, time, later, yr, you, child, adolescen, mature, old, beaut, fresh, pretty, look, env, aging
 - Included Keyword: light
 - Keyword Alternatives: little, barely, well, faint, hardly, gently, mild, subtl, slight
22. Key Phrase: Reena’s (Her) real name was Doreen.
- Included Keyword: Doreen
 - Keyword Alternatives:
23. Key Phrase: Doreen is a standard name for girls among West Indians.
- Included Keyword: Doreen
 - Keyword Alternatives:
 - Included Keyword: Indi
 - Keyword Alternatives: Barbados
24. Key Phrase: Reena’s (Her) mother was from Barbados (West Indies). (Her mother, like my parents, was from Barbados)

- Included Keyword: mother
 - Keyword Alternatives: mom, mum, ma
 - Included Keyword: Barbados
 - Keyword Alternatives: Indi
 - Included Keyword: Reena
 - Keyword Alternatives: Doreen
25. Key Phrase: The narrator’s parents were from Barbados. (Her mother, like my parents, was from Barbados)
- Included Keyword: parent
 - Keyword Alternatives: mother, mom, mum, father, pop, old, guardian, progenitor, nurtur, car, protect, provid, mam, pap, dad
 - Included Keyword: Barbados
 - Keyword Alternatives: Indi
 - Included Keyword: narrator
 - Keyword Alternatives: main, character
26. Key Phrase: Reena (She) changed her name to (started going by the name) Reena on her 12th birthday.
- Included Keyword: chang
 - Keyword Alternatives: alter, adjust, adapt, transform, convert, revamp, edit, renew, mod, amend, rename, going, made, make, maki, forc, people
 - Included Keyword: name
 - Keyword Alternatives: Reena
 - Included Keyword: 12
 - Keyword Alternatives: twel, birth, b-day, bday
27. Key Phrase: Reena (She) changed her name (started going by the name) as a ’present to herself.’

- Included Keyword: present
 - Keyword Alternatives: gift
 - Included Keyword: chang
 - Keyword Alternatives: alter, adjust, adapt, transform, convert, revamp, edit, renew, mod, amend, call, became, becom, decid, choos, chos, pick, set, rename
28. Key Phrase: Reena (She) enforced her new name (Reena) onto her family by refusing to answer to her old name (Doreen).
- Included Keyword: refus
 - Keyword Alternatives: rejec, declin, spurn, object, ignor, protest, renounc, accept, agree, consent, allow, permit, support, affirm, yield, grant, agree, assent, admit, accede, concur, conform, welcom, embrac, conced, compl, accomodat, acquiesc, acknowledg, endors, approv, dismiss, neglect, abid
 - Included Keyword: name
 - Keyword Alternatives: Doreen, wrong, old
29. Key Phrase: Reena (She) stressed that Reena has two e's.
- Included Keyword: 2
 - Keyword Alternatives: two, double, second, 2nd, pair, duo, twain, twin
 - Included Keyword: Reena
 - Keyword Alternatives:
30. Key Phrase: Reena (She) imprinted those e's (in Reena) in people's minds with the black of her eyes and her threatening finger (which was like a quill).
- Included Keyword: print
 - Keyword Alternatives: press, grain, still, stress, point, emphasiz, light, drill, underscor, etch, carv, plant, assert, forc, stamp, mark, hammer, pound, driv, drov, train, inundat, bed, attent, root, punctua, accent, push, thrust, beat, tens, address, fuel, exhaust, pierc
 - Included Keyword: eye

- Keyword Alternatives: optic, ocul, visual, vision, sight, view, see, perce, observ
- Included Keyword: finger
 - Keyword Alternatives: quill, phalanx, point, pinky, thumb, digitus, dactyl, phalange

31. Key Phrase: They (The narrator and Reena) were not friends through their own choice.

- Included Keyword: friend
 - Keyword Alternatives: boon, companion, intimate, confidante, confidant, ally, allies, comrade, associate, pal, bosom, chum, spar, sidekick, cully, crony, bezzie, mate, mucker, butty, bruvver, bruv, amigo, compadre, paisan, homie, homeboy, homie, homegirl, amiga, play, bud, allies, comrade, pal, bosom, chum, spar, sidekick, cully, crony, bezzie, mate, mucker, bitty, bruv, compadre, paisan, homie, homeboy, homie, homegirl, play, bud, relation, acquaint, bond, partner
- Included Keyword: choice
 - Keyword Alternatives: choos, voli, will, wish, want, desir, select, pick, deci, prefer, say, accord, volunt, option, consent, purpos, intent, intend, motiv, focus, plan, elect, mean, opt, mutual, active, pursu, initiat, aspir, inclin, conscious, mind, effort, consider, tried, try, tries, attempt, seek, set, arrang, authentic, agree, forc, coer, push, press, compel, drove, made, mak, drag, impos, requir, obligat, demand, dictat, command, direct, necess, cause, plan, result

32. Key Phrase: Their (The narrator and Reena's) mothers knew each other (since their childhood).

- Included Keyword: mother
 - Keyword Alternatives: mom, mum, ma
- Included Keyword: child
 - Keyword Alternatives: you, kid, adolesc, life, live, time, period, year, decade, prepubesc, back, earl, day, little, small, relation, acquaint, bond, partner, friend, boon, companion, intimate, confidante, confidant, ally, associate, butty, amigo, amiga, allies, comrade, pal, bosom, chum, spar, sidekick, cully, crony, bezzie, mate, mucker, bitty, bruv, compadre, paisan, homie, homeboy, homie, homegirl, play, bud, close, result

33. Key Phrase: Their (The narrator and Reena's) mothers had forced the relationship.

- Included Keyword: mother
 - Keyword Alternatives: mom, mum, ma
- Included Keyword: forc
 - Keyword Alternatives: coer, push, press, compel, drove, made, mak, drag, impos, requir, obligat, demand, dictat, command, direct, necess, cause, plan, choice, choos, voli, will, wish, want, desir, select, pick, deci, prefer, say, accord, volunt, option, consent, purpos, intent, intend, motiv, focus, plan, elect, mean, opt, mutual, active, pursu, initiat, aspir, inclin, concious, mind, effort, consider, tried, try, tries, attempt, seek, set, arrang, authentic, agree, result
- Included Keyword: relation
 - Keyword Alternatives: friend, boon, companion, intimate, confidante, confidant, ally, allies, comrade, associate, pal, bosom, chum, spar, sidekick, cully, crony, bezzie, mate, mucker, butty, bruvver, bruv, amigo, compadre, paisan, homie, homie, amiga, play, bud, allies, comrade, pal, bosom, chum, spar, sidekick, cully, crony, bezzie, mate, mucker, bitty, bruv, compadre, paisan, homie, homeboy, homie, homegirl, play, bud, acquaint, bond, partner

34. Key Phrase: Reena (She) had a quality that was unique (since Reena was 12).

- Included Keyword: unique
 - Keyword Alternatives: distinct, common, rare, usual, exception, extraordinary, exclusive, novel, parallel, precent, match, kind

35. Key Phrase: Reena (She) had a quality that was superior (since Reena was 12).

- Included Keyword: superior
 - Keyword Alternatives: high, great, advance, excellent, better, elevat, supreme, upper, outstanding, exceptional

36. Key Phrase: Reena (She) had a quality that was dangerous (since Reena was 12).

- Included Keyword: dangerous
 - Keyword Alternatives: hazard, perilous, risk, safe, treacher, threat, dead, lethal, menac, precarious, stable

37. Key Phrase: Reena (She) seemed defined (mature).

- Included Keyword: Reena
 - Keyword Alternatives:
- Included Keyword: defin
 - Keyword Alternatives: distin, establish, conspicuous, prominem, remarkable, salien, striking, pronounced, notab, respect, mistak, recogniz, notic, mature

38. Key Phrase: The raw edges of her (Reena's) adolescence smoothed over.

- Included Keyword: raw
 - Keyword Alternatives: edges

39. Key Phrase: Reena (She) seemed to have escaped adolescence altogether and made one dazzling leap from childhood into the very arena of adult life.

- Included Keyword: child
 - Keyword Alternatives: adoles, puberty, teen, juvenil, kid, little, small, young, youth
- Included Keyword: adult
 - Keyword Alternatives: grow, matur, old, elder, eldest

40. Key Phrase: Reena (She) was reading Zola (at 13).

- Included Keyword: Zola
 - Keyword Alternatives:

41. Key Phrase: Reena (She) was reading Hauptmann (at 13).

- Included Keyword: Reena
 - Keyword Alternatives: she
- Included Keyword: Hauptmann
 - Keyword Alternatives:

42. Key Phrase: Reena (She) was reading Steinbeck (at 13).

- Included Keyword: Steinbeck
 - Keyword Alternatives:
43. Key Phrase: The narrator was (They were) reading (in the thrall of) the Little Minister (at 13).
- Included Keyword: Little
 - Keyword Alternatives:
 - Included Keyword: Minister
 - Keyword Alternatives:
44. Key Phrase: The narrator was (They were) reading (in the thrall of) Lorna Doone (at 13).
- Included Keyword: Lorna
 - Keyword Alternatives: Doone
45. Key Phrase: The narrator (They) could barely conceive of the world beyond Brooklyn.
- Included Keyword: Brooklyn
 - Keyword Alternatives:
46. Key Phrase: Reena (She) talked about the Civil War in Spain.
- Included Keyword: Spain
 - Keyword Alternatives: civil, war
47. Key Phrase: Reena (She) talked about the lynchings in the South.
- Included Keyword: lynch
 - Keyword Alternatives: South
48. Key Phrase: Reena (She) talked about Hitler in Poland.
- Included Keyword: Hitler
 - Keyword Alternatives: Poland
49. Key Phrase: Reena (She) was talking with the outrage and passion of a revolutionary.

- Included Keyword: revolution
 - Keyword Alternatives: outrage, passion, spirit, fervor, intense, excited, dedicated, enthusiasms, energy, vigor, drive, zeal, radical, progress, fight, social, anger, fury, rage, wrath, disgust, shock, indignation, resent, offend, atrocious, devoted, raging, furious, outspoken, aggressive

50. Key Phrase: Reena (She) was really an adult masquerading as a child (this idea consoled the narrator).

- Included Keyword: adult
 - Keyword Alternatives: child, kid, grow, mature, young, old, elder, eldest
- Included Keyword: masquerade
 - Keyword Alternatives: pretend, act, trap

51. Key Phrase: The narrator thinks the narrator was not Reena's match. (The narrator had been at a disadvantage).

- Included Keyword: match
 - Keyword Alternatives: equal, same, differ, similar, level, more, less, inferior, superior, along, low, high, even, align, together, like, pair, partner, duo, little, counterpart, resemble

52. Key Phrase: Reena (She) had a negative attitude toward the narrator (them).

- Included Keyword: negative
 - Keyword Alternatives: threat, menace, hurt, hostile, nasty, bad, vicious, malignant, displeasing, scary, intimidates, frighten, terrify, daunt, formidable, fierce, ominous, dominating, portentous, horrible, dread, stress, nervous, pain, anxiety, discomfort, headache, suffer, ordeal, difficult, miserable, damaging, awful, sour, grim, obnoxious, harsh, positive, optimistic, hope, zeal, assurance, cheer, bright, cold, help, benevolent, warm, jovial, pleasing, joy, good, friend, amiable, cordial, heart, happy, glee, satisfied, light, content, jolly, spark, chip, merry, elated, sweet, agree, genial, affable, gentle, kind, nice, irritable, graceful, amusing, gloom, adverse, favor, enthusiastic, nay, dis, imp, valid, reject, oppos, antagonize, counter, detriment, affirm, gatory, repugnant, recusant, refuted, cruel, uplift, upbeat, upset, dislike, discomfort, disapproval, disrupt, dishearten, mean

53. Key Phrase: Reena put up with the narrator (them).

- Included Keyword: negat
 - Keyword Alternatives: threat, menace, hurt, hostile, nasty, bad, vicious, malign, dice, pleas, scar, intimidate, frighten, terrify, daunt, formidable, fierce, ominous, dominant, portentous, horror, dread, stress, nerve, pain, anxiety, comfort, headache, suffer, ordeal, difficult, miser, damage, awful, sour, grim, obnoxious, harsh, positive, optimistic, hope, zeal, assure, cheer, bright, cold, help, benevolent, warm, jovial, pleas, joy, good, friend, amiable, cordial, heart, happy, glee, satisfy, light, content, jolly, spark, chip, merry, elation, sweet, agree, genial, affable, gentle, kind, nice, irie, grace, amuse, gloom, advers, favor, enthus, nay, dis, imp, valid, reject, oppos, antagon, counter, detriment, affirm, gatory, repugnant, recusant, refut, cruel, uplift, upbeat, upset, dislike, discomfort, disapproval, disrupt, dishearten, mean

54. Key Phrase: Reena (she) was patronizing.

- Included Keyword: patroniz
 - Keyword Alternatives: condescend, arrogant, haughty, pompous, snob, disdain, contempt, belittle, overbear, supercilious, derisive, mock, sneer, insult

55. Key Phrase: Reena (she) was impatient.

- Included Keyword: impatient
 - Keyword Alternatives: restless, agitate, irritable, anxious, antsy, impetuous, hast, restive, fidget, tense, frustrate, impulsive

56. Key Phrase: Reena (she) used the narrator (them) as an audience to rehearse her ideas.

- Included Keyword: audience
 - Keyword Alternatives: rehears, talk, listen, rant, ramble, spam, practice, recite, relay, drill, present, ear, dump, load, idea, thought, belief, crowd, visitor, participant, guest, listener, observer, watcher, over, spectator, perform, deliver, conduct, carry, display, show, enact

57. Key Phrase: Reena (she) used the narrator (them) as the yardstick by which to measure her worldliness and knowledge.

- Included Keyword: worldl

- Keyword Alternatives: know, measur, skill, intel, smart, snoot, snob, aware, expert, pride, proud, proficien, god, compar, superior, inferior, high, low, inform, abilit, compet, power, worth, clever, sophisticat, experienc, genius, bright, brain, brillian, gift, astute, shrewd, erudit, wis, sharp, savv

58. Key Phrase: The US had supplied Japan with iron to make weapons against the US (them).

- Included Keyword: Japan
 - Keyword Alternatives:
- Included Keyword: iron
 - Keyword Alternatives: weapon, source, suppl, metal, gun, material

59. Key Phrase: Reena (she) overwhelmed the narrator (them).

- Included Keyword: over
 - Keyword Alternatives: much, exhaust, tire, wor, beat, swamp, stress, burden, load, weigh, dominat, oppress, encumber, harass, strain, torment, conquer, inundat, suf-focat, intens, drown, pressur, suppress

60. Key Phrase: Reena (she) overwhelmed her family.

- Included Keyword: over
 - Keyword Alternatives: much, exhaust, tire, wor, beat, swamp, stress, burden, load, weigh, dominat, oppress, encumber, harass, strain, torment, conquer, inundat, suf-focat, intens, drown, pressur, suppress
- Included Keyword: family
 - Keyword Alternatives: kin, blood, clan, relat, folk, tribe, household, lineage, ancestors, parents, kindred, brood, kith, kin, genealogy, relat, father, dad, pop, pap, mother, mam, mom, mum, bro, sis, sib, generation

61. Key Phrase: Reena (she) had a half dozen brothers and sisters.

- Included Keyword: sib
 - Keyword Alternatives: family, relative, bro, sis, member

62. Key Phrase: Reena’s brothers and sisters consumed quantities (lots) of bread and jam when they visited the narrator’s (their) family.

- Included Keyword: jam
 - Keyword Alternatives: toast, bread, crust
 - Included Keyword: sibling
 - Keyword Alternatives: family, relative, bro, sis, member
63. Key Phrase: Reena (she) behaved like an only child.
- Included Keyword: only
 - Keyword Alternatives: single, sole, lone, exclu, just, mere, simpl, singular, Pure, unique, specific, one, individual, 1, solo
64. Key Phrase: Reena (She) got away with (it) behaving like an only child.
- Included Keyword: only
 - Keyword Alternatives: single, sole, lone, exclu, just, mere, simpl, singular, Pure, unique, specific, one, individual, 1, solo
 - Included Keyword: child
 - Keyword Alternatives:
65. Key Phrase: Reena’s (Her) father was a gentleman (with skin the color of dried tobacco).
- Included Keyword: father
 - Keyword Alternatives: dad, pop, pap, old
 - Included Keyword: gent
 - Keyword Alternatives: fellow, chap, bloke, dude, man, beau, so-and-so, individual, being, someone, somebody, mortal, soul, character, creature, personage, entity, fellow, guy
66. Key Phrase: Reena (She) inherited her nose (jutting out like a crag) from her father (& his nondescript face).
- Included Keyword: nose
 - Keyword Alternatives: nasal, schnoz, honker, beak, sniffer, smeller, snoot
 - Included Keyword: father

- Keyword Alternatives: dad, pop, pap, old
 - Included Keyword: inherit
 - Keyword Alternatives: got, pass, down, same, common, shar, receiv, acquir, obtain, gain, get, secur, attain, procure, possess, deriv, assum, take, taki, adopt, alike, similar, parallel, resembl, comparabl, correspond, match, identical, mutual, equi, equa, akin, relat, link
67. Key Phrase: Reena’s (Her) father was from Georgia.
- Included Keyword: father
 - Keyword Alternatives: dad, pop, pap, old
 - Included Keyword: Georgia
 - Keyword Alternatives: GA
68. Key Phrase: Reena’s (Her) father made jokes about having married a foreigner (Reena’s mother).
- Included Keyword: marr
 - Keyword Alternatives: wed, uni, wife, spous, partner, companion, mate, half, conjugal, marital, settl, vow, commit, promis, ring, matrimon, knot, husband, mother
 - Included Keyword: father
 - Keyword Alternatives: dad, pop, pap, old
 - Included Keyword: foreign
 - Keyword Alternatives: abroad, exotic, native, alien, sea, external, shore, import, nation, outside, resident, local, genous, citizen
69. Key Phrase: Reena’s (Her) father was bewildered by his large family (when not joking around).
- Included Keyword: father
 - Keyword Alternatives: dad, pop, pap, old
 - Included Keyword: large

- Keyword Alternatives: big, huge, enormous, vast, mammoth, colossal, grand, massive, giant, substantial, immense, size, extensive, space, ample, consider, significant, expansive, wide, bewildered, thunderstruck, astonished, baffled, bemused, dazed, distracted, flustered, disconcerted, mystified, perplexed, puzzled, rattled, stumped, certain, comprehend, family, humongous

70. Key Phrase: Reena's (Her) father avoided her (because he was in awe of Reena).

- Included Keyword: father
 - Keyword Alternatives: dad, pop, pap, old
- Included Keyword: avoid
 - Keyword Alternatives: vert, ignore, evade, dodge, neglect, see, turn, run, ran, direct, over, Steer, Shun, Circumvent, Keep, away, Bypass, Stay, clear, Abstain, Refrain, Eschew, Reject, Forsake, Disregard, elude, step, escape, distant, exclude, contact, involve, abandon, side, scorn, disdain, contempt, snub, separate, spurn, blind, value, little, aloof, detach, attach, withdraw, withdrew, connect, interact, engage, social, associate, communicate, converse, attend, arms, length

71. Key Phrase: Reena's (Her) mother was a small, dry, formidable black woman.

- Included Keyword: mother
 - Keyword Alternatives: mam, mom, mum
- Included Keyword: small
 - Keyword Alternatives: little, compact, slight, meager, tin, min, petit, diminutive, microscopic, puny, size, paltry, dry, dull, drab, tedious, lackluster, interest, boring, life, formidable, bland, inspire, strong, tough, daunt, intimidate, challenge, impressive, power, overwhelm, herculean, fear, might, command, impose, fierce, domitable, invincible, force, strenuous, black, color, frighten, scary, respect

72. Key Phrase: Reena's (Her) mother was less of a person (to the narrator) than the abstract principle of force, power, energy.

- Included Keyword: mother
 - Keyword Alternatives: mam, mom, mum
- Included Keyword: force

- Keyword Alternatives: strength, might, control, command, sway, muscle, power, energ, poten, authorit, dominan, influen, suprem, intens, robust, capab, puissan, master, sovereign, capacit, ascendan, coerc, hypothetical, ethereal, abstract, concept, theor, represent, figur, object, philosoph, tangib, physical, symbol, material, transcend, intellect, imagin, concret, abstrus, elusiv, subject, ardor, pep, vigor, activ, driv, liv, vital, energy

73. Key Phrase: Reena’s (Her) mother was strict with Reena.

- Included Keyword: mother
 - Keyword Alternatives: mam, mom, mum
- Included Keyword: strict
 - Keyword Alternatives: stern, harsh, firm, demand, compromis, yield, rigid, flex, disciplin, exacting, string, tight, rigor, precis, sever, auster, authorit, control, order, exorable, exact, tough, draconian, relent, ascetic, regimen, spartan, peremptor, punct, steel, iron, bend, waver, swerv, flinch, resol, vari, mutab, transigen, regulat, permiss, alter, chang, obstinat, hard, impos, tenac, adapt, accomodat, pedant, domin, toler, forbid, censor, insist, stead, hibit, forc

74. Key Phrase: Reena’s (Her) mother was indulgent with Reena.

- Included Keyword: mother
 - Keyword Alternatives: mam, mom, mum
- Included Keyword: indulgen
 - Keyword Alternatives: liberal, forbear, easy, understand, soft, kind, merc, patient, care, caring, permiss, toler, easi, genero, lax, accommodat, consider, forgiv, gentl, passion, sympa, mild, broad, pardon, mind, lenien, humane, benevolen, coddl, spar, pamper, hand, placat, patien, heart, amiab, warm, pleas, placid, cordial, loos, moderat, restrict, chalan, pliab, friend, approach

75. Key Phrase: Reena’s (Her) mother was inconsistent.

- Included Keyword: mother
 - Keyword Alternatives: mam, mom, mum
- Included Keyword: consisten

- Keyword Alternatives: predict, reliable, erratic, contradic, capricious, fickle, chang, stead, haphazard, systematic, stab, fluct, odd, conflict, contra, errat, illogic, incompatib, irreconcilab, consisten, certain, predictab, uniform, constant, persist, vary, vari, depend, congisten, firm, even, consonan, homogen, equa, continu, interrupt, swerv, waver, level, alter, equi, mutable, parallel, sustain, brok, match, harmon, shift, compat, resolut, perturb, falter, cohes, tenac, balanc, current, congru, ceas, staunch, identical, coheren, system, same, alike, align, standard, solid, settl, smooth, troubl, deviat, relent, hinder, fick, volatile, random, chao, joint, sporadic, contradict, vacillat, oscillat, arbitrar, puls, regula, control, tumult, organi, jumbl, fragment, structur, method, arrang, array, symmetr, contrast, disparat, diverg, patch, scatter, coordinat, order, regular, oppos, exact, discord, discrep, similar, conform

76. Key Phrase: Reena’s (Her) mother was effective.

- Included Keyword: mother
 - Keyword Alternatives: mam, mom, mum
- Included Keyword: effect
 - Keyword Alternatives: success, impact, use, function, valid, able, efficien, competen, capab, proficien, poten, strong, productiv, power, fruit, skill, accomplish, worth, valuab, opera, rely, reli, efficac, adequat, resourc, virtu, result, influen, satisf

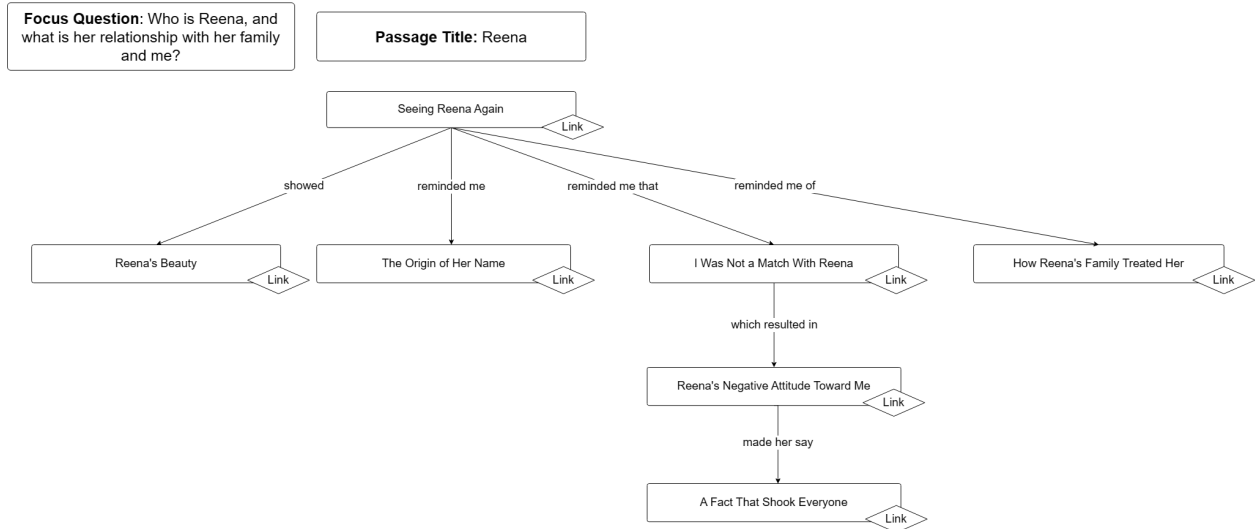


Figure B.45: Passage 6: Reena in Novakian Knowledge Model (K) condition - Master-map

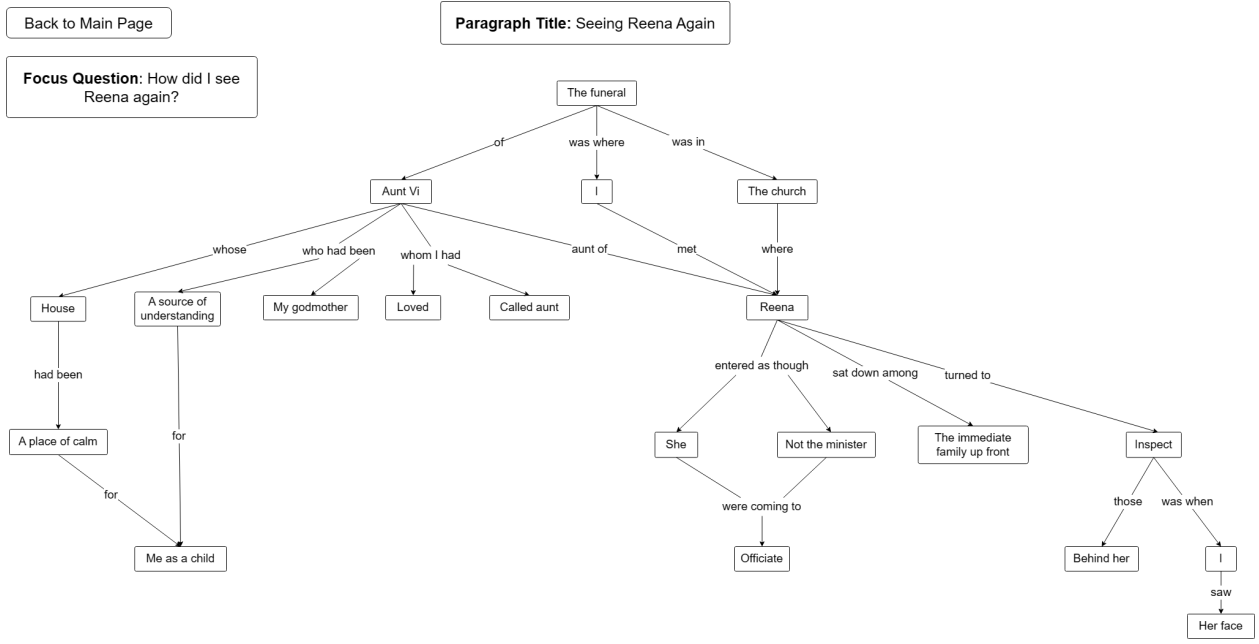


Figure B.46: Passage 6: Reena in Novakian Knowledge Model (K) condition - mini-map1

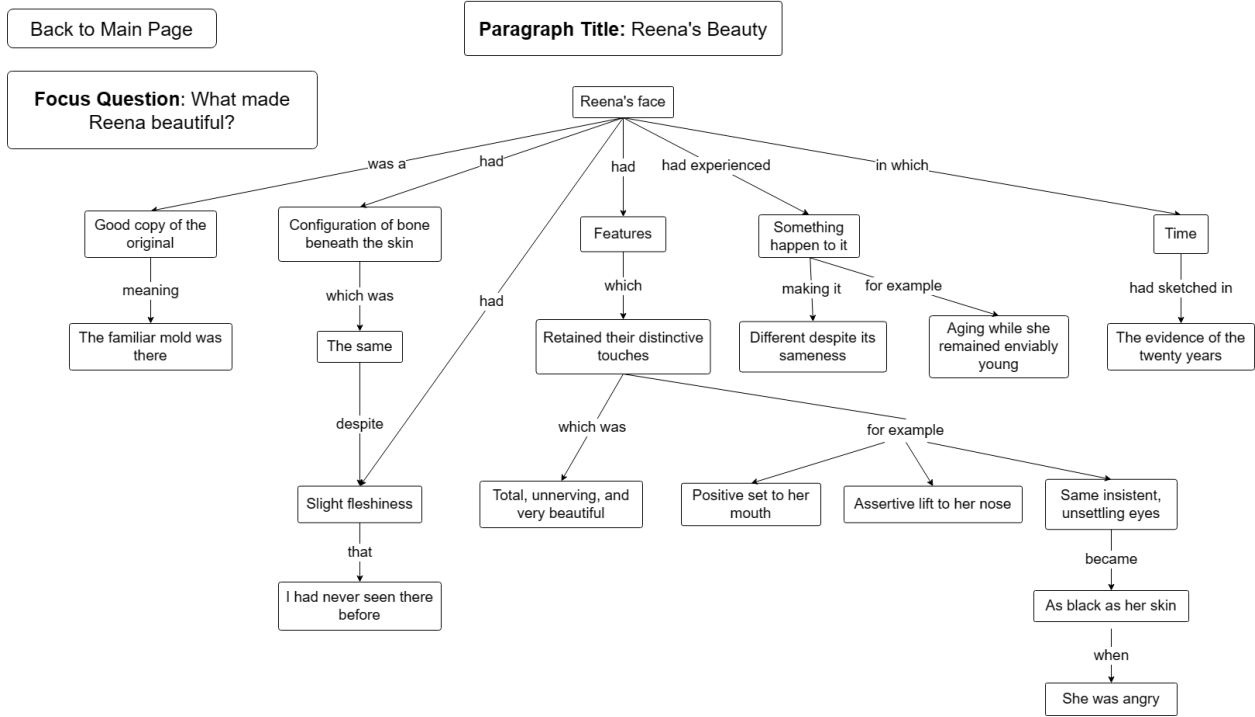


Figure B.47: Passage 6: Reena in Novakian Knowledge Model (K) condition - mini-map2

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Paragraph Title: The Origin of Her Name

Focus Question: How did people start calling her Reena?

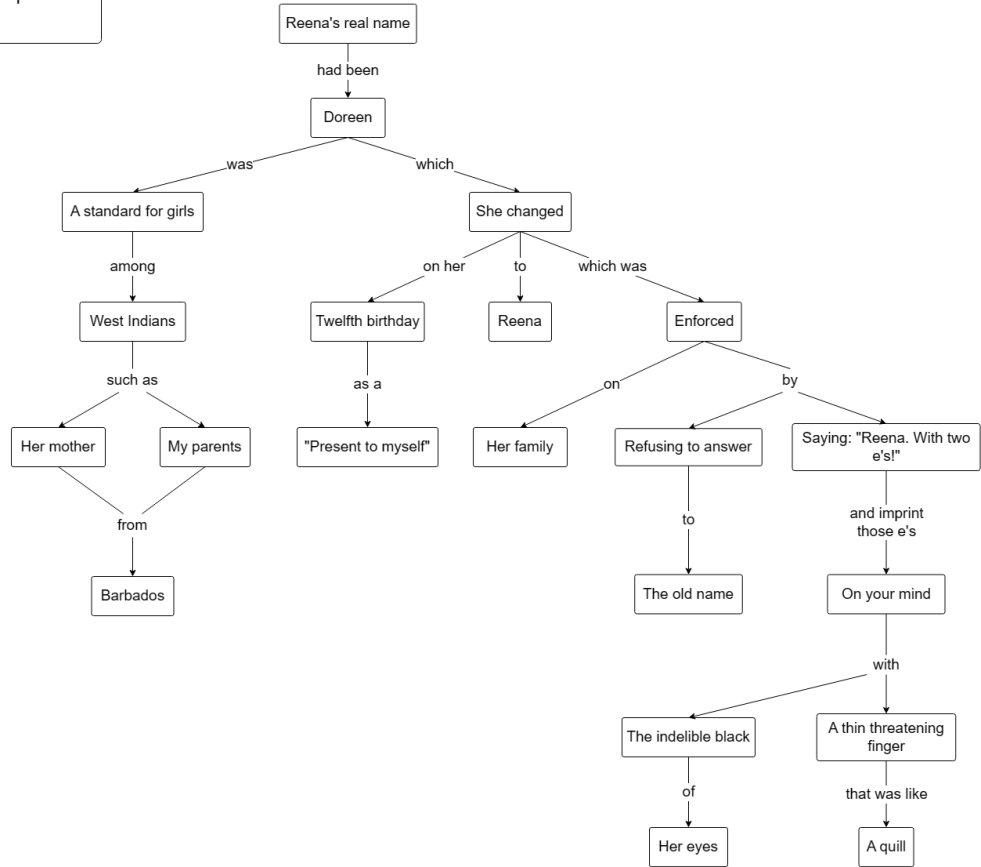


Figure B.48: Passage 6: Reena in Novakian Knowledge Model (K) condition - mini-map3

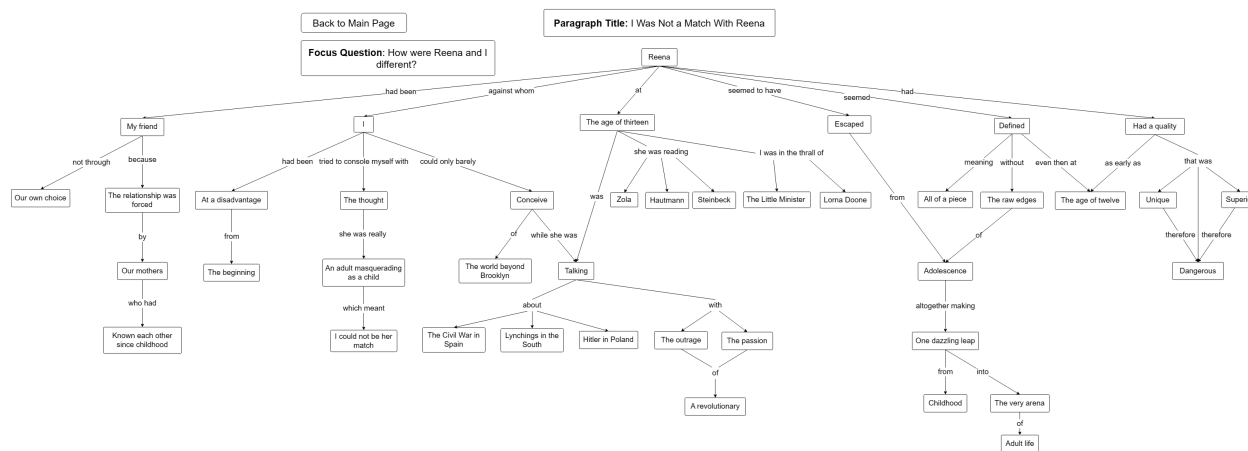


Figure B.49: Passage 6: Reena in Novakian Knowledge Model (K) condition - mini-map4

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Paragraph Title: Reena's Negative Attitude Towards Me

Focus Question: What was the narrator to Reena?

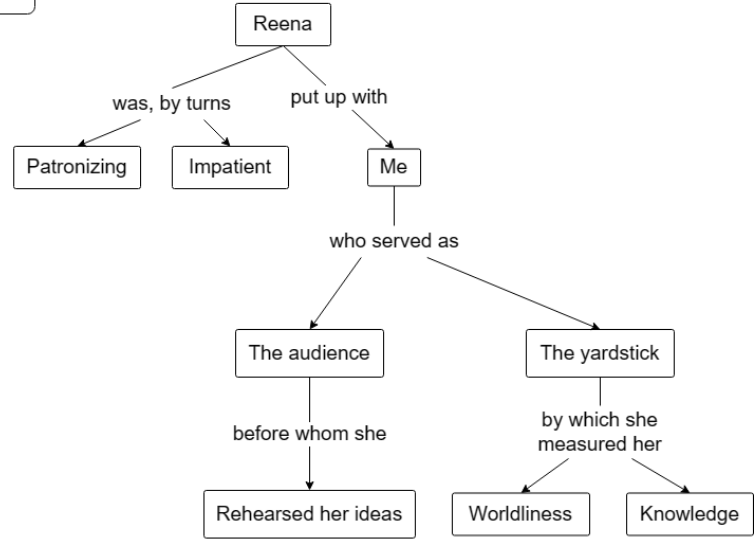


Figure B.50: Passage 6: Reena in Novakian Knowledge Model (K) condition - mini-map5

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Paragraph Title: A Fact That Shook Everyone

Focus Question: What did Reena say?



Figure B.51: Passage 6: Reena in Novakian Knowledge Model (K) condition - mini-map6

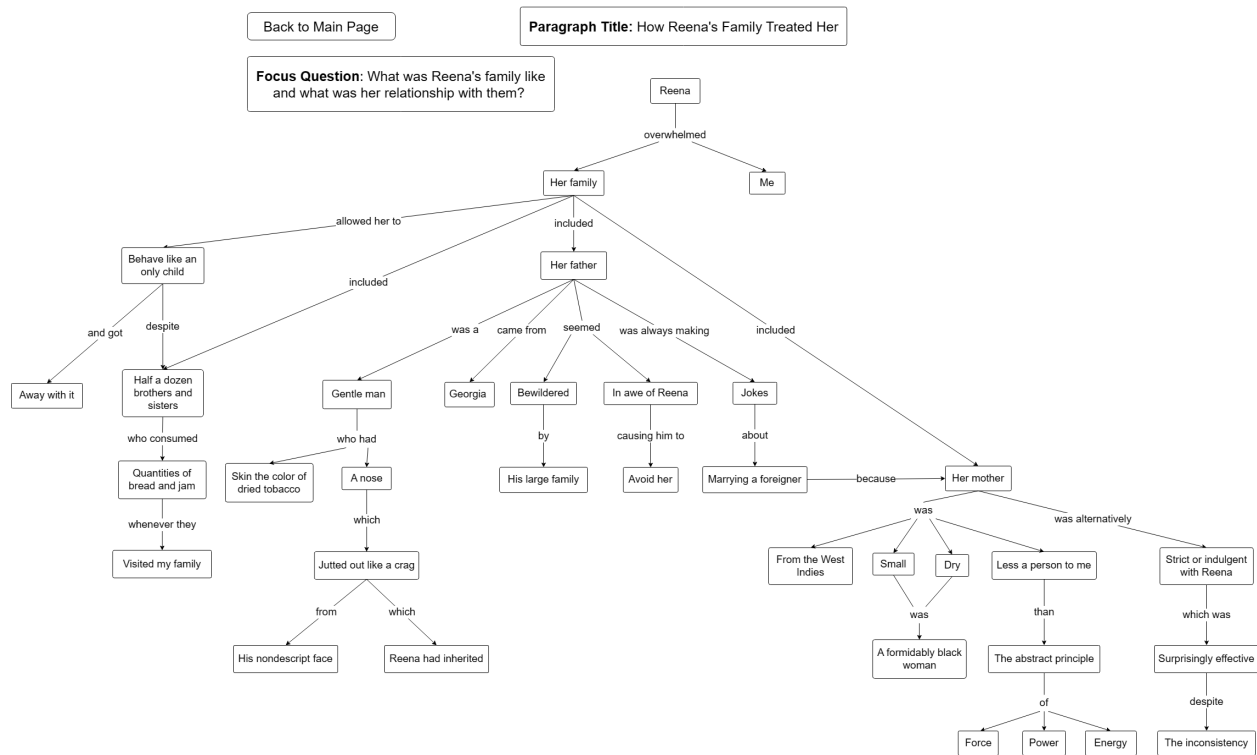


Figure B.52: Passage 6: Reena in Novakian Knowledge Model (K) condition - mini-map7

B.2.7 Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation

The modified multiple-choice questions used for this passage are as follows:

1. The main purpose of the passage is to:
 - (a) discuss the panda exhibit at the National Zoo, and Wang’s role in helping to design it
 - (b) explain the job of a conservation biologist through the example of Wang.
 - (c) describe Wang’s work and his position on the role of zoos in conservation efforts
 - (d) give an overview of the history of panda conservation, with emphasis on the importance of Wang’s research.

Question Type: Inferential

2. The passage indicates that the new panda exhibit at the National Zoo includes all of the following EXCEPT:
 - (a) a cooling rock.
 - (b) Decision Stations.
 - (c) wildlife corridors.
 - (d) a panda grotto.

Question Type: Factual

3. The passage primarily does which of the following regarding Wang’s work and the panda exhibit at the National Zoo?
 - (a) Indicates how new features of the panda exhibit are relevant to his work.
 - (b) Describes how zoo visitors respond to his work.
 - (c) Shows how the zoo has revealed problems with his work.
 - (d) Lists specific influences his work had on the new exhibit.

Question Type: Inferential

4. Based on the passage, the critics’ claim that zoos spend too much money on breeding pandas in captivity is best described as:

- (a) valid; money spent on pandas would be better spent on snow leopards.
- (b) valid; habitat destruction is the biggest threat to pandas' survival in the wild.
- (c) invalid; pandas have no hope of surviving without the help of captive breeding programs.
- (d) invalid; captive-bred pandas are required for Chinese political diplomacy.

Question Type: Factual

5. In the passage, Wang says that public interest in pandas is:
- (a) misguided and narrow.
 - (b) beneficial to zoos.
 - (c) good for wildlife conservation in general.
 - (d) growing because of Bao Bao.

Question Type: Inferential

6. Wang is said to have reacted to a mother panda leaving him to watch over her cub with:
- (a) Concern.
 - (b) Joy.
 - (c) Diplomacy.
 - (d) Surprise.

Question Type: Factual

7. The characterization of which of the following is used in the passage to illustrate the effect of the construction of wildlife corridors?
- (a) Rivers.
 - (b) Mountains.
 - (c) Fog groves.
 - (d) Ponds.

Question Type: Factual

8. The passage implies that the design of the new panda exhibit at the National Zoo was intended to:

- (a) warn visitors about the dangers of panda extinction.
- (b) provide a place for visitors to keep cool during hot weather.
- (c) give visitors a chance to experience some elements of panda habitat.
- (d) reproduce the size and style of the original panda exhibit.

Question Type: Inferential

The following shows the original ACT reading comprehension passage in linear format. This passage in Hybrid Map (H) format is shown in Figure B.53. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent Novakian concept maps (K) are shown in Figure B.54, Figure B.55, Figure B.56, Figure B.57, Figure B.58, Figure B.59, Figure B.60, Figure B.61 and Figure B.62. The interactive version that the participants studied through is available [here on Draw.io](#).

Conservationist and Diplomat: The Grey Areas of Panda Conservation

Dr. Dajun Wang has learned to walk a fine line between advocating for wildlife habitat conservation and advocating for zoos. Wang has spent hours in the mountains of western China, tracking the giant panda, one of the most endangered, elusive, and beloved creatures in the world. As a conservation biologist, his ultimate goal is to preserve species in the wild, and animal rights activists say that confining animals in zoos runs counter to this philosophy. In recent years, critics have attacked zoos for spending huge sums of money on breeding endangered species such as giant pandas in captivity while little is being done to stem the tide of habitat destruction in the wild.

At the National Zoo in Washington, D.C., the latest product of these breeding efforts, a 4-month-old giant panda named Bao Bao, is now on view to the public, and her fuzzy baby antics are attracting so many visitors that the zoo has extended its weekend hours to accommodate them all. The pandas at the National Zoo are easy for visitors to see, thanks to the 2006 opening of a 12,000 square foot, state-of-the-art habitat. Wang sees this new habitat as part of a positive trend in zoo design, with new elements that are making a difference in conservation.

As the National Zoo was preparing to build its new panda habitat, landscape designers consulted with researchers, including Wang, to learn what the animals need to stay comfortable, happy, and engaged. The new exhibit closely mimics the pandas' natural habitat, and is more interactive for visitors than was the small, spare one originally built in the 70s for the zoo's first pair of pandas, Hsing Hsing and Ling Ling. Visitors to the new exhibit can try out some of the same features the pandas enjoy, such as a

cooling rock that has cold water piped through it to keep the bears comfortable during hot weather, a panda grotto, and a fog grove.

What Wang likes best about the exhibit, however, are the Decision Stations that teach visitors about habitat loss and conservation efforts. His research has shown that human development, which has shrunk the pandas' natural habitat and broken it up into small parcels, is the main threat to the bears' survival in the wild. The Decision Stations give visitors a taste of what it's like to weigh economic decisions against the need to preserve panda habitats, and Wang says this experience helps them understand that the problem is a wider socio-economic one that biologists can't solve on their own.

Wang is concerned about all the animals affected by habitat loss, not just giant pandas, and he understands the argument of the growing number of critics who say that the focus on pandas means that too much money is being spent on a single species. However, he's also quick to point out the importance of animals such as pandas that can serve as ambassadors for conservation. The giant panda is an example of what scientists call "charismatic megafauna". Because of its universal appeal, it was chosen as the icon for the World Wildlife Federation, and has become a symbol for endangered species worldwide.

"In Chinese culture, pandas have long been symbols of peace and diplomacy," says Wang. He sees their role within the animal kingdom in the same way. Just as gifts of pandas have helped China negotiate diplomatic relations in years past, so too the bears now bring attention to conservation issues, and the money and research that they generate benefit other species as well. Panda conservation funds have made possible the construction of "corridors" of wild land that connect isolated remaining parcels of habitat, providing the pandas with better access to land, as well as to each other. In recent years, the wild panda population has begun to increase, indicating that the corridors are working. The corridors have also helped the snow leopard, another endangered species that shares the panda's habitat. Wang characterizes the corridors as rivers, where water can easily flow, instead of isolated ponds that are constantly in danger of drying out.

The panda's black and white fur is understood in China to be a physical manifestation of the idea of yin and yang, the balance of positive and negative energy in the world. Wang sees this idea as also integral to the future success of conservation efforts. He stresses the need to find balance between spending money on breeding cute baby pandas and addressing the underlying human behaviors that have endangered the panda in the first place.

Even Wang is not immune, though, to the charms of the giant pandas he studies. He is best known among the general public for a YouTube video in which he plays with a panda cub whose mother he had been tracking. The mother panda got so accustomed to Wang following her that on one occasion she left him in charge of her cub while she went to feed. One of Wang's colleagues captured the remarkable event on video. Though babysitting panda cubs isn't the focus of Wang's research, he doesn't mind the attention he's received from the video. "That was the best time in my life," he says.

B.2.7.1 Key Phrases and their Boolean Expressions for Conservationist and Diplomat: The Grey Areas of Panda Conservation

1. Key Phrase: Dr. Dajun Wang is an activist (conservation biologist).

- Included Keyword: Dr.
 - Keyword Alternatives: doctor, Dajun, Wang, man, guy, person, individual, protagonist, character, Mr., Wong
- Included Keyword: activist
 - Keyword Alternatives: support, reform, organize, research, aware, conserv, work, special, scien, help, teach, environment, preserv, ecolog, expert, bio, advocat, zoo, analy

2. Key Phrase: Dr. Dajun Wang balances (walks a fine line between) advocating for wildlife habitat conservation and advocating for zoos.

- Included Keyword: conserv
 - Keyword Alternatives: preserv, maintain, sustain, safe, protect, defend, guard, shield, sav, car, uphold, retain, restor, maintenanc, support, nourish, foster, aegis, prolong, tend, shelter, secur, fortif, ward, barr, bulwark, prevent, surviv, continu, endur, rescu, cover, screen, deflect, buffer, refug, umbrella, reinforc, facilitat, assist, promot, back, defend, support, propon, counsel, campaign, champ, expound, hold, speak, push, press, encourag, inspir, root, tout, jockey, toil, attempt, aim, boost, effort, dream, seek, fight, urg, driv, striv, propos, advanc
- Included Keyword: zoo
 - Keyword Alternatives: park, menagerie, sanctuar, exhibit, collection, garden, wildlife, reserve, preserv

3. Key Phrase: Wang has spent hours in the mountains of western China.

- Included Keyword: west
 - Keyword Alternatives: China
- Included Keyword: mount
 - Keyword Alternatives: cliff, crag, peak, pike, ridge, precipice, range, mesa, butte, highland, massif, summit

4. Key Phrase: Wang has spent hours (in the mountains of western China) tracking the giant panda.

- Included Keyword: track
 - Keyword Alternatives: locat, find, follow, record, shadow, tail, foot, trail, indicat, trace, mark, search, see, detect, spot, point, sign, scent, zero, come, upon, discover, identif, catch, area, position, region, site, place, turf, domain, terr, zone, sector, seek, tracing
- Included Keyword: panda
 - Keyword Alternatives: bear

5. Key Phrase: Giant pandas are one of the most endangered creatures.

- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: danger
 - Keyword Alternatives: scarc, common, few, threat, risk, frequen, limit, low, substantial, extinct, peril, jeapord, defen, out, diminish, declin, dwindl, shrink, re-duc, less, mini, wan, drop, populat, number, hazard, reced, count, amount, quantit, volum, total, troubl, saf, expos, fragil, delicat, sensitiv, rare, rarit, compromi, harm, gambl, ventur, vulnerab, compromis, secur, undermin, menac, threaten, susceptib, precarious, stak
- Included Keyword: most

- Keyword Alternatives: one, role, model, exemplar, among, significant, top, lead, critical, severe, high, grave, serious, brink, imminent, edge, edging, dire, extreme, verge, alarm, near, close, major, big, super, primary, foremost, upper, main, head, prominent, front, primary

6. Key Phrase: Giant pandas are one of the most elusive creatures.

- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: elusive
 - Keyword Alternatives: evasive, trick, sneak, deceive, slip, sly, cunning, wily, willfully, devious, shrewd, cautious, vigilant, shift, mislead, catch, grasp, pin, fugitive, capture, escape, elude, deceit, slick, tangible, enigma, attain, access, flee, vague, cryptic, mysterious, clandestine, stealth, camouflage, hidden, conspicuous, mystical, puzzling, hazy, obscure, ambiguous, dodgy, deft, find, found, trace, clever, craft, secret, covert, furtive, obtrusive, subtle, quiet, cognate, surreptitious, undercover, discreet, conceal, private, hush, shroud, guile, espionage, shadow, dupe, wit, disguise, duplicitous, bamboozle, hoodwink, swindle, delude, shy, timid, bashful, introvert, reticent, withdrawn, nervous, coy, diffident, hesitant, inhibit, meek, demure, assert, tremulous, tentative
- Included Keyword: most
 - Keyword Alternatives: one, role, model, exemplar, among, significant, top, lead, critical, severe, high, grave, serious, brink, imminent, edge, edging, dire, extreme, verge, alarm, near, close, major, big, super, primary, foremost, upper, main, head, prominent, front, great, maximum, supreme, eminent, stand, example, principal, first, best, ultimate, chief, paramount, dominant, central, center, primary

7. Key Phrase: Wang's ultimate goal is to preserve species in the wild.

- Included Keyword: Wang
 - Keyword Alternatives: Dr., doctor, Mr., Dajun, Wang, man, guy, person, individual, protagonist, character, activist, scientist, researcher, Wong, zoo
- Included Keyword: preserve
 - Keyword Alternatives: conserve, maintain, sustain, safe, protect, fence, guard, shield, keep, watch, look, shelter, tend, secure, fortify, ward, barrier, bulwark, prevent, avert, counter, survive, continue, endure, retain, uphold, prolong, save, rescue, cover

- Included Keyword: goal
 - Keyword Alternatives: objective, target, aim, ambition, destinat, intent, aspir, mission, quest, endeavor, mark, dream, ideal, plan, resolut, focus, pursuit, achiev, purpos, vision, striv, milestone, wish, hope, hoping, yearn, expect, anticipat, prospect, optimis, passion, devot, determin, ethusias, feveren, drive, driving

8. Key Phrase: Animal rights activists (Critics) say that zoos run counter to preserving species in the wild.

- Included Keyword: zoo
 - Keyword Alternatives: park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv
- Included Keyword: counter
 - Keyword Alternatives: against, oppos, contra, revers, conflict, class, advers, harm, antagon, obstruct, challeng, odd, undermin, impeded, inhibit, vert, disrupt, curb, hinder, way, rupt, interfer, neutral, threat, slow, compromis, hamper, hurt, diminish, declin, dwindl, shrink, reduc, less, mini, wan, drop, danger, risk, limit, low, peril, jeopard, damag, injur, destr, impair, mess, wreck, botch, interrupt, devastat, prevent, intrud, stall, stop, strain, thwart, upset, derail, block, screw, ruin, circumvent, halt, jeopardiz
- Included Keyword: preserv
 - Keyword Alternatives: conserv, maintain, sustain, safe, protect, fend, care, guard, shield, sav, caring, uphold, retain, restor, maintenanc, support, nourish, foster, aegis, prolong, tend, shelter, secur, fortif, ward, barr, bulwark, prevent, surviv, continu, endur, rescu, cover, screen, deflect, buffer, refug, umbrella, reinforc, facilitat, assist

9. Key Phrase: Animal rights activists (Critics) say that zoos spend a lot of money (huge sums) on breeding endangered species such as giant pandas in captivity.

- Included Keyword: zoo
 - Keyword Alternatives: park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv
- Included Keyword: specie

- Keyword Alternatives: life, liv, animal, natur, creat, organism, wild, panda, beast, critter, vertebrate, mammal, fauna, bear, breed, exist, quadruped, bipedal, bio, gen, eco, thing, being, entit, produc, offspring, danger, popul, birth, multi, propagat, cultivat, grow, foster, proliferat, increas, restor, mak, rais, rear, bring, brought, develop, expand, num, extinct, engender, rise, rising
 - Included Keyword: captiv
 - Keyword Alternatives: internment, coercion, arrest, seizure, control, imprison, confin, deten, incarcer, restrain, constrain, subjugat, custody, beget
10. Key Phrase: Animal rights activists (Critics) say that little is being done to slow habitat destruction (stem the tide) in the wild.
- Included Keyword: habitat
 - Keyword Alternatives: bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, where, position, sector, home
 - Included Keyword: destr
 - Keyword Alternatives: regress, hazard, injur, harm, detriment, depriv, worse, dec, down, fell, wast, ravag, sabotag, under, cripl, damag, hurt, corrupt, devastat, deteriorat, collaps, pollut, impair, extinct, eradicat, contaminat, disturb, ero, los, less, shrink, shrank, shrunk, weak, corro, end, tarnish, taint, ruin, wreck, degrad, break, fragment, reduc, fall, fell, disrupt, wrong, vandal, defac, attrit, wear, down, attenuat, debilitat, thin, fad, demolish, annihilat, extinguish, obliterated, dissipat, decimat, squander, exterminat, vanish, reced, kill, wip
11. Key Phrase: The National Zoo is in Washington D.C.
- Included Keyword: National
 - Keyword Alternatives: zoo, park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv
 - Included Keyword: Washington
 - Keyword Alternatives: D.C, DC, District, Columbia, capital, polis, municipalit, beltway, capitol

12. Key Phrase: Bao Bao was born in the National Zoo.

- Included Keyword: National
 - Keyword Alternatives: zoo, park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv, born, created, brought, given, birth, delivered, produced, originated, emerged, arisen, started, sprung, begotten, spawned, hatched, formed
- Included Keyword: Bao
 - Keyword Alternatives: panda, bear

13. Key Phrase: The giant panda is named Bao Bao.

- Included Keyword: Bao
 - Keyword Alternatives: panda, bear, Boa
- Included Keyword: nam
 - Keyword Alternatives: call, titl, designa, label, identif, refer, term, dubb, entitl, denot, known, given, assign, tag

14. Key Phrase: Bao Bao is 4 months old.

- Included Keyword: Bao
 - Keyword Alternatives: panda, bear, Boa
- Included Keyword: 4
 - Keyword Alternatives: four, month, week, year, old, day

15. Key Phrase: Bao Bao is on view to the public.

- Included Keyword: Bao
 - Keyword Alternatives: panda, bear, Boa
- Included Keyword: view
 - Keyword Alternatives: public, availabl, display, show, exhibit, access, expo, open, featur, present, visibl, see, look, watch, observ, comm, person, people, audienc, goer, visit, guest, crowd, spectat, listen, popul, folk, mass, witness, follow, fan, pass, patron, subscrib, societ, flaunt, parad, individ, attract, headlin, event, tour, travel, excursion, appeal, interest, star

16. Key Phrase: Bao Bao's antics are attracting many visitors.

- Included Keyword: antic
 - Keyword Alternatives: sill, humo, stunt, misch, shenanigan, nonsens, behav, fool, wild, rowd, chicane, escapade, jink, around, business, clown, ruckus, malarkey, absurd, craz, mad, ridiculous, goof, stupid, act, buffoon, order, chao, favor, anarch, mayhem, pandemonium, commotion, racket, discord, disarry, shambl, luna, insan, fren, turmoil, gimmick, trick, rascal, imp, naught, play, cut, fun, comic, prank, laugh, amus, live, vivac, jaunt, spirit, mirth, excit, rambunctious, hyper, cheer, joy, jolly, festiv, energ, entertain, display
- Included Keyword: attract
 - Keyword Alternatives: entic, draw, bring, appeal, lur, interest, hook, pull, grab, intrigu, delight, charm, admir, marvel, captiv, lik, ador, appreciat, fond, infatuat, attach, enchant, enjoy, coax, rop, suck, brought, tak, took, mesmer, impress, compel, curious, fascinat, rivet, appeal, absorb, grip, engag, enthrall, thrill, entranc, spell, hypnotiz, bewitch, beguil, enchant, ensorcell, dazzl, infatuat, move, fall, fell, lov, gather, mass, group, com, cam, travel, view, see, observ, watch, fan, witness, look, visit, spectat
- Included Keyword: Bao
 - Keyword Alternatives: panda, bear, Boa

17. Key Phrase: The zoo extended their weekend hours to accommodate visitors (for Bao Bao).

- Included Keyword: extend
 - Keyword Alternatives: leng, more, long, add, increas, broad, expand, wide, stretch, magnif, out, burgeon, elevat, rise, rose, high, lift, big, large, great, chang, adjust, mod, trans, alter, revis, shift, switch, constuct, swap, form, shape, adapt, accomodat, remake, remade, redid, redo, tune, fix, tailor, rectif, redress, tweak, improv, calibrat, amend, better, revamp, update, touch, rais, inflat, rising
- Included Keyword: zoo
 - Keyword Alternatives: park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv, week
- Included Keyword: visit

- Keyword Alternatives: view, spect, guest, group, com, observ, watch, fan, mass, witness, spectat, patron, invit, people, person, travel, tour, expedition, sight, client, custom, vacation, regular, audience, crowd, gather, public, admire, devout, follow, look, attend, particip, join, glimpse, behold, gander, see, exam, eye, peek, stare, survey, scope, scan, regard, gaze, ogl, adult, kid, guy

- Included Keyword: hour

- Keyword Alternatives: time, period, duration, length, week, day, interval, span, event, allot, stretch, clock, frame, block, segment, shift, timing

18. Key Phrase: Pandas at the National Zoo are easy for visitors to see (due to the new habitat).

- Included Keyword: National

- Keyword Alternatives: zoo, park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv

- Included Keyword: panda

- Keyword Alternatives: bear

- Included Keyword: visit

- Keyword Alternatives: view, spect, guest, group, com, observ, watch, fan, mass, witness, spectat, patron, invit, people, person, travel, tour, expedition, sight, client, custom, vacation, regular, audience, crowd, gather, public, admire, devout, follow, look, go, attend, particip, join, glimpse, behold, gander, see, exam, eye, peek, stare, survey, scope, scan, regard, gaze, ogl, adult, kid, guy

19. Key Phrase: The National Zoo has a state-of-the-art habitat.

- Included Keyword: National

- Keyword Alternatives: zoo, park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv

- Included Keyword: habitat

- Keyword Alternatives: bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, where, position, sector, home

20. Key Phrase: The (new) panda habitat is 12,000 square feet.

- Included Keyword: 12000
 - Keyword Alternatives: 12, twelve, thousand, sq, square, feet, ft

21. Key Phrase: The (new) panda habitat opened in 2006.

- Included Keyword: 2006
 - Keyword Alternatives: two, thousand, six, 2000

22. Key Phrase: Wang sees the (new) habitat as a positive trend in zoo design.

- Included Keyword: habitat
 - Keyword Alternatives: bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sector, home
- Included Keyword: positiv
 - Keyword Alternatives: good, well, better, construct, effect, worth, reason, practical, favor, intuit, respect, accept, admir, deserv, desir, val, great, recogni, laud, merit, use, benefi, profit, gain, advantag, agree, admira, wonder, comm, imp, signif, purpos, help, marvel, honor, first, gnarly, neat, splend, stupend, choice, satisf, exce, sup, prime, design, arrang, manag, administrat, organiz, over, develop, facilitat, architecture, comp, struct, sketch, draft, diagram, build, make, lay, scheme, model, print, pict, line, portrait, project
- Included Keyword: design
 - Keyword Alternatives: arrang, manag, administrat, organiz, over, develop, facilitat, architecture, comp, struct, sketch, draft, diagram, build, lay, scheme, model, print, pict, line, portrait, project, mak, element, component, feature, aspect, factor, constituent, characteristic, attribut

23. Key Phrase: Wang sees the (new) zoo design elements making a difference in conservation.

- Included Keyword: design

- Keyword Alternatives: arrang, manag, administrat, organiz, over, develop, facilitat, architecture, comp, struct, sketch, draft, diagram, build, lay, scheme, model, print, pict, line, portrait, project, mak, element, component, feature, aspect, factor, constituent, characteristic, attribut
- Included Keyword: conserv
 - Keyword Alternatives: preserv, maintain, sustain, safe, protect, fend, care, guard, shield, sav, caring, uphold, retain, restor, maintenanc, support, nourish, foster, aegis, prolong, tend, shelter, secur, fortif, ward, barr, bulwark, prevent, surviv, continu, endur, rescu, cover, screen, deflect, buffer, refug, umbrella, reinforc, facilitat, assist
- Included Keyword: National
 - Keyword Alternatives: zoo, park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv

24. Key Phrase: The National Zoo landscape designers consulted with researchers, including Wang, to learn what pandas need (to stay comfortable, happy, and engaged).

- Included Keyword: National
 - Keyword Alternatives: zoo, park, menagerie, sanctuar, exhibit, collection, garden, reserve, wildlife, preserv, landscape, designer
- Included Keyword: research
 - Keyword Alternatives: activist, advocate, conserv, support, environmental, preservation, ecolog, scien, invest, bio, zoo, expert, analy
- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: need
 - Keyword Alternatives: necess, essential, requisit, desidera, imperativ, vital, desperat, depend, indispens, crucial, urgent, intrinsic, fundament, pertinent, critical, priorit, integral

25. Key Phrase: The (new) exhibit closely mimics the pandas' natural habitat.

- Included Keyword: exhibit

- Keyword Alternatives: model, view, display, fair, present, expo, show, demo, enclos, model, view, display, fair, present, expo, show, demo, enclos, habitat, bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, where, position, sector
- Included Keyword: mimic
 - Keyword Alternatives: duplicat, replica, copy, imitat, mumm, echo, simulat, ditto, doppel, facsimil, reproduc, incarnat, mirror, similar, same, close, equal, like, compar, equiv, analogous, kin, near, correspon, relat, equiv, counter, parallel, synonym, common, uni, even, distinguish, match, image, different, oppos, contrast, vari, resembl, model, reflect, emulat
- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: habitat
 - Keyword Alternatives: bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, where, position, sector

26. Key Phrase: The new exhibit is more interactive for visitors than the previous one.

- Included Keyword: exhibit
 - Keyword Alternatives: model, view, display, fair, present, expo, show, demo, enclos, habitat, bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, where, position, sector
- Included Keyword: interact
 - Keyword Alternatives: engag, respon, touch, more, participat, partak, action, life, live, flesh, complet, enhanc, augment, refin, stuff, things, develop, embelish, expand, extend, magnif, fill, tweak, beef, soup, large, elaborate, define, ameliorat, reform, rich, surpass, better, improv, updat

- Included Keyword: previous
 - Keyword Alternatives: former, prior, past, earl, preced, anteced, fore, old

27. Key Phrase: The previous exhibit was built in the 70s.

- Included Keyword: 70
 - Keyword Alternatives: 70, 1970, seven

28. Key Phrase: The previous exhibit was built for the zoo's first pair of pandas: Hsing Hsing and Ling Ling.

- Included Keyword: exhibit
 - Keyword Alternatives: model, view, display, fair, present, expo, show, demo, enclos, habitat, bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sector
- Included Keyword: first
 - Keyword Alternatives: initial, origin, pioneer, lead, earl, prem, intr, start, prim, front, head, begin, outset, key, before, incept, ante, prelim, precursor, past, previous, former, quondam, preceed, erst, whilom, 1st
- Included Keyword: panda
 - Keyword Alternatives: bear, Hsing, Ling

29. Key Phrase: Visitors to the new exhibit can try out some of the features that pandas enjoy.

- Included Keyword: visit
 - Keyword Alternatives: people, person, those, adult, kid, view, spect, guest, group, com, observ, watch, fan, mass, witness, spectat, patron, invit, travel, tour, expedition, sight, client, custom, vacation, regular, audience, crowd, gather, public, admire, devot, follow, look, attend, particip, join, glimpse, behold, gander, see, exam, eye, peek, stare, survey, scope, scan, regard, gaze, ogl, guy
- Included Keyword: feature

- Keyword Alternatives: aspect, rock, grotto, grove, place, thing, part, area, region, environment, habitat, compon, attribut, qual, prop, trait, character, element, exhib, zoo, factor, enclos, facet, interest, point, locat, posit, activit, toy, game, leisure, hobb, stuff, what, view, spot, item, tool, gadget, object, where
 - Included Keyword: panda
 - Keyword Alternatives: bear
30. Key Phrase: The cooling rock has cold water piped through it to keep pandas comfortable (during hot weather).
- Included Keyword: rock
 - Keyword Alternatives: stone, boulder
 - Included Keyword: cool
 - Keyword Alternatives: cold, water, temp, heat, hot, warm, sweat, blaz, boil, scorch, bak, burn, roast, swelt, sizzl, torrid, blister, fever, flam, fiery, fire, igneous, steam, smok, sear, chill, refresh, condition, pleas, air, climate, comfort, calm, peace, relax, appropriate, rejuvenat, cozy, sooth, fresh, refrigerat, relie, comfy, satisf, tranquil, home
 - Included Keyword: panda
 - Keyword Alternatives: bear
31. Key Phrase: The new features include a cooling rock.
- Included Keyword: rock
 - Keyword Alternatives: stone, boulder, pebble, gravel, cobble, frag, piece, bed
32. Key Phrase: The new features include a panda grotto.
- Included Keyword: grotto
 - Keyword Alternatives: cave, cavern, grot, hollow, den, retreat, place, antre, burrow, hole, gorge, rock, stone, boulder, mineral
33. Key Phrase: The new features include a fog grove.
- Included Keyword: fog

- Keyword Alternatives: water, drop, tiny, small, mist, haze, vapor, vapour, cloud, murk, obscur, fume, gloom, white, smok, haz, nebul, gas, steam
- Included Keyword: grove
 - Keyword Alternatives: wood, tree, cluster, group, orchard, plant, vegeta, thick, copse, clump, stand, bosk, spinney, timber, bush, shrub, land, ground, soil, coppice, arbor, forest, patch

34. Key Phrase: Wang likes the Decision Stations the most.

- Included Keyword: decision
 - Keyword Alternatives: station
- Included Keyword: Wang
 - Keyword Alternatives: Dr, Dajun, Wang

35. Key Phrase: The Decision Stations teach visitors about habitat loss.

- Included Keyword: decision
 - Keyword Alternatives: station
- Included Keyword: habitat
 - Keyword Alternatives: bio, eco, envi, hom, conserv, nest, burrow, breed, den, lair, resid, terr, hol, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sector, lost, losing, hazard, harm, detriment, dec, destr, wast, ravag, damag, devastat, deteriorat, collaps, pollut, extinct, contaminat, disturb, ero, disrupt, corro, ruin, dissipat, annihilat, squander, exterminat, vanish, reced, kill, degrad, modif, frag, encroach, clear, shrink, declin, reduc, drop, diminish, disappear, life, live, living

36. Key Phrase: The Decision Stations teach visitors about conservation efforts.

- Included Keyword: decision
 - Keyword Alternatives: station
- Included Keyword: conserv

- Keyword Alternatives: preserv, maintain, sustain, safe, protect, fend, care, guard, shield, sav, caring, uphold, retain, restor, maintenanc, support, nourish, foster, aegis, prolong, tend, shelter, secur, fortif, ward, barr, bulwark, prevent, surviv, continu, endur, rescu, cover, screen, deflect, buffer, refug, umbrella, reinforc, facilitat, assist, danger, effort

37. Key Phrase: (Wang’s research has shown that) Human development is the main threat to the panda bears’ survival in the wild.

- Included Keyword: human

- Keyword Alternatives: develop, industr, progress, product, avanc, evol, build, invent, creat, discover, genui, research, auto, grow, curio, greed, spread, tech, people, person, societ, responsib, resource, com, innovat, modern, mechan

- Included Keyword: surviv

- Keyword Alternatives: endur, persist, weather, thrive, overcom, prevail, sust, vital, liv, remain, exist, continu, life, longevit, sufficien, resilien, main

- Included Keyword: threat

- Keyword Alternatives: risk, peril, problem, vulnera, compromis, chang, take, jeopard, threat, danger, imp, risk, weak, ruin, mar, damag, hurt, dis, blight, hazard, injur, harm, detriment, depriv, wors, destroy, down, fell, wast, ravag, sabotag, under, peril, counter, offset, cancel, null, annul, undo, valid, balanc, restrict, curb, check, diminish, strain, inhibit, debilitat, bridl, regula, circum, bound, confin, impact, influen, negat, crippl, declin, challeng, menac, against, oppos, contra, revers, conflict, class, advers, harm, antagon, obstruct, challeng, odd, undermin, imped, inhibit, vert, disrupt, hinder, rupt, interfer, neutral, slow, hamper, dwindl, shrink, reduc, less, mini, wan, drop, limit, low, peril, jeopard, injur, impair, mess, wreck, botch, interrupt, devastat, prevent, intrud, stall, stop, thwart, upset, derail, block, screw, ruin, halt, shrunk, narrow, trim, slim, taper, dwarf, shrank, decreas, compress, curtail, subtract

- Included Keyword: panda

- Keyword Alternatives: bear

38. Key Phrase: (Wang’s research has shown that) Human development has shrunk the pandas’ natural habitat into small parcels.

- Included Keyword: human
 - Keyword Alternatives: develop, industr, progress, product, advanc, evol, build, invent, creat, discover, genui, research, auto, grow, curio, greed, spread, tech, people, person, societ, responsib, resource, com, innovat, modern, mechan
- Included Keyword: habitat
 - Keyword Alternatives: bio, eco, envi, hom, conserv, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sector, preserv, los, hazard, harm, detriment, dec, destr, wast, ravag, damag, devastat, deteriorat, collaps, pollut, extinct, contaminat, disturb, ero, disrupt, corro, ruin, dissipat, annihilat, squander, exterminat, vanish, reced, kill, lif, shrunk, shrink

39. Key Phrase: The Decision Stations show visitors what it's like to weigh economic decisions against the need to preserve panda habitats.

- Included Keyword: decision
 - Keyword Alternatives: station
- Included Keyword: econom
 - Keyword Alternatives: mone, spen, cash, currenc, financ, income, decision, dough, bread, choice, option, capital, expen, fund, wealth, fortun, sum, budget, invest, buck, sourc, rich, business, market, commer, fiscal, indust, pecuniary, product, mercantile, profit, remunerat, sale, sell, good, merch, service, suppl, money, pay, paid
- Included Keyword: habitat
 - Keyword Alternatives: bio, eco, envi, hom, conserv, nest, burrow, breed, den, lair, resid, terr, hol, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sector, lost, losing, hazard, harm, detriment, dec, destr, wast, ravag, damag, devastat, deteriorat, collaps, pollut, extinct, contaminat, disturb, ero, disrupt, corro, ruin, dissipat, annihilat, squander, exterminat, vanish, reced, kill, degrad, modif, frag, encroach, clear, shrink, declin, reduc, drop, diminish, disappear, life, live, living

- Included Keyword: preserv
 - Keyword Alternatives: conserv, maintain, sustain, safe, protect, fend, care, guard, shield, sav, caring, uphold, retain, restor, maintenanc, support, nourish, foster, aegis, prolong, tend, shelter, secur, fortif, ward, barr, bulwark, prevent, surviv, continu, endur, rescu, cover, screen, deflect, buffer, refug, umbrella, reinforc, facilitat, assist

40. Key Phrase: The Decision Stations help people understand that the problem (of conservation) is a wider socio-economic one that biologists can't solve on their own.

- Included Keyword: decision
 - Keyword Alternatives: station
- Included Keyword: problem
 - Keyword Alternatives: issue, dilemma, complicat, trouble, obstacle, quandry, mess, pickle, predicament, question, difficult, situation, circumstance, stat, case, condition, process, place, position, scene, point, outlook, phase, event, limit, factor, detail, matter, concern, occur, thing, affair, future, exigen, interven, occasion, crisis, context, mess, plight, perplex, emergen, tangle, sol, answer, fix, result, key, clarif, expla, deal, out, determin, crack, deciph, decod, elucid, get, reason, ravel, fold, lock, two, conclu, clear, settle, take, stance, understand
- Included Keyword: socio-economic
 - Keyword Alternatives: socio, econom, social, mone, spen, cash, currenc, financ, income, decision, dough, bread, choice, option, capital, expen, fund, wealth, fortun, sum, budget, invest, buck, sourc, rich, business, market, commer, fiscal, indust, pecuniary, product, mercantile, profit, remunerat, sale, sell, good, merch, service, suppl, pay, paid, societ, commun, collect, group, cultur, public, common, shar, person, relat, cooperat, connect, collab, human, civil, ethic, behav

41. Key Phrase: Wang is concerned about all the animals affected by habitat loss.

- Included Keyword: habitat
 - Keyword Alternatives: bio, eco, envi, hom, hous, nest, burrow, breed, den, lair, resid, terr, hol, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, where, position, sector, live, living

- Included Keyword: loss
 - Keyword Alternatives: lost, losing, hazard, harm, detriment, dec, destr, wast, ravag, damag, devastat, deteriorat, collaps, pollut, extinct, contaminat, disturb, ero, disrupt, corro, ruin, dissipat, annihilat, squander, exterminat, vanish, reced, kill, degrad, modif, frag, encroach, clear, shrink, declin, reduc, drop, diminish, disappear
- Included Keyword: Dr.
 - Keyword Alternatives: doctor, Mr., Dajun, Wang, man, guy, person, individual, protagonist, character, activist, scientist, researcher, Wong, zoo

42. Key Phrase: Wang understands the critics' argument (over the focus on pandas).

- Included Keyword: critic
 - Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch, several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic, pessimist, believ, contrar, negativ, opponen, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scorn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter
- Included Keyword: understand
 - Keyword Alternatives: understood, comprehen, grasp, appreciat, acknowledg, discern, get, realiz, sympath, see, recogni, cogni, follow, sens, interpret, empath, regist, fathom, intepret, perce, absor, catch, reali, apprehen, figur, conceiv, deduc, digest, know, gather, take, taking, decipher, read, descr, internali, view, point, outlook, approach, refer, fram, attitude, stand, angl, vision, visual, position, opinion, lens, consider, aspect, mind, impress, context, stance, sight, slant, prais

43. Key Phrase: Critics dislike the focus on pandas.

- Included Keyword: critic
 - Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch,

several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic, pessimist, believ, contrar, negativ, opponen, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scourn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter

- Included Keyword: focus
 - Keyword Alternatives: center, target, subject, core, spotlight, priorit, central, main, prime, fix, emphasi, highlight, engag, concentrat, atten, obsess, occup, infatuat, enthusias, mind, invest, attach, indulg, involv, absor, monomania, fascinat, thought, care, caring, diligen, aware, interest, recogni, presen, focal, limelight
- Included Keyword: panda
 - Keyword Alternatives: bear

44. Key Phrase: Critics dislike spending too much money on a single species.

- Included Keyword: mone
 - Keyword Alternatives: spen, cash, currenc, financ, income, dough, bread, salar, wage, amount, expen, fund, wealth, fortun, sum, budget, invest, buck, sourc, rich, client, patron, business, market, econom, capital, pocket, fork, dish, shell, drain, splurg, disburs, cost, pay, paid, squander, dissipat, consum, wast, commer, fiscal, indust, pecuniary, product, mercantile, profit, remunerat, sale, sell, good, merch, service, suppl
- Included Keyword: specie
 - Keyword Alternatives: life, liv, animal, natur, creat, organism, wild, panda, beast, critter, vertebrate, mammal, fauna, bear, singl, one, 1, sol, individual
- Included Keyword: critic
 - Keyword Alternatives: naysay, detract, disparat, complain, doubt, disput, nitpick, fault, whin, cry, crie, fuss, wuss, people, person, some, one, other, oppos, comment, judg, pundit, review, analy, annotat, interpret, many, few, couple, bunch, several, countless, lot, arbit, assess, examin, oppon, disparag, eval, skeptic, cynic, pessimist, believ, contrar, negativ, opponen, dissen, object, scoff, anthrop, question, trust, conform, defect, support, deny, deni, nihil, optimist, downer, sour, poop, sceptic, Cassandra, scourn, observ, assay, protest, gripe, kvetch, moan, carp, beef, reproach, quibbl, repin, grumbl, niggl, cavil, mutter

45. Key Phrase: Pandas can serve as ambassadors for conservation.

- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: ambassador
 - Keyword Alternatives: diplomat, envoy, attaché, consul, plenipotentiary, messenger, proxy, herald, agent, spokesperson, icon, face, represent, mediat, emissar, minister, commissioner, courier, advocat, attache, negociat, legate, importan, atten
- Included Keyword: conserv
 - Keyword Alternatives: preserv, maintain, sustain, safe, protect, fend, care, guard, shield, sav, caring, uphold, retain, restor, maintenanc, support, nourish, foster, aegis, prolong, tend, shelter, secur, fortif, ward, barr, bulwark, prevent, surviv, continu, endur, rescu, cover, screen, deflect, buffer, refug, umbrella, reinforc, facilitat, assist, effort, habitat, bio, eco, envi, hom, nest, burrow, breed, den, lair, resid, terr, hol, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sector, lost, losing, hazard, harm, detriment, dec, destr, wast, ravag, damag, devastat, deteriorat, collaps, pollut, extinct, contaminat, disturb, ero, disrupt, corro, ruin, dissipat, annihilat, squander, exterminat, vanish, reced, kill, degrad, modif, frag, encroach, clear, shrink, declin, reduc, drop, diminish, disappear, life, live, living

46. Key Phrase: Scientists call giant pandas: “charismatic megafauna” (attractive large animals).

- Included Keyword: charisma
 - Keyword Alternatives: mega, fauna

47. Key Phrase: Pandas have universal appeal. (Giant pandas are one of the most beloved creatures.)

- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: universal

- Keyword Alternatives: global, cultural, international, recog, icon, symbol, known, worldwide, charm, magnet, charisma, desirab, irresistib, popular, appeal, enchant, attract, engag, captivat, pull, fascinat, allur, interest, widespread, ubiquitous, draw, love, adore, cherish, precious, dear, treasure, favorite, fond, respect, idol, loving, cute, like, liking, lika, welcom, infatuat, ador, admir, esteem, favor, favour, priz, treasur, dote, doting, darling, revere, revering, devot, sweet, enamour, enamor, valu, honor, honour, heart, venerat, special, affection

48. Key Phrase: Pandas were chosen as the icon for the World Wildlife Federation.

- Included Keyword: wwf
 - Keyword Alternatives: world, wildlife, federation, fed, w.w.f.

49. Key Phrase: Pandas become a symbol for endangered species worldwide.

- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: specie
 - Keyword Alternatives: life, liv, animal, natur, creat, organism, wild, panda, beast, critter, vertebrate, fauna, bear, breed, exist, quadruped, bipedal, bio, gen, eco, thing, being, entit, produc, offspring, danger, popul, birth, multi, propagat, cultivat, grow, foster, proliferat, increas, restor, mak, rais, rear, bring, brought, develop, expand, num, extinct, engender, rise, rising, mammal, being, risk, scarce, rar, common, few, threat, frequent, limit, substantial, peril, jeopard, vulnerable, defence, expose, out, diminish, declin, dwindl, shrink, reduc, less, mini, wan, drop, hazard, reced, count, amount, quantity, volume, total, trouble
- Included Keyword: symbol
 - Keyword Alternatives: emblem, icon, symbol, figur, imag, represent, sign, model, mark, seal, badg, token, indicat, crest, motif, stamp, logo, insignia, attribut, brand, allegor, portrayal, express, blueprint, roadmap, guid

50. Key Phrase: “In Chinese culture, pandas have long been symbols of peace and diplomacy.” (explained by Wang).

- Included Keyword: chin

- Keyword Alternatives: asia, tradition, cust, cultur, belief, ceremon, ritual, habit, pattern, convention, folkway, heritage, routin, norm, histor, practic, pratic
- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: peace
 - Keyword Alternatives: diploma, present, prime, lead, virtu, harmony, rapport, stab, pacif, concord, balanc, tranquil, seren, calm, harmon, conciliat, violen, unity, unities, unif, content, coop, stab, agree, resolut, repos, equanimit, friend, troubl, pleas, placid, compos, negotiat, relation, statecraft, tact, mediat, summit
- Included Keyword: symbol
 - Keyword Alternatives: emblem, icon, figur, imag, represent, sign, model, mark, seal, badg, token, indicat, crest, motif, stamp, logo, insignia, attribut, brand, allegor, portrayal, express, ambassador, diplomat, envoy, attaché, consul, plenipotentary, messenger, proxy, herald, agent, spokesperson, icon, face, represent, mediat, emissar, minister, commissioner, courier, advocat, attache, negotiat, legate

51. Key Phrase: Gifts of pandas have helped China negotiate diplomatic relations.

- Included Keyword: chin
 - Keyword Alternatives: asia
- Included Keyword: gift
 - Keyword Alternatives: present, giv, send, deliver, bestow, grant, receiv, arriv, exchang, get, got, hav, acquir, accept, gather, distribut, offer, donat, award, hand, permit, allow, shar, provi, sell, trust, relinquish, parcel, gain, earn, trans, tak, collect, snag, pull, inherit, procur, pick, latch, possess, sent
- Included Keyword: diploma
 - Keyword Alternatives: politic, relation, affair, foreign, state, govern, nation, cultur, connect, coop, negotiat, allianc, link, network, affiliat, bond, partner, collab, friend, exchang, engag, contact, rapport, entente, global, accord, agree, polic

52. Key Phrase: The money that pandas generate benefits other species.

- Included Keyword: specie

- Keyword Alternatives: life, liv, animal, natur, creat, organism, wild, panda, beast, critter, vertebrate, mammal, fauna, bear, earth, world, breed, exist, quadruped, bipedal, bio, gen, eco, thing, being, entit, produc, offspring, popul, birth, multi, grow, mak, rear, num, other, add, many, alter, more, else, group, vari, divers, kind, strain, typ, class, categor, rang, scop, array, signific, world, nation, importan, spectrum, span, scal, extent, expans, gamut, field, reach, famil
- Included Keyword: benefi
 - Keyword Alternatives: advantage, gain, profit, blessing, asset, boon, merit, perk, upside, value, good, favor, positive, plus, help, impact, influen, welfare, wellness, aid, assist, improv, bless, relie, contribut, boost, support, backup, backing, car, reward, servic
- Included Keyword: mone
 - Keyword Alternatives: spen, cash, currenc, financ, income, dough, bread, salar, wage, amount, expen, fund, wealth, fortun, sum, budget, invest, buck, sourc, rich, client, patron, business, market, econom, capital, pocket, fork, dish, shell, drain, splurg, disburs, cost, pay, paid, squander, dissipat, consum, wast, commer, fiscal, indust, pecuniary, product, mercantile, profit, remunerat, sale, sell, good, merch, service, suppl

53. Key Phrase: The research that pandas generate benefits other species.

- Included Keyword: research
 - Keyword Alternatives: examin, stud, analy, explor, quir, investigat, prob, learn, experiment, inquisit, question, test, observ, inspect, view, assess, brainstorm, check, look, ponder, think, reason, reflect, find, data, result, thought, info, discuss, conclu, proce, trial, session, document, know, work, understand, understood, measur, exercis, activist, conserv, support, environmental, preservation, ecolog, scien, bio, zoo, expert, infer, gaug, parameter, variable, extrapolat, specific, guideline, criteria, framework, inspect, inter, inquir, scrutin, enquir, surve, review, eval, discover, compil, catalog, sampl, project, fact, verific, delv, disquisition, rummag
- Included Keyword: specie
 - Keyword Alternatives: life, liv, animal, natur, creat, organism, wild, panda, beast, critter, vertebrate, mammal, fauna, bear, earth, world, breed, exist, quadruped, bipedal, bio, gen, eco, thing, being, entit, produc, offspring, popul, birth, multi,

grow, mak, rear, num, other, add, many, alter, more, else, group, vari, divers, kind, strain, typ, class, categor, rang, scop, array, signific, world, nation, importan, spectrum, span, scal, extent, expans, gamut, field, reach, famil, reach, famil

- Included Keyword: benefit

- Keyword Alternatives: advantage, gain, profit, blessing, asset, boon, merit, perk, upside, value, good, favor, positive, benefit, plus, help, impact, influen, welfare, wellness, aid, assist, improv, bless, relie, contribut, boost, support, backup, backing, car, reward, servic

54. Key Phrase: Panda conservation funds connect isolated parcels of habitat (create “corridors” between them).

- Included Keyword: fund

- Keyword Alternatives: spen, cash, currenc, financ, income, dough, bread, salar, wage, amount, expen, pa, mone, wealth, fortun, sum, budget, invest, buck, sourc, rich, client, patron, business, market, econom, capital, pocket, fork, dish, shell

- Included Keyword: habitat

- Keyword Alternatives: bio, eco, envi, hom, conserv, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, esta, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, where, position, sect, passag, par, batch, acre, park, propert, ground, grass, field, pastur, meadow, rang, closur, yard, patch, lawn, green, plan, prair, savanna, spac, reserv, forest, wood, grove, jungle

- Included Keyword: connect

- Keyword Alternatives: corridor, link, join, attach, bond, tie, unit, associa, combin, relat, bridg, merg, coupl, integra, fus

55. Key Phrase: Corridors (between isolated parcels of land) provide pandas with better access to land.

- Included Keyword: better

- Keyword Alternatives: improve, enhance, superior, advantag, convenien, upgrad, ameliorat, elevat, prefer, favor, simplif, enrich, augment, high, increas, enlarg, optimiz, amplif, strength, boost, advanc, progress, develop, refin, height

- Included Keyword: access
 - Keyword Alternatives: passage, entr, admiss, availab, approach, utiliz, ingress, use, enter, opportun, way, direct, connect, gate, path, channel, route, right, avenue, door, corridor, alley, vestibule, lane, conduit
- Included Keyword: land
 - Keyword Alternatives: territor, habitat, domain, ground, soil, area, space, region, locale, terrain, home, environment, zone, country, place, niche, abode, resid, range, dwell, turf, domicile, house, shelter, pad, haven

56. Key Phrase: Corridors (between isolated parcels of land) provide pandas with better access to each other.

- Included Keyword: better
 - Keyword Alternatives: improve, enhance, superior, advantag, convenien, upgrad, ameliorat, elevat, prefer, favor, simplif, enrich, augment, high, increas, enlarg, optimiz, amplif, strength, boost, advanc, progress, develop, refin, height
- Included Keyword: access
 - Keyword Alternatives: passage, entr, admiss, availab, approach, utiliz, ingress, use, enter, opportun, way, direct, connect, gate, path, channel, route, right, avenue, door, corridor, alley, vestibule, lane, conduit
- Included Keyword: other
 - Keyword Alternatives: each, another, one, mutual, reciprocal, interchang, together, joint, collab, combin, symbiot, cooperat, harmony, coexist, cohabit, share, cohes, partner

57. Key Phrase: In recent years, the wild panda population has begun to increase.

- Included Keyword: increas
 - Keyword Alternatives: prop, prolif, more, add, expan, broad, raise, inflate, wide, magni, burgeon, elevat, ris, rose, high, lift, big, large, great, up, improv, better, breed, gen, produc, have, bear, birth, restor, amp, progress, promot, augment, boost, bolst, swell, grow, grew, develop, build, built, exceed, advanc, multi, hik, inflat, surg, accum, heig

- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: population
 - Keyword Alternatives: count, number, amount, commun, denizen, native, dwell, volume, quanit, lot, sum, total, tall, score, mark, estimat, stock, supply, figure, stat, bulk, chunk, load, packs, magnitude, colon, mass, group, cluster, bunch, set, batch, clump, abundan, assoc, pool

58. Key Phrase: Panda population growth indicates that the corridors (between isolated parcels of land) are working.

- Included Keyword: grow
 - Keyword Alternatives: prop, prolif, more, add, expan, broad, raise, inflate, wide, magni, burgeon, elevat, ris, rose, high, lift, big, large, great, up, improv, better, breed, gen, produc, have, bear, birth, restor, amp, progress, promot, augment, boost, bolst, swell, increas, grew, develop, build, built, exceed, advanc, multi, hik, inflat, surg, accum, heig, hazard, injur, harm, detriment, depriv, worse, dec, destr, down, fell, wast, ravag, sabotag, under, cripl, damag, hurt, corrupt, devastat, deteriorat, collaps, pollut, impair, extinct, eradicat, contaminat, disturb, ero, los, less, shrink, shrank, shrunk, weak, corro, end, tarnish, taint, ruin, wreck, degrad, break, fragment, reduc, fall, fell, disrupt, wrong, vandal, defac, attrit, wear, down, attenuat, debilitat, thin, fad, demolish, wipe, annihilat, extinguish, obliterated, dissipat, decimat, squander, exterminat, vanish, reced, kill, regress
- Included Keyword: corridor
 - Keyword Alternatives: habitat, bio, eco, envi, hom, conserv, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, esta, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sect, par, batch, acre, park, proptert, ground, grass, field, pastur, meadow, rang, closur, yard, patch, lawn, green, plan, prair, savanna, spac, reserv, forest, wood, grove, jungle

59. Key Phrase: Corridors (between isolated parcels of land) have also helped the snow leopard.

- Included Keyword: corridor

- Keyword Alternatives: habitat, bio, eco, envi, hom, conserv, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, esta, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sect, par, batch, acre, park, propert, ground, grass, field, pastur, meadow, rang, closur, yard, patch, lawn, green, plan, prair, savanna, spac, reserv, forest, wood, grove, jungle

- Included Keyword: leopard
 - Keyword Alternatives: snow

60. Key Phrase: Snow leopards are an endangered species.

- Included Keyword: endangered
 - Keyword Alternatives: snow, leopards, impact, rare, threat, vulnerabl, environ-ment, critical, exist, extinct, extant, peril, risk, danger, dying, die, decline, jeop-ardy, vanish, brink, close, precarious, population, species, diminish, verge
- Included Keyword: snow
 - Keyword Alternatives: leopard

61. Key Phrase: Snow leopards share the panda’s habitat (with them).

- Included Keyword: share
 - Keyword Alternatives: exist, habit, dwell, together, live, occupy, join, mingle, coher, resid, livi, interact, surviv, populat, roam, simultaneous, locat
- Included Keyword: snow
 - Keyword Alternatives: leopard

62. Key Phrase: Wang characterizes the corridors as rivers, rather than isolated ponds (that are constantly in danger of drying out).

- Included Keyword: corridor
 - Keyword Alternatives: habitat, bio, eco, envi, hom, conserv, nest, burrow, breed, den, lair, resid, terr, hol, liv, turf, site, settl, esta, populat, occup, camp, dwell, exist, bunk, raise, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sect, par, batch, acre, park, propert, ground, grass, field, pastur, meadow, rang, closur, yard, patch, lawn, green, plan, prair, savanna, spac, reserv, forest, wood, grove, jungle

- Included Keyword: river
 - Keyword Alternatives: channel, flow, stream, course, run, branch, way, path, estuary, mov, motion, tide, rout, chance, free, access, enter, open, door, entry, ingress, gate, mouth, drive, thresh, admi, avenue, opportun, lobby, pass, exit, leav, approach, connect, travel, road, com, between, bridg, link, line, work, tying, shortcut, medium, alley, lane, depart, mov, journey, navigat, bilit, voyag, option, potential, alter, priorit, choic, select, prefer, privileg, benefit, act, see, use, using, mobil, isol, pond, alone

63. Key Phrase: The panda's black and white fur is a physical manifestation of yin and yang.

- Included Keyword: fur
 - Keyword Alternatives: coat, tuft, fluff, pelt, hide, jacket, panda, bear
- Included Keyword: yin
 - Keyword Alternatives: yang

64. Key Phrase: Yin and Yang refers to the balance of positive and negative energy in the world.

- Included Keyword: yin
 - Keyword Alternatives: yang
- Included Keyword: positiv
 - Keyword Alternatives: negativ, optimis, hope, zeal, assur, cheer, bright, progress, help, benefi, sun, jovial, pleas, joy, good, friend, amiab, cordial, heart, happ, glee, satisf, up, light, content, jolly, spark, chirp, merry, elat, sweet, agree, genial, affable, gentl, kind, nice, irie, grac, amus, bad, terr, contra, gloom, advers, pess, favor, enthus, nay, den, dis, dual, imp, valid, refuse, reject, oppos, antagon, counter, cynic, detriment, affirm, interest, will, nugatory, repugnant, resist, recusant, refut, evil, wrong, right, corrupt, dark, light, order, chaos, harm

65. Key Phrase: Wang sees the idea of yin and yang (positive and negative energy) as integral to the future success of conservation efforts.

- Included Keyword: yin

- Keyword Alternatives: yang, balanc, equi, harmon, tension, dual, counter, even, parit, symm, stab, level, neutral, control, contra, positiv, negativ, good, corr, order, chaos, null, anarchy, peace, oppos, comp, equan, adjust, deal, parallel, match, stead, tie, pair, set, adapt, regul, acom, align, conform, fit, level, suit, tailor, recon, tun, weigh, bad, calc, remedy, sol, fix, antidot, treat, deci, support
- Included Keyword: conserv
 - Keyword Alternatives: preserv, maintain, sustain, safe, protect, fend, care, guard, shield, sav, caring, uphold, retain, restor, maintenanc, support, nourish, foster, aegis, prolong, tend, shelter, secur, fortif, ward, barr, bulwark, prevent, surviv, continu, endur, rescu, cover, screen, deflect, buffer, refug, umbrella, reinforc, facilitat, assist, effort, habitat, bio, eco, envi, hom, nest, burrow, breed, den, lair, resid, terr, hol, turf, site, settl, establish, populat, occup, camp, dwell, exist, bunk, surround, natur, world, wild, land, domain, haven, quarter, abod, zone, area, plac, spot, point, position, sector, lost, losing, hazard, harm, detriment, dec, destr, wast, ravag, damag, devastat, deteriorat, collaps, pollut, extinct, contaminat, disturb, ero, disrupt, corro, ruin, dissipat, annihilat, squander, exterminat, vanish, reced, kill, degrad, modif, frag, encroach, clear, shrink, declin, reduc, drop, diminish, disappear, life, live, living, rais

66. Key Phrase: Wang stresses the need to find balance between spending money on breeding pandas and addressing underlying human behaviors.

- Included Keyword: balanc
 - Keyword Alternatives: equi, harmon, tension, dual, counter, even, parit, symm, stab, level, neutral, control, contra, positiv, negativ, good, corr, order, chaos, null, anarchy, peace, oppos, comp, equan, adjust, deal, parallel, match, stead, tie, pair, set, adapt, regul, acom, align, conform, fit, level, suit, tailor, recon, tun, weigh, bad, calc, remedy, sol, fix, antidot, treat, deci, support
- Included Keyword: panda
 - Keyword Alternatives: bear, breed, popul, birth, multi, propagat, cultivat, grow, foster, increas, restor, mak, rais, rear, bring, brought, develop, expand, num, increas, prop, prolif, more, add, expan, broad, wide, magni, burgeon, elevat, rose, high, lift, big, large, great, up, improv, better, breed, gen, produc, have, bear, birth, restor, amp, progress, promot, augment, boost, bolst, swell, grow, grew, develop, build, built, exceed, advanc, multi, hik, inflat, surg, accum, heig, rise, rising

- Included Keyword: human
 - Keyword Alternatives: behavior, develop, industr, progress, product, advanc, evol, build, invent, creat, discover, genui, research, auto, grow, curio, greed, spread, tech, people, person, societ, responsib, resource, com, innovat, modern, mechan, impac, influen, effect, conduct, manner, demeanor, deportment, attitude, perform, act, habit, ethic, bearing, soci, practic, deci, inclin, dispo

67. Key Phrase: Wang is not immune to the charms of the giant pandas.

- Included Keyword: Wang
 - Keyword Alternatives: Dr, Dajun
- Included Keyword: panda
 - Keyword Alternatives: bear
- Included Keyword: charm
 - Keyword Alternatives: attract, entic, draw, bring, appeal, lur, interest, hook, pull, grab, intrigu, delight, captur, admir, marvel, captiv, lik, ador, appreciat, fond, in-fatuat, attach, enchant, enjoy, coax, rop, suck, bring, tak, took, mesmer, impress, compel, curious, fascinat, rivet, absorb, grip, engag, enthrall, thrill, entranc, spell, hypnotiz, bewitch, beguil, enchant, ensorcell, dazzl, mov, fetch, fan, lov, friend, cute, warm, pleas, great, awesom, nifty, peach, swell, wonder, satisf, dandy, wel-com, amiabl, approv, respect, sweet, joy, person, heart, tender, yearn, adul, smit, ami, cherish, devot, fervor

68. Key Phrase: Wang is best known for a YouTube video.

- Included Keyword: know
 - Keyword Alternatives: cogni, distinguish, pop, famous, mem, recall, recollect, familiar, aware, ident, discern, prominen, receiv, establish, see, spot, view, remark, perceiv, observ, notice, renown, respect, celebrat, eminent, acclaim, regard, reput, fame, illustrious, popular
- Included Keyword: youtube
 - Keyword Alternatives: online, video, net, media, clip, web

69. Key Phrase: In the YouTube video, Wang plays with a panda cub.

- Included Keyword: youtube
 - Keyword Alternatives: online, video, net, media, clip, web
- Included Keyword: cub
 - Keyword Alternatives: panda, bear, kid, child, bab, juven, whelp, infant, you, kin, offspring

70. Key Phrase: The mother panda (Wang had been tracking) left Wang in charge of her cub (while she went to feed).

- Included Keyword: mother
 - Keyword Alternatives: mom, mum, ma, parent, panda, bear
- Included Keyword: cub
 - Keyword Alternatives: kid, child, bab, juven, whelp, infant, you, kin, offspring

71. Key Phrase: The mother panda (Wang had been tracking) got accustomed to Wang.

- Included Keyword: mother
 - Keyword Alternatives: mom, mum, ma, parent, panda, bear
- Included Keyword: acc
 - Keyword Alternatives: use, normal, close, acquaint, adapt, famil, habit, frien, break, get, know, attach, admir, amia, approv, respect, lik, fond, comfort, complacent, soft, eas, relax, secure, okay, worr, calm, up, down, home, bud, pal, mate, companion, associ, chum, hom, partner, camarad, comrade, confidant, bro, consort, ally, allie
- Included Keyword: Wang
 - Keyword Alternatives: Dr., Dajun, man, guy, person, individual, protagonist, character, activist, scientist, researcher, Wong, doctor, Mr.

72. Key Phrase: The video was captured by one of Wang's colleagues.

- Included Keyword: video
 - Keyword Alternatives: clip, film, movie, tape, record
- Included Keyword: colleag

- Keyword Alternatives: work, assoc, peer, contemp, collab, cohort, mate, partner, assist, aid, support, intern, comrade, consort, affilliat, fellow, team, ally, allie

73. Key Phrase: Babysitting panda cubs isn't the focus of Wang's research.

- Included Keyword: bab
 - Keyword Alternatives: watch, look, car, guid, maintain, manag, direct, foster, handl, mind, nurs, nutur, see, perform, shepherd, shield, sup, cater, do, eye, tab, minister, wing, tend, cover, keep, patrol, bulwark, chaperon, conduct, convoy, polic, sav, screen, shelter, surve, heed, hear, listen, obey, catch, spot, awar, order, behav, lin, notic, cautio, vigil, spec, command, cradl, nourish, pamp, harbor, treat, feed, medic, charg, train, drill, teach, taught, disciplin, rear, atten
- Included Keyword: research
 - Keyword Alternatives: examin, stud, analy, explor, quir, investigat, prob, learn, experiment, inquisit, question, test, survey, observ, inspect, view, assess, brainstorm, check, look, ponder, think, reason, reflect, find, data, result, thought, info, discuss, conclu, proce, trial, session, document, know, work, understand, understood, measur, exercis, activist, conserv, support, ecolog, scien, bio, zoo, expert, infer, evaluat, gaug, parameter, variable, extrapolat, specific, guideline, criteri, framework, inspect, inter, inquir, scrutin, enquir, surve, review, eval, discover, compil, catalog, sampl, project, fact, verif, delv, disquisition, rummag, job, knew, found, environment, preserv

74. Key Phrase: Wang doesn't mind the attention he's received from the video.

- Included Keyword: atten
 - Keyword Alternatives: know, recogni, lack, fam, mem, recall, recollect, familiar, aware, celeb, no, prime, premier, star, whiz, hot, prominen, renown, vip, distinguish, head, top, panjandrum, high, influen, reput, regard, v.i, import, icon, idol, name, public, light, prestig, status, merit, cover, expos, acclaim, eminent, giant, pop, big, out, excellen, one, l, compar, match, domin, rival, stellar, supreme, major, success, ace, prais, commend, sens, recept, perce, respon, aware, conscious, detect, determin, observ, intuit, discern, clout
- Included Keyword: video
 - Keyword Alternatives: online, net, media, clip, web, youtube

75. Key Phrase: Playing with the panda cub was the best time in Wang's life.

- Included Keyword: panda
 - Keyword Alternatives: bear, kid, child, bab, juven, whelp, infant, you, kin, cub, offspring

- Included Keyword: best
 - Keyword Alternatives: most, num, ulti, appeal, attract, crit, lov, fam, cruc, prominen, favor, favour, valu, worth, important, impact, sensation, signif, essen, caught, vit, catch, chief, princip, celebrat, prim, lead, not, prefer, pivot, known, prevail, regnant, rif, great, fine, out, perfect, 10, ten, ace, chief, top, premium, high, cool, optim, para, super, class, comp, amit, match, less, awe, fantas, amaz, grand, monument, stood, stand, equ, distin, dom, fun, happ, gold, joy, exc, blast, ecsta, wond, spectac, stell, key, incred, fab, marvel, tremend, stupend, phenomen, extraordinar, remark, astound, none, breath, lik, stagger, imagin, believ, overwhelm, dynamit, blew, blow, surpass, dream, astonish, magnificen, rad, thrill, good, reward

- Included Keyword: Wang
 - Keyword Alternatives: Dajun, life, Dr., Dajun, life, man, guy, person, individual, protagonist, character, activist, scientist, researcher, Wong, doctor, Mr.

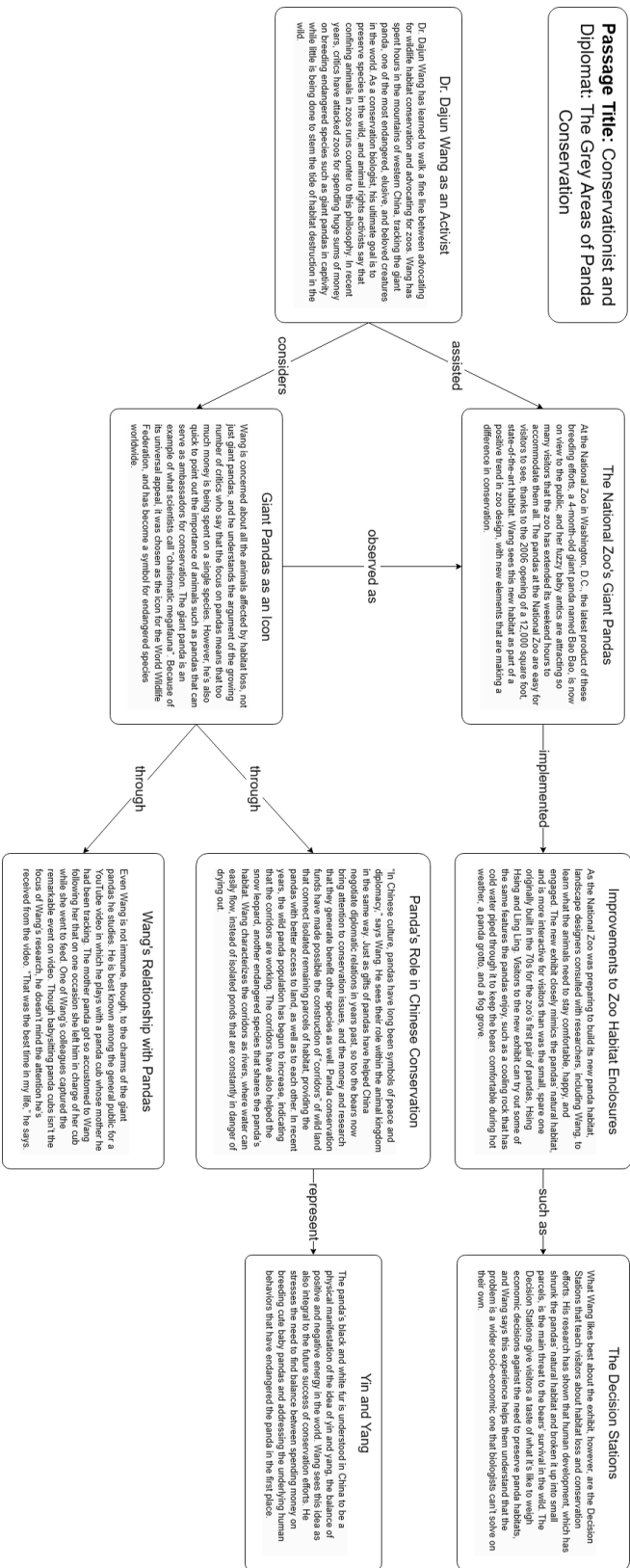


Figure B.53: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Hybrid Map (H) condition

Focus question: What does Dr. Wang advocate for and why?

Passage Title: Conservationist and Diplomat: The Grey Areas of Panda Conservation

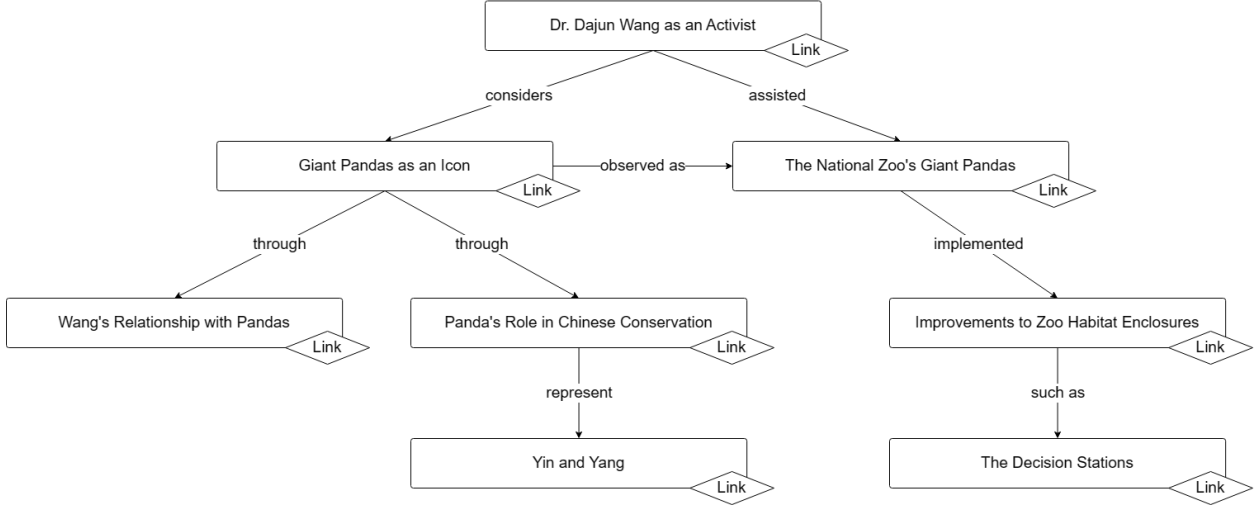


Figure B.54: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - Master-map

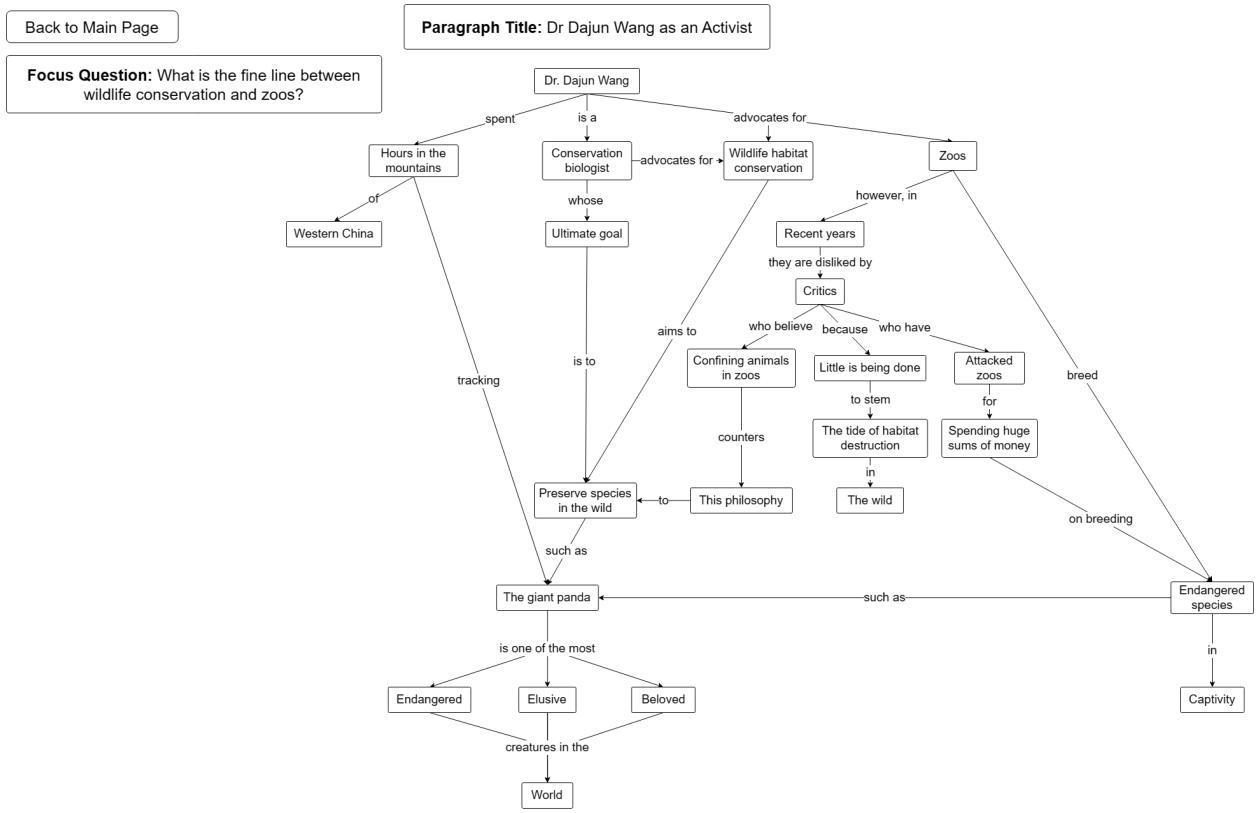


Figure B.55: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map1

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Paragraph Title: The National Zoo's Giant Pandas

Focus Question: Why does Dr. Wang support the new giant panda exhibit?

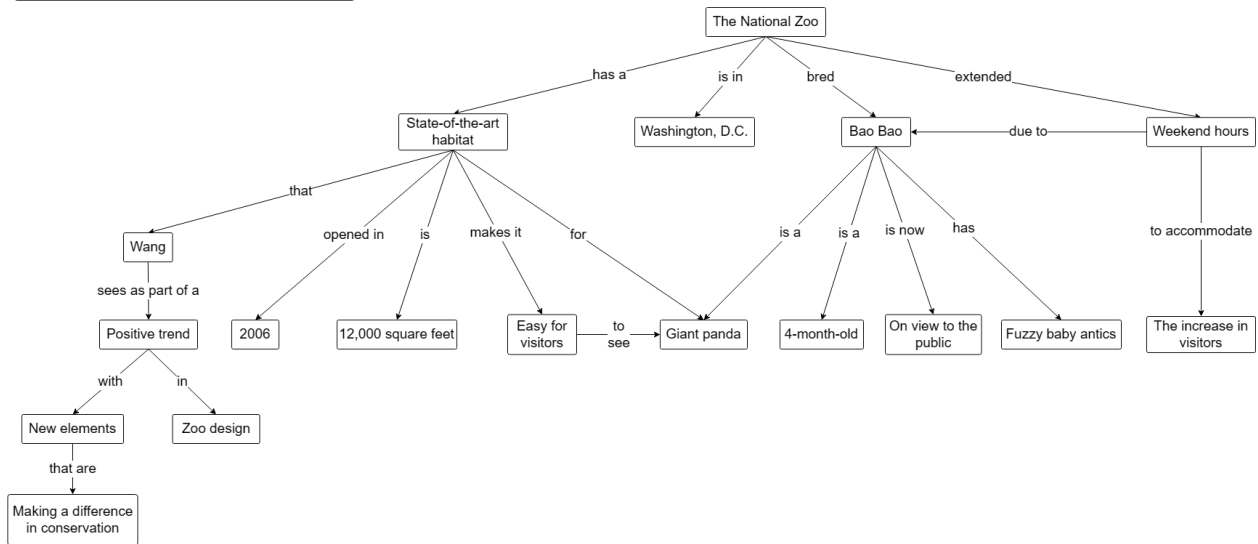


Figure B.56: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map2

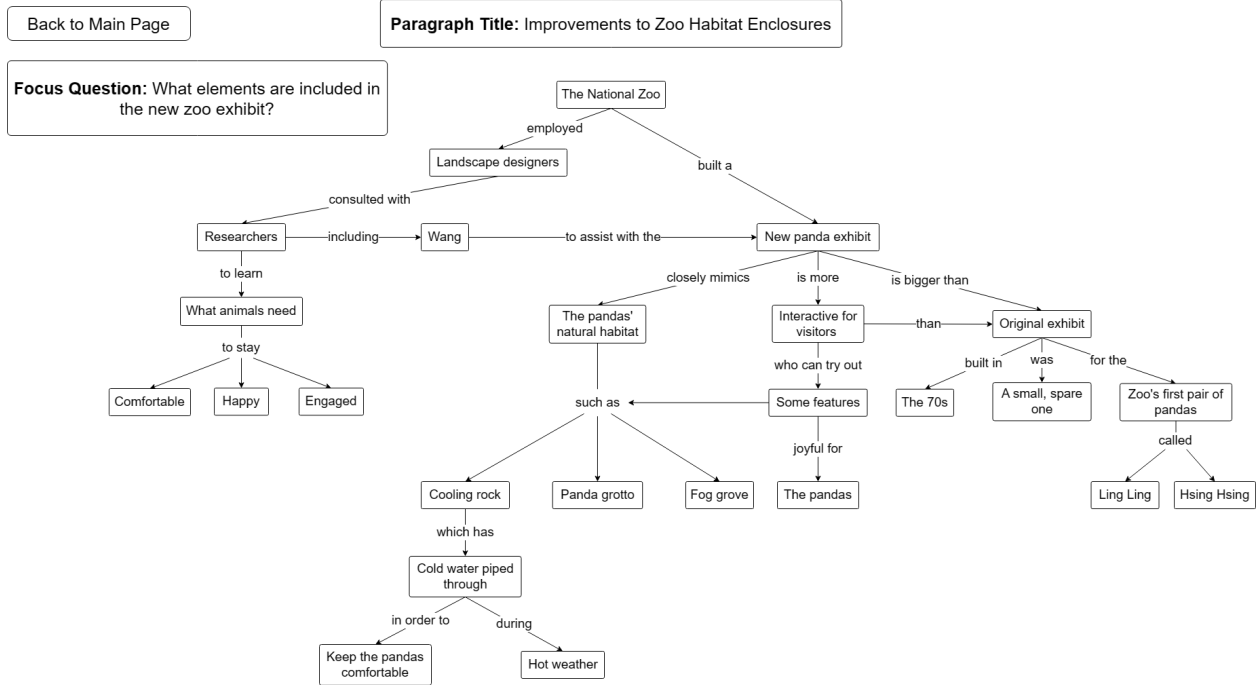


Figure B.57: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map3

Back to Main Page

Paragraph Title: The Decision Stations

Focus Question: What do visitors learn from the decision stations?

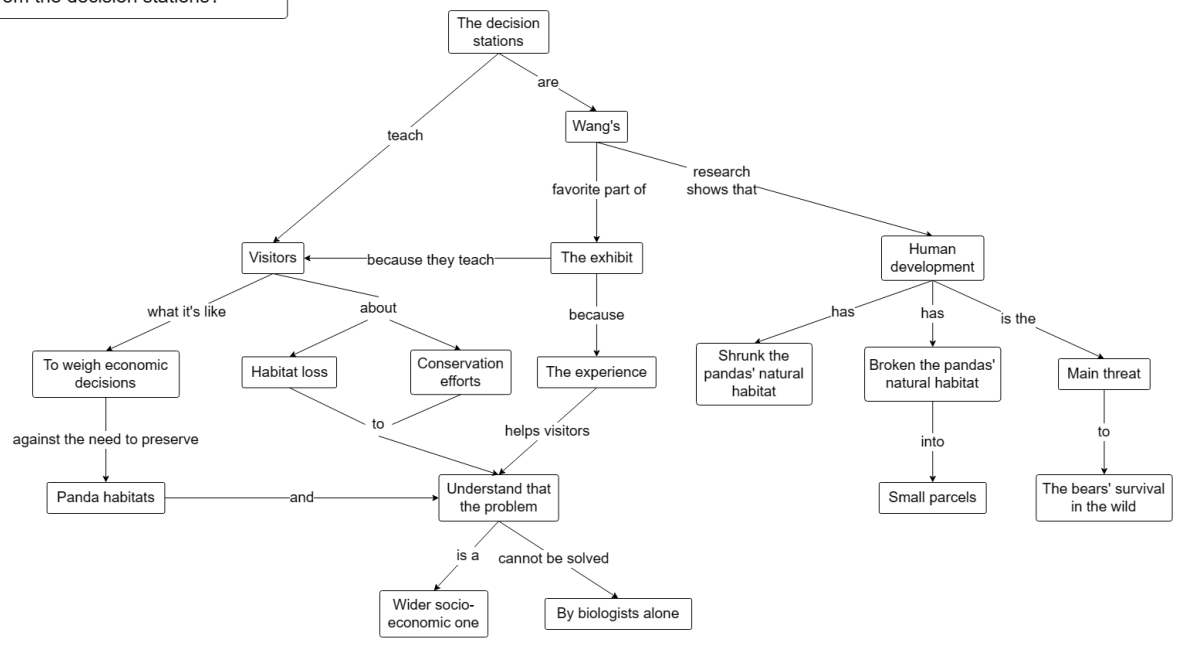


Figure B.58: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map4

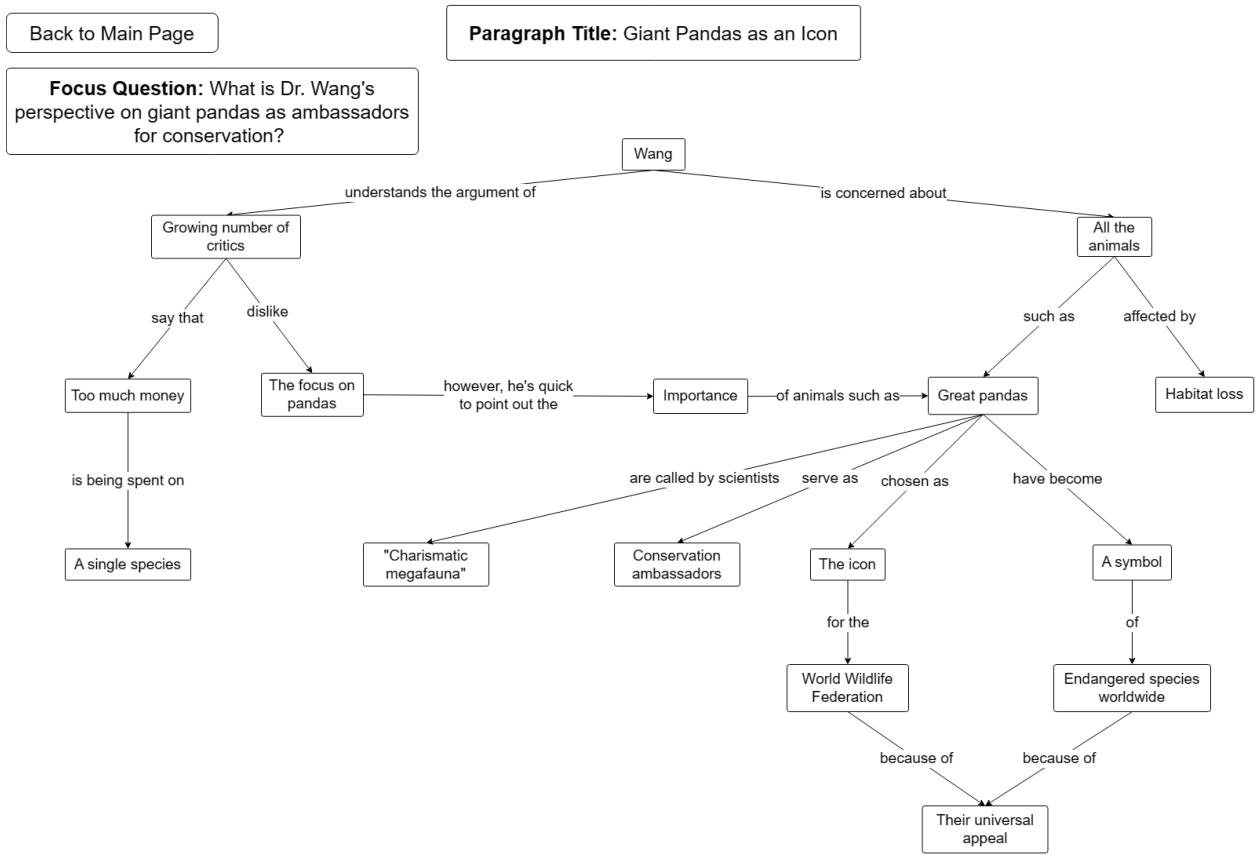


Figure B.59: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map5

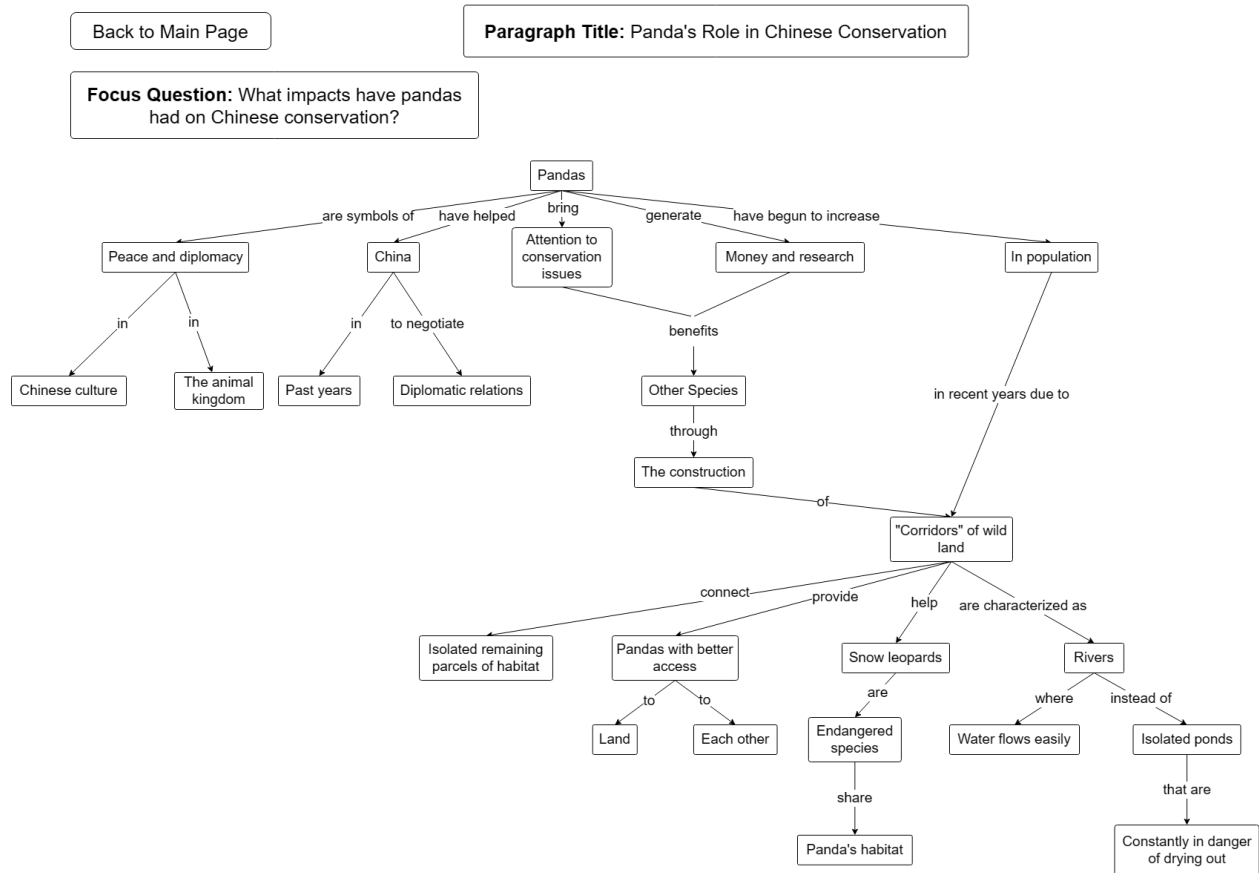


Figure B.60: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map6

Back to Main Page

Paragraph Title: Yin and Yang

Focus Question: Why does Wang see Yin and Yang as relevant to conservation?

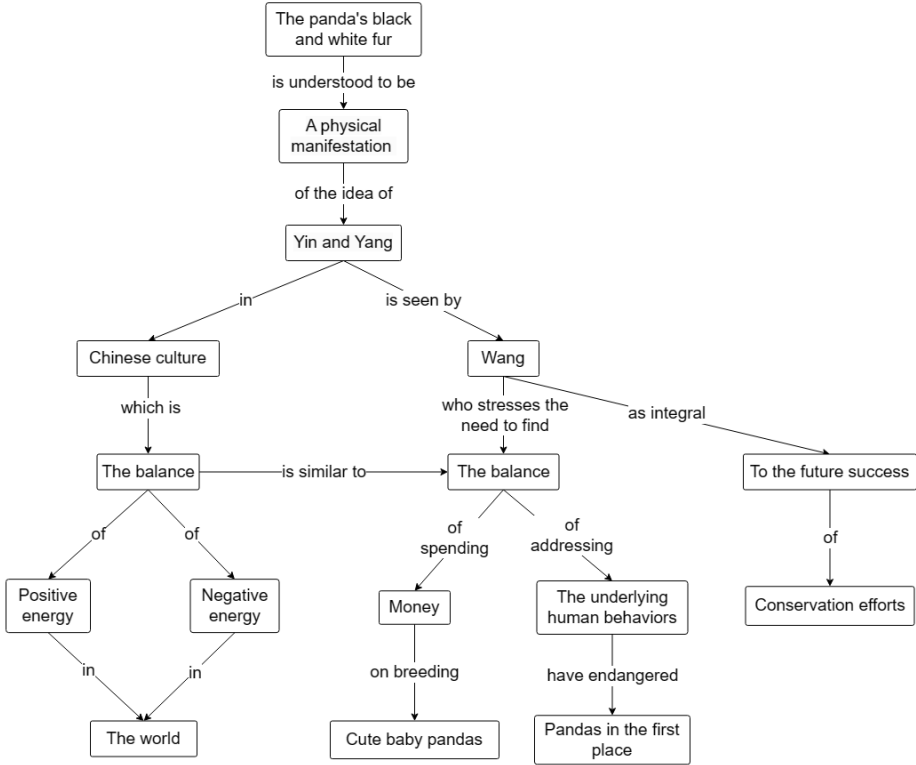


Figure B.61: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map7

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Paragraph Title: Wang's Relationship with Pandas

Focus Question: What is Wang best known for?

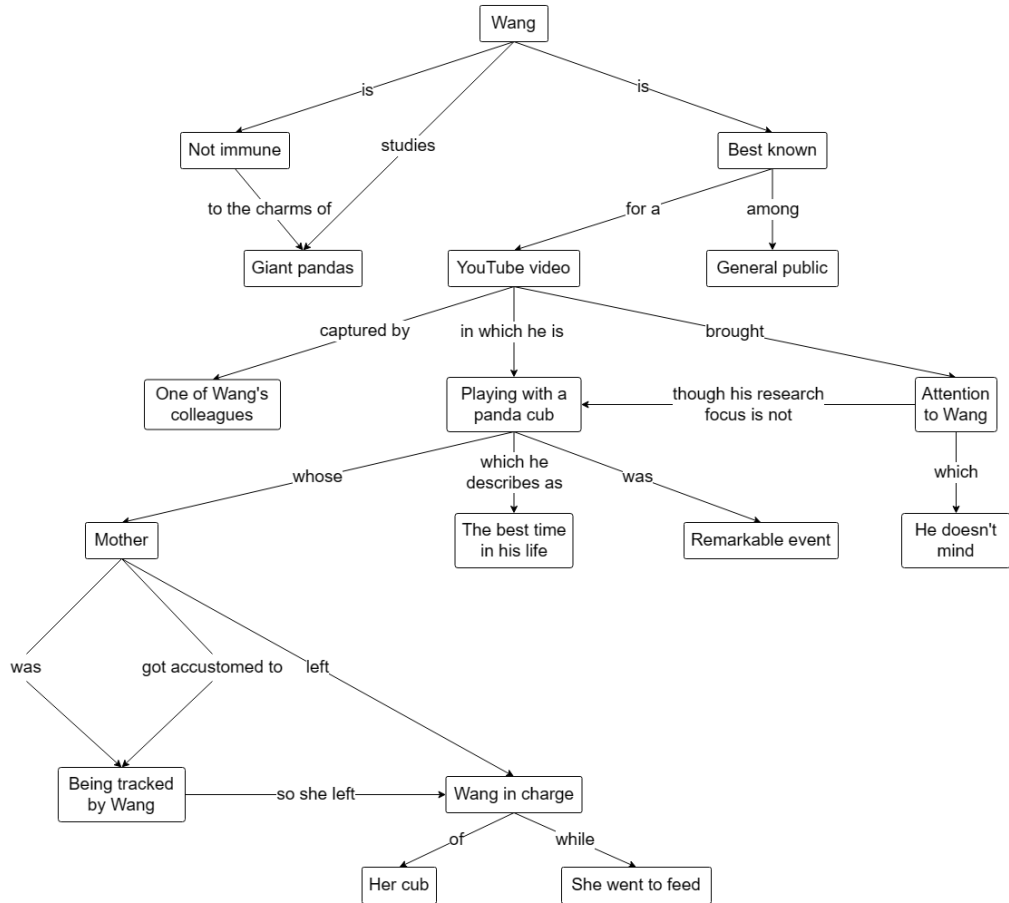


Figure B.62: Passage 7: Conservationist and Diplomat: The Grey Areas of Panda Conservation in Novakian Knowledge Model (K) condition - mini-map8

B.2.8 Passage 8: Managerial Decision Making

The modified multiple-choice questions used for this passage are as follows:

1. Which form of business/economic data does not provide useful information for forecasting?
 - (a) Regression models
 - (b) Correct: Queuing models
 - (c) Inferential statistics
 - (d) Time series models

Question Type: Inferential

2. According to the passage, what is needed for numerical methods to characterize location and variability?
 - (a) Correct: Calculation of sample statistics
 - (b) Measures of association
 - (c) Hypothesis testing
 - (d) Significance level

Question Type: Factual

3. Which of the following is false regarding a test statistic?
 - (a) A test statistic will have an implicit p-value
 - (b) A test statistic depends on the size of the sample
 - (c) Correct: A test statistic is bounded by the critical value
 - (d) A test statistic can be used in a test with a significance level

Question Type: Inferential

4. Which is true regarding a linear relationship?
 - (a) It could be a simple linear regression model
 - (b) It can be seen in qualitative variables only
 - (c) Correct: It could be a multiple linear regression model
 - (d) It can be seen in quantitative variables only

Question Type: Factual

5. When are nonparametric techniques used in the normal distribution?
- (a) Correct: When populations do not follow the normal distribution
 - (b) When populations follow the normal distribution
 - (c) When estimates can be obtained from a sample
 - (d) When estimates cannot be obtained from a sample

Question Type: Factual

6. What is true of an error term?
- (a) It can be evaluated through diagnostic tests
 - (b) It has a systematic component of the regression equation
 - (c) It can be used in forecasting the regression equation
 - (d) Correct: It is an unsystematic component of the regression equation

Question Type: Factual

7. What is the relationship between diagnostic tests and an error term?
- (a) A regression equation is always a nonlinear equation
 - (b) Correct: Diagnostic tests check for the randomness of an error term
 - (c) Diagnostic tests provide estimates of an error term
 - (d) A regression equation may consist of dummy variables

Question Type: Factual

8. What does differencing do?
- (a) It is a method for estimation of a stationary process
 - (b) It defines a estimation model
 - (c) Correct: It uses non-stationary processes to generate a stationary process
 - (d) It provides forecasts that generate combined forecasts

Question Type: Factual

9. How is the Breusch-Pagan test different from the Durbin-Watson test?

- (a) The Breusch-Pagan test checks for autocorrelation and the Durbin-Watson test checks for heteroscedasticity
- (b) Correct: The Breusch-Pagan test checks for heteroscedasticity and the Durbin-Watson test checks for autocorrelation
- (c) The Breusch-Pagan test checks for statistical significance and the Durbin-Watson test checks for misspecification
- (d) The Breusch-Pagan test checks for misspecification and the Durbin-Watson test checks for statistical significance

Question Type: Inferential

The following shows the reading comprehension passage in linear format converted from concept map format. This passage was obtained from (available at [IHMC website](#)). This passage in Hyper map (H) format is shown in Figure B.63. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent Novakian concept maps (K) are in Figure B.64, Figure B.65, Figure B.66, Figure B.67, Figure B.68, Figure B.69, Figure B.70, Figure B.71, Figure B.72, and Figure B.73. The interactive version that the participants studied through is available [here on Draw.io](#).

Managerial decision making is a systematic process. A systematic process helps to solve business/economics problems. These problems can be analyzed with mathematical representations that lead ultimately to a course of action. In order to solve these business/economics problems, business/economic data is required, which can be represented in the form of time series data, cross sectional data, or panel data. These types of data are first summarized using descriptive statistics. They are then analyzed using results from inferential statistics and are utilized in the estimation of parameters which can be carried out using regression models and time series models. All of these models provide information useful for forecasting and allow decision makers to take a course of action. A systematic process also requires the definition of variables and factors, which are used to define a model and are combined in mathematical representations, which involve quantitative analysis. Quantitative analysis can then be carried out under conditions of uncertainty and certainty. Example models of uncertainty could be statistical models, simulation, inventory, and queuing models while examples of models of certainty could be linear programming and inventory models.

Descriptive statistics involves summarizing data, which can be quantitative or qualitative. Both quantitative and qualitative data can be summarized using graphical methods and numerical methods. Examples of graphical methods include histograms or

scatter diagrams. Scatter diagrams provide an approximation of the correlation. Numerical methods involve the calculation of sample statistics that characterize the location and the variability. Numerical methods also provide measures of association such as covariance and correlation.

Inferential statistics are based on the notion of probability. Probability measures the likelihood of random variables. Random variables can follow the normal distribution, the binomial distribution, and other distributions. These variables are included in probability distributions, which are characterized by their expected value and their variance. Inferential statistics provide parametric and non-parametric techniques. Parametric techniques are used when populations follow the normal distribution and non-parametric techniques are used when populations do NOT follow the normal distribution. The normal distribution can approximate the binomial distribution and the sample distribution of the mean of x , which converges to a normal distribution thanks to a result from a central limit theorem. Inferential statistics allow the analyst to study a population, which contains parameters that characterize probability distributions. Those parameters are estimated through sample statistics. Sample statistics are calculated to make inferences which are carried out through hypothesis testing. Inferential statistics uses a sample that provides estimates of parameters. A sample has information to calculate sample statistics, and it also provides information to obtain estimates. Estimates of parameters allow the analyst to make inferences. Estimates from many samples generate a sampling distribution such as the sample distribution of the mean of x . Examples of estimates include point estimates and interval estimates which are computed using confidence intervals. A sample generates results containing errors. Errors can be random or systematic errors. Systematic errors cause bias.

Hypothesis testing is a statistical procedure to corroborate a conjecture using a test statistic. Hypothesis tests need a null hypothesis and an alternative hypothesis to allow for the researcher to reject the rejection region that is bounded by the critical value. Test statistics are used in order to perform a test with a given significance level defined by the rejection region and the critical value. While test statistics depend on its sample size, once they are carried out, they will have an implicit p-value that is related to type I and type II errors to define statistical significance. These test statistics range from Student t-test like the one-side tests and two-side tests used to test the population mean, the Chi-squared test, and the F-test.

Regression analysis studies the relationships among quantitative and qualitative variables. These two variables can either have a linear or a nonlinear relationship. A

linear relationship could be a simple linear regression model or a multiple linear regression model. A nonlinear relationship could be a simple linear regression model or a multiple linear regression model.

A simple linear regression model summarizes the relationship between two variables and allows for the estimation of parameters. Variables are combined in and unknown parameters are estimated through a regression equation. A regression equation has a systematic component and an unsystematic component (or error term). Regression equations are evaluated through diagnostic tests and can be used in forecasting and in the analysis of parameters.

The multiple regression model is represented by a regression equation. The multiple regression model summarizes the relationship between more than two variables and includes parameters. Variables are combined in and unknown parameters are estimated through a regression equation. It has a systematic component and an unsystematic component (or error term). A diagnostic test checks for randomness in unsystematic components and evaluates a regression equation. Regression equations can be used in forecasting and in the analysis of parameters. The analysis of parameters depends on functional forms, including the double-log functional form. The analysis of parameters includes slope coefficients and an elasticity coefficient. Slope coefficients can be an elasticity coefficient which is provided by the double-log functional form. Regression equations can contain dummy variables and can be a linear or a non-linear equation. Linear equations are consistent with different functional forms while non-linear equations can have a variety of functional forms.

Diagnostic tests check for statistical significance, randomness of error term, and misspecification. Statistical significances are checked with the t-test and the F-test which allows to verify linear restrictions. Randomness of error can be violated due to autocorrelation which is checked with the Durbin-Watson test and the h-test. It can also be violated due to heteroscedasticity which is checked with the Goldfield-Quandt test and the Breusch-Pagan test. Randomness of error term can be checked with Runs test or Chi-square test. Misspecification can be detected through the lack of randomness of error. This can be caused by irrelevant variables that are not significant which can be a symptom of multicollinearity. Misspecification can also be caused by an incorrect functional form.

Time series models use time series data that can be characterized by their components. Examples of time series models can be in smoothing methods, ARIMA, and others. In smoothing methods such as moving averages, simple exponential smooth-

ing, and Winter's exponential smoothing, they all provide forecasts that can generate combine forecasts. They can also be evaluated based on turning points and they must be checked through an evaluation process. ARIMA uses the autocorrelation function and the partial autocorrelation function which is a basic tool for identification. ARIMA is a method for the estimation of stationary processes that can be obtained through differencing. Identification involves finding autoregressive terms, moving average terms, and involves finding the degree of differencing. Autoregression terms and moving average terms help to define a primary model for an estimation which is generated at the end of forecasts and is followed by diagnostic checking procedures. Differencing on the other hand generates a stationary process from non-stationary processes which include the random-walk model and for estimation generated at the end of forecasts followed by diagnostic checking procedures.

B.2.8.1 Key Phrases and their Boolean Expressions for Managerial Decision Making

1. Key Phrase: Managerial decision making is a systematic process.

- Included Keyword: system
 - Keyword Alternatives: method, structur, organiz, standard, formal, arrang, proce, operation, cours, approach, technique, way
- Included Keyword: decision
 - Keyword Alternatives: choice, chos, opt, select, ruling, resol, order, conclu, settl, judg

2. Key Phrase: A systematic process helps to solve business/economic problems.

- Included Keyword: system
 - Keyword Alternatives: method, structur, organiz, standard, formal, arrang, proce, operation, cours, approach, technique, way
- Included Keyword: problem
 - Keyword Alternatives: issue, complicat, dilemma, concern, pitfall, nuisance, mishap, business, econom, challeng, conundrum, setback, mess, drawback

3. Key Phrase: Business/economic problems are analyzed with mathematical representations.

- Included Keyword: problem

- Keyword Alternatives: issue, complicat, dilemma, obstacle, hurdle, troubl, challeng, difficult, conundrum, concern, pitfall, nuisance, mishap, setback, mess, drawback, business, econ
 - Included Keyword: math
 - Keyword Alternatives: numeric, arithmetic, formula, equation, expression, algebra, comput, calc, quantit
4. Key Phrase: Mathematical representations (models) lead ultimately to a course of action.
- Included Keyword: math
 - Keyword Alternatives: numeric, arithmetic, calculat, represent, model, figure, framework, quanti, eval, assess, exam, investig, algebra, comput, formula, equat, express
 - Included Keyword: cours
 - Keyword Alternatives: action, plan, step, trajector, proce, approach, advance, strateg, system, avenue, rout, track, direct, channel, way
5. Key Phrase: Business/economic problems require business/economic data.
- Included Keyword: problem
 - Keyword Alternatives: issue, complicat, dilemma, obstacle, hurdle, troubl, challeng, difficult, conundrum, concern, pitfall, nuisance, mishap, setback, mess, drawback, econ, business
 - Included Keyword: data
 - Keyword Alternatives: info, evidence, input, record, figur
6. Key Phrase: Business/economic data can be time series data.
- Included Keyword: problem
 - Keyword Alternatives: issue, complicat, dilemma, obstacle, hurdle, troubl, challeng, difficult, conundrum, concern, pitfall, nuisance, mishap, setback, mess, drawback, econ, business
 - Included Keyword: data

- Keyword Alternatives: info, evidence, input, record, figur

7. Key Phrase: Business/economic data can be cross sectional data.

- Included Keyword: data
 - Keyword Alternatives: info, evidence, input, record, figur
- Included Keyword: cross
 - Keyword Alternatives:
- Included Keyword: sect
 - Keyword Alternatives:

8. Key Phrase: Business/economic data can be panel data.

- Included Keyword: data
 - Keyword Alternatives: info, evidence, input, record, figur
- Included Keyword: panel
 - Keyword Alternatives:

9. Key Phrase: Business/economic data can be summarized using descriptive statistics.

- Included Keyword: data
 - Keyword Alternatives: info, evidence, input, record, figur
- Included Keyword: summar
 - Keyword Alternatives: expla, compre, descri, outlin, condens, encap

10. Key Phrase: Business/economic data are analyzed using results from inferential statistics.

- Included Keyword: data
 - Keyword Alternatives: info, evidence, input, record, figur
- Included Keyword: stat
 - Keyword Alternatives:

11. Key Phrase: Business/economic data are utilized in the estimation of parameters.

- Included Keyword: data
 - Keyword Alternatives: info, evidence, input, record, figur
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, aniticpat, infer, expect, outlook, project, approx, evaluat, deduc, calc, assess, gaug, measur, parameter, variable, extrapolat, specific, measure, guideline, criteri, framework, speculat, conjecture, guess, determin, examin

12. Key Phrase: Estimation of parameters can be carried out using regression models.

- Included Keyword: estimat
 - Keyword Alternatives: aniticpat, outlook, project, approx, evaluat, deduc, calc, measur, parameter, variable, extrapolat, specific, criteri, framework, forecast, predict, infer, expect, assess, gaug, measure, guideline, speculat, conjecture, guess, determin, examin
- Included Keyword: regress
 - Keyword Alternatives:

13. Key Phrase: Estimation of parameters can be carried out using time series models.

- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, aniticpat, infer, expect, outlook, project, approx, evaluat, deduc, calc, assess, gaug, measur, parameter, variable, extrapolat, specific, measure, guideline, criteri, framework, speculat, conjecture, guess, determin, examin
- Included Keyword: time
 - Keyword Alternatives:
- Included Keyword: ser
 - Keyword Alternatives:

14. Key Phrase: Regression models provide information useful for forecasting.

- Included Keyword: regress

- Keyword Alternatives: model, algebra, calc, math
 - Included Keyword: forecast
 - Keyword Alternatives: predict, estimat, anticipat, infer, expect, outlook, project, foresee, guess, determin, examin
15. Key Phrase: Time series models provide information useful for forecasting.
- Included Keyword: time
 - Keyword Alternatives:
 - Included Keyword: series
 - Keyword Alternatives:
 - Included Keyword: forecast
 - Keyword Alternatives: predict, estimat, anticipat, infer, expect, outlook, project, foresee, guess, determin, examin
16. Key Phrase: Business/economic problems can be analyzed through a model.
- Included Keyword: problem
 - Keyword Alternatives: issue, complicat, dilemma, obstacle, hurdle, troubl, challeng, difficult, conundrum, concern, pitfall, nuisance, mishap, setback, mess, drawback, econ, business
 - Included Keyword: model
 - Keyword Alternatives: present, figure, framework, pict, graph
17. Key Phrase: A systematic process requires the definition of variables and factors.
- Included Keyword: system
 - Keyword Alternatives: method, structur, organiz, standard, formal, arrang, proce, operation, cours, approach, technique, way
 - Included Keyword: defin
 - Keyword Alternatives: interpret, clarif, identif, expla, represent, outlin, setting, list, variable, factor, illust, rational, indicat

18. Key Phrase: Variables and factors help to define a model.

- Included Keyword: variable
 - Keyword Alternatives: factor, element, aspect, compon, featur, attribut, constituent
- Included Keyword: model
 - Keyword Alternatives: defin, present, figure, framework, interpret, clarif, identif, expla, indicat, outlin, represent

19. Key Phrase: Variables and factors are combined in mathematical representations.

- Included Keyword: variable
 - Keyword Alternatives: factor, element, aspect, compon, featur, attribut, constituent
- Included Keyword: math
 - Keyword Alternatives: represent, model, figure, framework, comput, formula, arithmetic, algebra, equat, express, invest, math, eval, assess, exam, numeric, quanti, analy, study, research, calc

20. Key Phrase: Variables and factors are used in quantitative analysis.

- Included Keyword: variable
 - Keyword Alternatives: factor, element, aspect, compon, featur, attribut, constituent
- Included Keyword: quanti
 - Keyword Alternatives: represent, model, figure, framework, comput, formula, algebra, equat, express, invest, math, eval, assess, exam, numeric, analy, study, re-search, calc, arithmetic

21. Key Phrase: A model is quantitatively described using mathematical representations.

- Included Keyword: model
 - Keyword Alternatives: figure, frame, represent
- Included Keyword: math
 - Keyword Alternatives: numeric, arithmetic, quanti, eval, assess, exam, investig, algebra, comput, formul, express, equat, calc

22. Key Phrase: Mathematical representations involve quantitative analysis.

- Included Keyword: math
 - Keyword Alternatives: represent, model, figure, framework, quanti, eval, assess, exam, comput, formula, numeric, arithmetic, algebra, equat, express, invest, calc
- Included Keyword: quanti
 - Keyword Alternatives: research, analy, study, num

23. Key Phrase: Quantitative analysis could be carried out under conditions of uncertainty.

- Included Keyword: math
 - Keyword Alternatives: numeric, arithmetic, calculat, eval, assess, exam, investig, quanti, analy
- Included Keyword: uncertain
 - Keyword Alternatives: condition, confiden, uncertit, case, stat, defini, unsur, situation, cirumstan, context, background, setting

24. Key Phrase: Quantitative analysis could be carried out under conditions of certainty.

- Included Keyword: math
 - Keyword Alternatives: calculat, quanti, analy, eval, assess, exam, numeric, arithmetic, invest
- Included Keyword: certain
 - Keyword Alternatives: condition, confiden, certit, stat, defini, sur, case, situation, cirumstan, context, background, setting

25. Key Phrase: Mathematical representations can model uncertainty e.g. statistical models.

- Included Keyword: math
 - Keyword Alternatives: represent, model, figure, framework, quanti, eval, assess, exam, investig, algebra, comput, formula, equat, numeric, arithmetic, calc
- Included Keyword: uncertain
 - Keyword Alternatives: present, figure, framework, stat, model, ambiguity, doubt, indecision, confusion, unpredictab, fluctuat, tentative

- Included Keyword: stat
 - Keyword Alternatives:

26. Key Phrase: Mathematical representations can model uncertainty e.g. simulation.

- Included Keyword: math
 - Keyword Alternatives: represent, model, figure, framework, quanti, eval, assess, exam, algebra, comput, formula, equat, numeric, arithmetic, calc, invest
- Included Keyword: uncertain
 - Keyword Alternatives: present, figure, framework, simulat, replic, imitat, model, ambigu, doubt, deci, confus, fluctuat, tentative, predict

27. Key Phrase: Mathematical representations can model uncertainty e.g. inventory models.

- Included Keyword: math
 - Keyword Alternatives: represent, model, figure, framework, quanti, eval, assess, exam, investig, algebra, comput, formula, equat, numeric, arithmetic, calc
- Included Keyword: uncertain
 - Keyword Alternatives: invent, model, present, figure, framework, ambigu, doubt, deci, confus, fluctuat, tentative, predict

28. Key Phrase: Mathematical representations can model uncertainty e.g. queuing models.

- Included Keyword: uncertain
 - Keyword Alternatives: queu, model, present, figure, framework, ambigu, doubt, deci, confus, fluctuat, tentative, predict
- Included Keyword: math
 - Keyword Alternatives: numeric, arithmetic, calc, represent, model, figure, framework, quanti, eval, assess, exam, investig, algebra, comput, formula, equat, express

29. Key Phrase: Mathematical representations can model certainty e.g. linear programming.

- Included Keyword: math
 - Keyword Alternatives: represent, model, figure, framework, quanti, eval, assess, exam, algebra, comput, formula, equat, numeric, arithmetic, calc, invest

- Included Keyword: certain
 - Keyword Alternatives: present, figure, framework, stat, model, resolut, reliabil, line, program, confiden, defini, absolut, deci

30. Key Phrase: Mathematical representations can model certainty e.g. inventory models.

- Included Keyword: math
 - Keyword Alternatives: represent, model, figure, framework, quanti, eval, assess, exam, algebra, comput, formula, equat, numeric, arithmetic, calc, invest
- Included Keyword: certain
 - Keyword Alternatives: present, figure, framework, stat, model, reliabil, invent, confiden, defini, absolut, deci, resolut

31. Key Phrase: Descriptive statistics involves summarizing data.

- Included Keyword: descriptive
 - Keyword Alternatives:
- Included Keyword: stat
 - Keyword Alternatives: data

32. Key Phrase: Data can be quantitative data.

- Included Keyword: data
 - Keyword Alternatives: info
- Included Keyword: quanti
 - Keyword Alternatives: math, num, represent, model, figure, framework, comput, formula, arithmetic, algebra, equat, express, invest, eval, assess, exam, analy, study, research, calc

33. Key Phrase: Data can be qualitative data.

- Included Keyword: quali
 - Keyword Alternatives: character, categor, observ, descri, subject, empiric, num, math, aspect, summar, theme, thematic

- Included Keyword: data
 - Keyword Alternatives: info

34. Key Phrase: Quantitative data can be summarized using graphical methods.

- Included Keyword: graph
 - Keyword Alternatives: model, present, figure, plot, diagram, pict, chart
- Included Keyword: quanti
 - Keyword Alternatives: math, num, represent, model, figure, framework, comput, formula, arithmetic, algebra, equat, express, invest, eval, assess, exam, analy, study, research, calc

35. Key Phrase: Quantitative data can be summarized using numerical methods.

- Included Keyword: num
 - Keyword Alternatives: calculat, math, stat, descri, alg, comput, quanti, empiric, arithmetic
- Included Keyword: quanti
 - Keyword Alternatives: math, num, represent, model, figure, framework, comput, formula, arithmetic, algebra, equat, express, invest, eval, assess, exam, analy, study, research, calc

36. Key Phrase: Qualitative data can be summarized using graphical methods.

- Included Keyword: graph
 - Keyword Alternatives: model, present, figure, diagram, pict, chart, plot
- Included Keyword: quali
 - Keyword Alternatives: character, categor, observ, descri, subject, empiric, num, math, aspect, summar, theme, thematic

37. Key Phrase: Qualitative data can be summarized using numerical methods.

- Included Keyword: num
 - Keyword Alternatives: quanti, empiric, calculat, math, stat, descri, alg, comput, arithmetic

- Included Keyword: quali
 - Keyword Alternatives: character, categor, observ, descri, subject, empiric, num, math, aspect, summar, theme, thematic
38. Key Phrase: Graphical methods e.g. a histogram.
- Included Keyword: histogram
 - Keyword Alternatives:
39. Key Phrase: Graphical methods e.g. a scatter diagram.
- Included Keyword: scatter
 - Keyword Alternatives:
40. Key Phrase: A scatter diagram provides an approximation of correlation.
- Included Keyword: scatter
 - Keyword Alternatives:
 - Included Keyword: associat
 - Keyword Alternatives: corr, compar, relat, link, similar, inter, concur, depend, connect
41. Key Phrase: Numerical methods involves the calculation of sample statistics.
- Included Keyword: num
 - Keyword Alternatives: quanti, empiric, calculat, math, stat, descri, alg, comput, arithmetic
 - Included Keyword: sampl
 - Keyword Alternatives: stat, data, subset
42. Key Phrase: Sample statistics characterize the location.
- Included Keyword: sampl
 - Keyword Alternatives: stat, data, subset
 - Included Keyword: region

- Keyword Alternatives: spac, area, terr, section, site, part, position, spot, locat, plac

43. Key Phrase: Sample statistics characterize the variability.

- Included Keyword: sampl
 - Keyword Alternatives: stat, data, subset
- Included Keyword: varia
 - Keyword Alternatives: spread, deviat, diverg, differ, disper, distrib, fluctuat, scatter

44. Key Phrase: Numerical methods provide measures of association.

- Included Keyword: num
 - Keyword Alternatives: quanti, empiric, calculat, math, stat, descri, alg, comput, arithmetic
- Included Keyword: associat
 - Keyword Alternatives: corr, compar, link, similar, inter, concur, depend, connect, relat

45. Key Phrase: Measures of association include the covariance.

- Included Keyword: associat
 - Keyword Alternatives: correlat, compar, link, similar, inter, concur, depend, connect, relat
- Included Keyword: covari
 - Keyword Alternatives: joint

46. Key Phrase: Measures of association include the correlation.

- Included Keyword: associat
 - Keyword Alternatives: correlat, compar, relation, link, similar, inter, concur, depend, connect
- Included Keyword: corr
 - Keyword Alternatives:

47. Key Phrase: Inferential statistics are based on the notion of probability.

- Included Keyword: probabilit
 - Keyword Alternatives: likelihood, chance, odds
- Included Keyword: inferential
 - Keyword Alternatives:
- Included Keyword: stat
 - Keyword Alternatives: data

48. Key Phrase: Probability measures the likelihood of random variables.

- Included Keyword: probabilit
 - Keyword Alternatives: chance, odds
- Included Keyword: random
 - Keyword Alternatives: stochastic, chance
- Included Keyword: variable
 - Keyword Alternatives: value, element, parameter, measure

49. Key Phrase: Random variables can follow the normal distribution.

- Included Keyword: random
 - Keyword Alternatives: chance, stochastic
- Included Keyword: variable
 - Keyword Alternatives: element, value
- Included Keyword: normal
 - Keyword Alternatives: bell
- Included Keyword: distribut
 - Keyword Alternatives: curve

50. Key Phrase: Random variables can follow the binomial distribution.

- Included Keyword: random
 - Keyword Alternatives: chance, stochastic
- Included Keyword: variable
 - Keyword Alternatives: element
- Included Keyword: binomial
 - Keyword Alternatives: distribution, model

51. Key Phrase: Random variables can follow other distributions.

- Included Keyword: random
 - Keyword Alternatives: chance
- Included Keyword: variable
 - Keyword Alternatives: element, value
- Included Keyword: distribution
 - Keyword Alternatives: curve

52. Key Phrase: Random variables are included in probability distributions.

- Included Keyword: random
 - Keyword Alternatives: chance, stochastic
- Included Keyword: variable
 - Keyword Alternatives: value, element
- Included Keyword: probability
 - Keyword Alternatives: chance, odds, likelihood
- Included Keyword: distribution
 - Keyword Alternatives: curve

53. Key Phrase: Probability distributions are characterized by their expected value.

- Included Keyword: probability

- Keyword Alternatives: chance, odds, likelihood
- Included Keyword: distribut
 - Keyword Alternatives: curve
- Included Keyword: expected
 - Keyword Alternatives: anticipate, forecast, predict, intend
- Included Keyword: value
 - Keyword Alternatives: number, quantity, magnitude

54. Key Phrase: Probability distributions are characterized by their variance.

- Included Keyword: probability
 - Keyword Alternatives: chance, odds, likelihood
- Included Keyword: distribution
 - Keyword Alternatives: curve
- Included Keyword: varia
 - Keyword Alternatives: diverge, fluctuat, oscillat, despers, predictabl

55. Key Phrase: Inferential statistics provides parametric techniques.

- Included Keyword: inferen
 - Keyword Alternatives:
- Included Keyword: stat
 - Keyword Alternatives: data
- Included Keyword: parametric
 - Keyword Alternatives: system, method, structure, formula, standard, process, operation, course, approach, technique, way

56. Key Phrase: Inferential statistics provides non-parametric techniques.

- Included Keyword: nonparametric

- Keyword Alternatives: non-parametric, non, parametric, system, method, structure, formula, standard, process, operation, course, approach, technique, way
 - Included Keyword: inferen
 - Keyword Alternatives:
 - Included Keyword: stat
 - Keyword Alternatives: data
57. Key Phrase: Parametric techniques are used when populations follow the normal distribution.
- Included Keyword: parametric
 - Keyword Alternatives: specific, measure, guideline, criteri, framework
 - Included Keyword: normal
 - Keyword Alternatives: bell
 - Included Keyword: distribut
 - Keyword Alternatives: curve
58. Key Phrase: Non-parametric are used when populations do NOT follow the normal distribution.
- Included Keyword: nonparametric
 - Keyword Alternatives: non-parametric, non, parametric
 - Included Keyword: normal
 - Keyword Alternatives: bell
 - Included Keyword: distribut
 - Keyword Alternatives: curve
 - Included Keyword: not
 - Keyword Alternatives:
59. Key Phrase: The normal distribution can approximate the binomial distribution.

- Included Keyword: binomial
 - Keyword Alternatives:
- Included Keyword: distribution
 - Keyword Alternatives: curve
- Included Keyword: normal
 - Keyword Alternatives: bell

60. Key Phrase: The normal distribution can approximate the sample distribution of the mean of \bar{x} .

- Included Keyword: normal
 - Keyword Alternatives: bell
- Included Keyword: distribution
 - Keyword Alternatives: curve
- Included Keyword: sampl
 - Keyword Alternatives: fragment, part, represent, stat, data, subset
- Included Keyword: mean
 - Keyword Alternatives: average

61. Key Phrase: A sampling distribution of the mean of \bar{x} converges to a normal distribution thanks to a result from the central limit theorem.

- Included Keyword: sampl
 - Keyword Alternatives: fragment, part, represent, stat, data, subset
- Included Keyword: distribution
 - Keyword Alternatives: curve
- Included Keyword: mean
 - Keyword Alternatives: average
- Included Keyword: normal

- Keyword Alternatives:
 - Included Keyword: central
 - Keyword Alternatives: lim, theorem, CLT
62. Key Phrase: Inferential statistics allows the analyst to study a population.
- Included Keyword: inferential
 - Keyword Alternatives:
 - Included Keyword: stat
 - Keyword Alternatives: data
 - Included Keyword: popu
 - Keyword Alternatives: society, people, community, public, demograph, mass
63. Key Phrase: A population contains parameters.
- Included Keyword: parameter
 - Keyword Alternatives: specific, measure, guideline, criteri, framework
 - Included Keyword: popul
 - Keyword Alternatives:
64. Key Phrase: Parameters characterize probability distributions.
- Included Keyword: parameter
 - Keyword Alternatives: specific, measure, guideline, criterion, framework
 - Included Keyword: probability
 - Keyword Alternatives: chance, odds, likelihood
 - Included Keyword: distribut
 - Keyword Alternatives: curve
65. Key Phrase: Parameters are estimated through sample statistics.
- Included Keyword: parameter

- Keyword Alternatives: parameter, specific, measure, guideline, criterion, framework
- Included Keyword: sampl
 - Keyword Alternatives: stat, data, subset, fragment, part, represent

66. Key Phrase: Sample statistics are calculated to make inferences.

- Included Keyword: sampl
 - Keyword Alternatives: stat, data, subset
- Included Keyword: infer
 - Keyword Alternatives: estimat, forecast, predict, anticipat, expect, project, approx, evaluat, assess, gaug, measur, deduc, calc, extrapolat, conjectur, hypothe, guess, determin, examin

67. Key Phrase: Inferences are carried out through hypothesis testing.

- Included Keyword: infer
 - Keyword Alternatives: conjectur, estimat, forecast, predict, anticipat, expect, project, approx, evaluat, assess, gaug, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: hypothes
 - Keyword Alternatives:
- Included Keyword: test
 - Keyword Alternatives:

68. Key Phrase: Inferential statistics uses a sample.

- Included Keyword: inferen
 - Keyword Alternatives:
- Included Keyword: stat
 - Keyword Alternatives: data
- Included Keyword: sampl

- Keyword Alternatives: part, represent, fragment, subset, data

69. Key Phrase: A sample provides information to obtain estimates of parameters.

- Included Keyword: sampl
 - Keyword Alternatives: data, subset, fragment, part, represent
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, anticipat, infer, expect, project, approx, evaluat, assess, gaug, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: parameter
 - Keyword Alternatives: specific, measure, guideline, criteri, framework
- Included Keyword: info
 - Keyword Alternatives: input, record, evidence

70. Key Phrase: A sample has information to calculate sample statistics.

- Included Keyword: sampl
 - Keyword Alternatives: data, subset, fragment, part, represent
- Included Keyword: stat
 - Keyword Alternatives: data

71. Key Phrase: Estimates of parameters allow the analyst to make inferences.

- Included Keyword: estimat
 - Keyword Alternatives: approx, evaluat, assess, gaug, measur, deduc, calc, parameter, guideline, criteri, framework, guess
- Included Keyword: analys
 - Keyword Alternatives:
- Included Keyword: infer
 - Keyword Alternatives: forecast, predict, anticipat, expect, outlook, project, determin, examin

72. Key Phrase: Estimates from many samples generate a sampling distribution.

- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, anticipat, infer, expect, project, approx, evaluat, assess, gaug, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: sampl
 - Keyword Alternatives: stat, data, subset, fragment, part, represent
- Included Keyword: distribution
 - Keyword Alternatives: curve

73. Key Phrase: A sampling distribution e.g. the sample distribution of the mean of x .

- Included Keyword: sampl
 - Keyword Alternatives: fragment, part, represent, stat, data, subset
- Included Keyword: distribution
 - Keyword Alternatives: curve
- Included Keyword: mean
 - Keyword Alternatives: average

74. Key Phrase: Estimates e.g. point estimates.

- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat
- Included Keyword: point
 - Keyword Alternatives: value, best

75. Key Phrase: Estimates e.g. interval estimates.

- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin

- Included Keyword: interval
 - Keyword Alternatives: range, parameter, period

76. Key Phrase: Interval estimates are computed using confidence intervals.

- Included Keyword: interval
 - Keyword Alternatives: range, parameter, period
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: confidence
 - Keyword Alternatives: CI

77. Key Phrase: A sample generates results containing errors.

- Included Keyword: sampl
 - Keyword Alternatives: data, stat, subset, fragment, part, represent
- Included Keyword: error
 - Keyword Alternatives: mistak, inaccur, calc, wrong, disturbance

78. Key Phrase: Errors can be random errors.

- Included Keyword: random
 - Keyword Alternatives: chance
- Included Keyword: error
 - Keyword Alternatives: mistak, inaccur, calc

79. Key Phrase: Errors can be systematic errors.

- Included Keyword: error
 - Keyword Alternatives: mistak, inaccur, calc, disturbance
- Included Keyword: system
 - Keyword Alternatives: bias, human

80. Key Phrase: Systematic errors cause bias.

- Included Keyword: system
 - Keyword Alternatives: bias, human
- Included Keyword: error
 - Keyword Alternatives: mistak, inaccur, calc
- Included Keyword: bias
 - Keyword Alternatives:

81. Key Phrase: Hypothesis testing is a statistical procedure to corroborate a conjecture using a test statistic.

- Included Keyword: hypothesis
 - Keyword Alternatives:
- Included Keyword: test
 - Keyword Alternatives: exam, eval
- Included Keyword: conject
 - Keyword Alternatives: predict, hypothes, guess, estimat, infer, deduc, determin, examin
- Included Keyword: stat
 - Keyword Alternatives: data

82. Key Phrase: Hypothesis testing needs a null hypothesis.

- Included Keyword: hypothesis
 - Keyword Alternatives:
- Included Keyword: test
 - Keyword Alternatives: exam, eval
- Included Keyword: null
 - Keyword Alternatives: H0

83. Key Phrase: Hypothesis testing needs an alternative hypothesis.

- Included Keyword: hypothesis
 - Keyword Alternatives:
- Included Keyword: test
 - Keyword Alternatives: exam, eval
- Included Keyword: alternat
 - Keyword Alternatives: test, HA

84. Key Phrase: A null and an alternative hypothesis allows the researcher to reject the rejection region.

- Included Keyword: reject
 - Keyword Alternatives: deny, dismiss, exclud, disallow
- Included Keyword: null
 - Keyword Alternatives: H0
- Included Keyword: alternat
 - Keyword Alternatives: HA

85. Key Phrase: The rejection region is bounded by the critical value.

- Included Keyword: reject
 - Keyword Alternatives: RR
- Included Keyword: critical
 - Keyword Alternatives: CV

86. Key Phrase: A test statistic is used in order to perform a test with a given significance level.

- Included Keyword: test
 - Keyword Alternatives: exam, eval, assess
- Included Keyword: stat
 - Keyword Alternatives: data

- Included Keyword: significan
 - Keyword Alternatives:

87. Key Phrase: Significance level is defined by the rejection region and the critical value.

- Included Keyword: significa
 - Keyword Alternatives:
- Included Keyword: reject
 - Keyword Alternatives: RR
- Included Keyword: critical
 - Keyword Alternatives: CV

88. Key Phrase: A test statistic depends on sample size.

- Included Keyword: test
 - Keyword Alternatives: exam, eval, assess
- Included Keyword: stat
 - Keyword Alternatives: data
- Included Keyword: size
 - Keyword Alternatives: sampl

89. Key Phrase: A test statistic once carried out will have an implicit p-value.

- Included Keyword: test
 - Keyword Alternatives: exam, eval, assess
- Included Keyword: stat
 - Keyword Alternatives: data
- Included Keyword: p-val
 - Keyword Alternatives: pval, p val

90. Key Phrase: P-value is related to type I and type II errors.

- Included Keyword: p-val
 - Keyword Alternatives: p val, pval
- Included Keyword: type
 - Keyword Alternatives: alpha, beta, FALSE, positive, negative, 1, 2, I, II

91. Key Phrase: Significance level is related to type I and type II errors.

- Included Keyword: significa
 - Keyword Alternatives:
- Included Keyword: type
 - Keyword Alternatives: alpha, beta, FALSE, positive, negative, I, II, 1, 2

92. Key Phrase: Type I and type II errors define statistical significance.

- Included Keyword: significa
 - Keyword Alternatives:
- Included Keyword: type
 - Keyword Alternatives: alpha, beta, FALSE, positive, negative, I, II, 1, 2

93. Key Phrase: A test statistic e.g. Student t-test.

- Included Keyword: test
 - Keyword Alternatives: exam, eval, assess
- Included Keyword: stat
 - Keyword Alternatives: data
- Included Keyword: t-test
 - Keyword Alternatives: ttest, t test

94. Key Phrase: Student t-test e.g. one-side tests.

- Included Keyword: t-test
 - Keyword Alternatives: t test, ttest

- Included Keyword: one
 - Keyword Alternatives: 1
- Included Keyword: side
 - Keyword Alternatives: tail

95. Key Phrase: Student t-test e.g. two-side tests.

- Included Keyword: t-test
 - Keyword Alternatives: t test, ttest
- Included Keyword: two
 - Keyword Alternatives: 2
- Included Keyword: side
 - Keyword Alternatives: tail

96. Key Phrase: One-side tests can be used to test the population mean.

- Included Keyword: one
 - Keyword Alternatives: 1
- Included Keyword: side
 - Keyword Alternatives: tail
- Included Keyword: popul
 - Keyword Alternatives:
- Included Keyword: mean
 - Keyword Alternatives: averag

97. Key Phrase: Two-side tests can be used to test the population mean.

- Included Keyword: two
 - Keyword Alternatives: 2
- Included Keyword: side

- Keyword Alternatives: tail
- Included Keyword: popul
 - Keyword Alternatives:
- Included Keyword: mean
 - Keyword Alternatives: averag

98. Key Phrase: A test statistic e.g. Chi-square test.

- Included Keyword: test
 - Keyword Alternatives: exam, eval, assess
- Included Keyword: stat
 - Keyword Alternatives: data
- Included Keyword: chi
 - Keyword Alternatives: sq, x^2 , Breusch, Pagan

99. Key Phrase: A test statistic e.g. F-test.

- Included Keyword: test
 - Keyword Alternatives: exam, eval, assess
- Included Keyword: stat
 - Keyword Alternatives: data
- Included Keyword: f-test
 - Keyword Alternatives: f test, ftest

100. Key Phrase: Regression analysis studies relationships among quantitative and qualitative variables.

- Included Keyword: regress
 - Keyword Alternatives:
- Included Keyword: relat
 - Keyword Alternatives: associat, link, corr, connect, inter, concur, comparar

101. Key Phrase: Quantitative and qualitative variables can have a linear relationship.

- Included Keyword: variable
 - Keyword Alternatives:
- Included Keyword: line
 - Keyword Alternatives:

102. Key Phrase: Quantitative and qualitative variables can have a nonlinear relationship.

- Included Keyword: variable
 - Keyword Alternatives:
- Included Keyword: nonlinear
 - Keyword Alternatives: non-linear, non linear, not linear

103. Key Phrase: A linear relationship could be a simple linear regression model.

- Included Keyword: line
 - Keyword Alternatives:
- Included Keyword: simple
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:

104. Key Phrase: A linear relationship could be a multiple linear regression model.

- Included Keyword: line
 - Keyword Alternatives:
- Included Keyword: multiple
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:

105. Key Phrase: A nonlinear relationship could be a simple linear regression model.

- Included Keyword: nonlinear
 - Keyword Alternatives: non-linear, non linear, not linear
- Included Keyword: simple
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:

106. Key Phrase: A nonlinear relationship could be a multiple linear regression model.

- Included Keyword: nonlinear
 - Keyword Alternatives: non-linear, non linear, not linear
- Included Keyword: multiple
 - Keyword Alternatives:
- Included Keyword: line
 - Keyword Alternatives:

107. Key Phrase: A simple linear regression model summarizes the relationship between two variables.

- Included Keyword: line
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:
- Included Keyword: relation
 - Keyword Alternatives: connect, correlat, link, inter, concur, associat, compar
- Included Keyword: two
 - Keyword Alternatives: 2

108. Key Phrase: A simple linear regression model allows for the estimation of parameters.

- Included Keyword: line
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, anticipat, infer, expect, project, approx, evaluat, assess, gaug, measur, extrapolat, guess, determin, examin, outlook, deduc, calc, parameter, variable, specific, guideline, criteri, framework
- Included Keyword: parameter
 - Keyword Alternatives: specific, measure, guideline, criteri, framework, argument

109. Key Phrase: Variables are combined in a regression equation.

- Included Keyword: variable
 - Keyword Alternatives: combine, multiple, integrate, joined, together, incorporat, with, factor, element
- Included Keyword: regression
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives:

110. Key Phrase: Unknown parameters are estimated through a regression equation.

- Included Keyword: parameter
 - Keyword Alternatives: specific, measure, guideline, criteri, framework, argument
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, anticipat, infer, expect, project, approx, evaluat, assess, gaug, measur, extrapolat, guess, determin, examin
- Included Keyword: equation
 - Keyword Alternatives: model, formula, calcul, comput, asses, eval, analy, test

- Included Keyword: unknown
 - Keyword Alternatives: unidentif
- Included Keyword: regression
 - Keyword Alternatives:

111. Key Phrase: A regression equation has a systematic component.

- Included Keyword: regression
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: model, formula, calcul, comput, asses, eval, analy, test
- Included Keyword: system
 - Keyword Alternatives: method, structur, formul, standard, proce, operation, cours, approach, technique, way
- Included Keyword: component
 - Keyword Alternatives: piece, composition, part, aspect, segment, portion, constituent, element, ingredient, item, piece, unit, factor, member, basis, character, block, feature, trait, detail, model

112. Key Phrase: A regression equation has an unsystematic component (or an error term).

- Included Keyword: system
 - Keyword Alternatives: error, residual, method, structur, formul, standard, proce, operation, cours, approach, technique, way
- Included Keyword: regression
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: model, formula, calcul, comput, asses, eval, analy, test

113. Key Phrase: A regression equation is evaluated through diagnostic tests.

- Included Keyword: regression

- Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: equation, model, formula, calcul, comput, asses, eval, analy, test
- Included Keyword: diagnos
 - Keyword Alternatives: identif, charac, indicat

114. Key Phrase: A regression equation can be used in forecasting.

- Included Keyword: regression
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: model, formula, calcul, comput, asses, eval, test, analy
- Included Keyword: forecast
 - Keyword Alternatives: predict, anticipat, estim, forecast, infer, expect, project, approx, evaluat, assess, gaug, measur, deduc, calc, extrapolat, guess, determin, examin

115. Key Phrase: A regression equation can be used in analysis of parameters.

- Included Keyword: regression
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: model, formula, calcul, comput, asses, eval, test, analy
- Included Keyword: analy
 - Keyword Alternatives: calculat, quanti, eval, assess, exam, investig
- Included Keyword: parameter
 - Keyword Alternatives: specific, measure, guideline, criteri, framework, variable, extrapol

116. Key Phrase: The multiple regression model is represented by a regression equation.

- Included Keyword: mult
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:
- Included Keyword: equat
 - Keyword Alternatives: model, formula, calcul, comput, asses, eval, test, analy

117. Key Phrase: The multiple regression model summarizes the relationship between more than two variables.

- Included Keyword: multipl
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:
- Included Keyword: relat
 - Keyword Alternatives: assoc, link, inter, corr, bond, tie, conn
- Included Keyword: two
 - Keyword Alternatives: 2, duo, couple, several, few, mult, more, sum, many, various, Handful, number, smattering, scattering, bit

118. Key Phrase: The multiple regression model includes parameters.

- Included Keyword: mult
 - Keyword Alternatives:
- Included Keyword: regress
 - Keyword Alternatives:
- Included Keyword: parameter
 - Keyword Alternatives: specific, measure, guideline, criteri, framework

119. Key Phrase: Unsystematic component (An error term) is checked for randomness using diagnostic tests.

- Included Keyword: system
 - Keyword Alternatives: error, method, structur, formul, standard, proce, operation, cours, approach, technique, way
- Included Keyword: component
 - Keyword Alternatives: piece, composition, part, aspect, segment, portion, constituent, element, ingredient, item, piece, unit, factor, member, basis, character, block, feature, trait, detail, model
- Included Keyword: random
 - Keyword Alternatives: chance, stochastic
- Included Keyword: diagnos
 - Keyword Alternatives: identif, charac, indicat

120. Key Phrase: Analysis of parameters depends on functional forms.

- Included Keyword: function
 - Keyword Alternatives: use, behavior, business, duty, job, part, purpose, appl, role, service, task, operat, perform, serv, work
- Included Keyword: analy
 - Keyword Alternatives: infer, evaluat, invest, stud, exam, assess, gaug, measur, parameter, variable, extrapolat, specific, measure, guideline, criteri, framework, review, inspect, survey, inter, research

121. Key Phrase: Functional forms include the double-log functional form.

- Included Keyword: function
 - Keyword Alternatives: use, behavior, business, duty, job, part, purpose, appl, role, service, task, operat, perform, serv, work
- Included Keyword: double
 - Keyword Alternatives: two, 2, twice, twin, dual, pair
- Included Keyword: log
 - Keyword Alternatives:

122. Key Phrase: Analysis of parameters includes slope coefficients.

- Included Keyword: analy
 - Keyword Alternatives: infer, evaluat, invest, stud, exam, assess, gaug, measur, parameter, variable, extrapolat, specific, measure, guideline, criteri, framework, review, inspect, survey, inter, research
- Included Keyword: slope
 - Keyword Alternatives: trend

123. Key Phrase: Slope coefficients can be an elasticity coefficient.

- Included Keyword: slope
 - Keyword Alternatives: trend
- Included Keyword: coefficient
 - Keyword Alternatives: modulus, term, variable, value
- Included Keyword: elastic
 - Keyword Alternatives:

124. Key Phrase: The double-log functional form provides estimates of elasticity coefficient.

- Included Keyword: slope
 - Keyword Alternatives: trend
- Included Keyword: coefficient
 - Keyword Alternatives: modulus, term, variable, value
- Included Keyword: elastic
 - Keyword Alternatives:

125. Key Phrase: Regression variables can contain dummy variables.

- Included Keyword: regress
 - Keyword Alternatives:
- Included Keyword: variable

- Keyword Alternatives: element
- Included Keyword: dummy
 - Keyword Alternatives: categor, nominal, ordinal, qual

126. Key Phrase: A regression equation can be a linear equation.

- Included Keyword: regression
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: equation, model, formula, calcul, comput, asses, eval, test, analy
- Included Keyword: linear
 - Keyword Alternatives:

127. Key Phrase: A regression equation can be a non-linear equation.

- Included Keyword: regression
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: equation, model, formula, calcul, comput, asses, eval, test, analy
- Included Keyword: non-linear
 - Keyword Alternatives: linear

128. Key Phrase: A linear equation is consistent with different functional forms.

- Included Keyword: linear
 - Keyword Alternatives:
- Included Keyword: equation
 - Keyword Alternatives: method, structur, formul, standard, proce, operation, cours, approach, technique, way

- Included Keyword: function
 - Keyword Alternatives: use, behavior, business, duty, job, part, purpose, appl, role, service, task, operat, perform, serv, work

129. Key Phrase: A non-linear equation can have a variety of functional forms.

- Included Keyword: function
 - Keyword Alternatives: use, behavior, business, duty, job, part, purpose, appl, role, service, task, operat, perform, serv, work
- Included Keyword: linear
 - Keyword Alternatives: non-linear

130. Key Phrase: Diagnostic tests check for statistical significance.

- Included Keyword: diagnos
 - Keyword Alternatives: identif, charac, indicat
- Included Keyword: test
 - Keyword Alternatives: procedure, exam, eval, assess, analys
- Included Keyword: significa
 - Keyword Alternatives:

131. Key Phrase: Diagnostic tests check for randomness of error term.

- Included Keyword: diagnos
 - Keyword Alternatives: identif, charac, indicat
- Included Keyword: test
 - Keyword Alternatives: prcedure, exam, eval, assess, analys
- Included Keyword: random
 - Keyword Alternatives: stochastic, chance
- Included Keyword: error
 - Keyword Alternatives: disturbanc, mistak, inaccur, calc, wrong

132. Key Phrase: Diagnostic tests check for misspecification.

- Included Keyword: diagnos
 - Keyword Alternatives: identif, charac, indicat
- Included Keyword: test
 - Keyword Alternatives: procedure, exam, eval, assess, analy
- Included Keyword: specifica
 - Keyword Alternatives:

133. Key Phrase: Statistical significance is checked with the t-test.

- Included Keyword: significa
 - Keyword Alternatives:
- Included Keyword: t-test
 - Keyword Alternatives: t test, ttest

134. Key Phrase: Statistical significance is checked with the F-test.

- Included Keyword: significa
 - Keyword Alternatives:
- Included Keyword: f-test
 - Keyword Alternatives: f test, ftest

135. Key Phrase: The F-test allows verification of linear restrictions.

- Included Keyword: f-test
 - Keyword Alternatives: f test, ftest
- Included Keyword: line
 - Keyword Alternatives:
- Included Keyword: restrict
 - Keyword Alternatives:

136. Key Phrase: Randomness for error term can be violated due to autocorrelation.

- Included Keyword: random
 - Keyword Alternatives: stochastic, chance
- Included Keyword: error
 - Keyword Alternatives: disturbance, mistak, inaccur, calc, wrong
- Included Keyword: autocorrelat
 - Keyword Alternatives: serial

137. Key Phrase: Autocorrelation is checked with the Durbin-Watson test.

- Included Keyword: autocorrelat
 - Keyword Alternatives: serial
- Included Keyword: Durbin-Watson
 - Keyword Alternatives: Durbin and Watson, Durbin & Watson, Durbin Watson, DW, D-W, D&W, Durbin, Watson

138. Key Phrase: Autocorrelation is checked with the h-test.

- Included Keyword: autocorrelat
 - Keyword Alternatives: serial
- Included Keyword: h-test
 - Keyword Alternatives: h test, htest

139. Key Phrase: Randomness for error term can be violated due to heteroscedasticity.

- Included Keyword: random
 - Keyword Alternatives: stochastic, chance
- Included Keyword: error
 - Keyword Alternatives: disturbance, mistak, inaccur, calc, wrong
- Included Keyword: heteroscedastic
 - Keyword Alternatives:

140. Key Phrase: Heteroscedasticity is checked with the Goldfeld-Quandt test.

- Included Keyword: heteroscedastic
 - Keyword Alternatives:
- Included Keyword: Goldfeld-Quandt
 - Keyword Alternatives: Goldfeld Quandt, Goldfeld and Quandt, Goldfeld & Quandt, GQ, G&Q, G-Q, Goldfeld, Quandt

141. Key Phrase: Heteroscedasticity is checked with the Breusch-Pagan test.

- Included Keyword: heteroscedastic
 - Keyword Alternatives:
- Included Keyword: Breusch-Pagan
 - Keyword Alternatives: Bruesch Pagan, Bruesch and Pagan, Bruesch & Pagan, BP, B&P, B-P, Bruesch, Pagan

142. Key Phrase: Randomness of error term can be checked with the Runs test.

- Included Keyword: random
 - Keyword Alternatives: stochastic, chance
- Included Keyword: error
 - Keyword Alternatives: disturbance, mistak, inaccur, calc, wrong
- Included Keyword: run
 - Keyword Alternatives:

143. Key Phrase: Randomness of error term can be checked with Chi-square tests.

- Included Keyword: random
 - Keyword Alternatives: stochastic, chance
- Included Keyword: error
 - Keyword Alternatives: disturbance, mistak, inaccur, calc, wrong
- Included Keyword: chi-square

- Keyword Alternatives: chi square, χ^2 , chi, square

144. Key Phrase: Misspecification can be detected through the lack of randomness of error terms.

- Included Keyword: specifica
 - Keyword Alternatives:
- Included Keyword: random
 - Keyword Alternatives: stochastic
- Included Keyword: error
 - Keyword Alternatives: disturbance

145. Key Phrase: Misspecification can be caused by irrelevant variables.

- Included Keyword: specifica
 - Keyword Alternatives:
- Included Keyword: irrelevant
 - Keyword Alternatives: superfluous, extraneous, unnecessary, unrelated, inapplicable, not relevant, not relat

146. Key Phrase: Irrelevant variables that are not significant can be a symptom of multicollinearity.

- Included Keyword: irrelevant
 - Keyword Alternatives: superfluous, extraneous, not relevant, not relat, relat, necessary, appl, relevant
- Included Keyword: variable
 - Keyword Alternatives:
- Included Keyword: multicollinear
 - Keyword Alternatives:

147. Key Phrase: Misspecification can be caused by incorrect functional form.

- Included Keyword: specifica

- Keyword Alternatives:
- Included Keyword: incorrect
 - Keyword Alternatives: wrong, false, correct, mistak, erro, valid, accurat, true
- Included Keyword: functional
 - Keyword Alternatives:
- Included Keyword: form
 - Keyword Alternatives:

148. Key Phrase: Time series models use time series data.

- Included Keyword: time
 - Keyword Alternatives: period
- Included Keyword: ser
 - Keyword Alternatives: data
- Included Keyword: model
 - Keyword Alternatives: graph, present, figure, diagram, pict, chart, plot

149. Key Phrase: Time series data can be characterized by their components.

- Included Keyword: time
 - Keyword Alternatives: period
- Included Keyword: ser
 - Keyword Alternatives: data
- Included Keyword: component
 - Keyword Alternatives: piece, composition, part, aspect, segment, portion, constituent, element, ingredient, item, piece, unit, factor, member, basis, character, block, feature, trait, detail, model

150. Key Phrase: Time series models e.g. smoothing methods.

- Included Keyword: time

- Keyword Alternatives: period
- Included Keyword: ser
 - Keyword Alternatives: data
- Included Keyword: smooth
 - Keyword Alternatives: even, level, flat

151. Key Phrase: Time series models e.g. ARIMA.

- Included Keyword: time
 - Keyword Alternatives: period
- Included Keyword: ser
 - Keyword Alternatives: data
- Included Keyword: ARIMA
 - Keyword Alternatives: auto

152. Key Phrase: Time series models e.g. other.

- Included Keyword: time
 - Keyword Alternatives: period
- Included Keyword: ser
 - Keyword Alternatives: data
- Included Keyword: other
 - Keyword Alternatives: besides, more, includ, limit, add, alt, etc, cetera, extra, further

153. Key Phrase: Smoothing methods e.g. moving averages.

- Included Keyword: smooth
 - Keyword Alternatives: even, level, flat
- Included Keyword: moving
 - Keyword Alternatives: average, mean

154. Key Phrase: Smoothing methods e.g. simple exponential smoothing.

- Included Keyword: smooth
 - Keyword Alternatives: even, level, flat
- Included Keyword: exponent
 - Keyword Alternatives: multi

155. Key Phrase: Smoothing methods e.g. Winter's exponential smoothing.

- Included Keyword: smooth
 - Keyword Alternatives: even, level, flat
- Included Keyword: exponent
 - Keyword Alternatives: multi
- Included Keyword: Winter
 - Keyword Alternatives:

156. Key Phrase: Moving averages provide forecasts.

- Included Keyword: moving
 - Keyword Alternatives: series, roll, run
- Included Keyword: forecast
 - Keyword Alternatives: estimat, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: mean
 - Keyword Alternatives: average

157. Key Phrase: Simple exponential smoothing provides forecasts.

- Included Keyword: smooth
 - Keyword Alternatives: even, level, flat
- Included Keyword: forecast

- Keyword Alternatives: estimat, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: exponent
 - Keyword Alternatives: multi

158. Key Phrase: Winter's exponential smoothing provides forecasts.

- Included Keyword: smooth
 - Keyword Alternatives: even, level, flat
- Included Keyword: forecast
 - Keyword Alternatives: estimat, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: exponent
 - Keyword Alternatives: multi
- Included Keyword: Winter
 - Keyword Alternatives:

159. Key Phrase: Forecasts can generate combined forecasts.

- Included Keyword: forecast
 - Keyword Alternatives: estimat, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: combin
 - Keyword Alternatives: multi, integrate, join, together, incorporat, with, mix, merge, comp

160. Key Phrase: Forecasts can also be evaluated based on turning points.

- Included Keyword: forecast
 - Keyword Alternatives: estimat, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: turn

- Keyword Alternatives: flip, chang, critical, pivot

161. Key Phrase: Forecasts must be checked through an evaluation process.

- Included Keyword: forecast
 - Keyword Alternatives: estimat, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: eval
 - Keyword Alternatives: check, assess, review, analy, invest, exam, criteri, inspect, parameter, test

162. Key Phrase: ARIMA uses the autocorrelation function.

- Included Keyword: ARIMA
 - Keyword Alternatives: auto
- Included Keyword: autocorrelat
 - Keyword Alternatives: auto-correlat

163. Key Phrase: ARIMA uses the partial autocorrelation function.

- Included Keyword: ARIMA
 - Keyword Alternatives: auto
- Included Keyword: part
 - Keyword Alternatives:
- Included Keyword: autocorrelat
 - Keyword Alternatives: auto-correlat

164. Key Phrase: The autocorrelation function is a basic tool for identification.

- Included Keyword: autocorrelat
 - Keyword Alternatives: auto-correlat
- Included Keyword: identif
 - Keyword Alternatives: diagnos, determin, classif, indicat, recogni, verif

165. Key Phrase: The partial autocorrelation function is a basic tool for identification.

- Included Keyword: part
 - Keyword Alternatives:
- Included Keyword: autocorrelat
 - Keyword Alternatives: auto-correlat
- Included Keyword: identif
 - Keyword Alternatives: diagnos, determin, classif, indicat, recogni, verif

166. Key Phrase: ARIMA is a method for estimation of a stationary processes.

- Included Keyword: ARIMA
 - Keyword Alternatives: auto
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: station
 - Keyword Alternatives: strict, strong
- Included Keyword: proce
 - Keyword Alternatives: method, act, operat, step

167. Key Phrase: Stationary processes can be obtained through differencing.

- Included Keyword: station
 - Keyword Alternatives: strict, strong
- Included Keyword: differ
 - Keyword Alternatives:
- Included Keyword: proce
 - Keyword Alternatives: method, act, operat, step

168. Key Phrase: Identification involves finding autoregressive terms.

- Included Keyword: identif
 - Keyword Alternatives: diagnos, determin, classif, indicat, recogni, verif
- Included Keyword: autoregress
 - Keyword Alternatives: auto-regress

169. Key Phrase: Identification involves finding moving average terms.

- Included Keyword: identif
 - Keyword Alternatives: diagnos, determin, classif, indicat, recogni, verif
- Included Keyword: moving
 - Keyword Alternatives: mean, roll, run, series
- Included Keyword: mean
 - Keyword Alternatives: average

170. Key Phrase: Identification involves finding the degree of differencing.

- Included Keyword: identif
 - Keyword Alternatives: diagnos, determin, classif, indicat, recogni, verif
- Included Keyword: differ
 - Keyword Alternatives: degree, degree-of-diff, angle

171. Key Phrase: Autoregressive terms help to define a primary model for estimation.

- Included Keyword: autoregress
 - Keyword Alternatives: auto-regress, auto
- Included Keyword: mode
 - Keyword Alternatives: system, method, structur, formul, standard, proce, operation, cours, approach, technique, way, graph, present, figure, diagram, pict, chart, plot, prim
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat

172. Key Phrase: Moving average terms help to define a primary model for estimation.

- Included Keyword: moving
 - Keyword Alternatives: series, roll, run
- Included Keyword: mode
 - Keyword Alternatives: system, method, structur, formul, standard, proce, operation, cours, approach, technique, way, graph, present, figure, diagram, pict, chart, plot
- Included Keyword: eval
 - Keyword Alternatives: check, assess, review, analy, invest, exam, criteri, inspect, parameter, test
- Included Keyword: mean
 - Keyword Alternatives: average

173. Key Phrase: The primary model for estimation is generated at the end of forecasts.

- Included Keyword: prim
 - Keyword Alternatives: system, method, structur, formul, standard, proce, operation, cours, approach, technique, way, graph, present, figure, diagram, pict, chart, plot, mode
- Included Keyword: forecast
 - Keyword Alternatives: predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, estimat
- Included Keyword: end
 - Keyword Alternatives: after, result, follow, subsequent, next

174. Key Phrase: The primary model for estimation is followed by diagnostic checking procedures.

- Included Keyword: model
 - Keyword Alternatives: system, method, structur, formul, standard, proce, operation, cours, approach, technique, way, graph, present, figure, diagram, pict, chart, plot, mode

- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, guess, determin, examin
- Included Keyword: diagnos
 - Keyword Alternatives: identif, determin, classif, indicat, recogni, verif, check, proce, method, act, operat, step

175. Key Phrase: Differencing generates a stationary process for estimation.

- Included Keyword: differ
 - Keyword Alternatives:
- Included Keyword: station
 - Keyword Alternatives: strict, strong
- Included Keyword: proce
 - Keyword Alternatives: method, act, operat, step

176. Key Phrase: Differencing generates a stationary process from non-stationary processes.

- Included Keyword: differ
 - Keyword Alternatives:
- Included Keyword: station
 - Keyword Alternatives: strict, strong
- Included Keyword: proce
 - Keyword Alternatives: method, act, operat, step

177. Key Phrase: Non-stationary processes include the random-walk model.

- Included Keyword: station
 - Keyword Alternatives: strict, strong, proce, method, act, operat, step
- Included Keyword: random-walk
 - Keyword Alternatives: random, walk

- Included Keyword: mode
 - Keyword Alternatives: system, method, structur, formul, standard, proce, operation, cours, approach, technique, way, graph, present, figure, diagram, pict, chart, plot

178. Key Phrase: Differencing for estimation is generated at the end of forecasts.

- Included Keyword: differ
 - Keyword Alternatives:
- Included Keyword: forecast
 - Keyword Alternatives: predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat, estimat, guess, determin, examin
- Included Keyword: end
 - Keyword Alternatives: after, result, follow, subsequent, next

179. Key Phrase: Differencing for estimation is followed by diagnostic checking procedures.

- Included Keyword: differ
 - Keyword Alternatives:
- Included Keyword: estimat
 - Keyword Alternatives: forecast, predict, infer, expect, project, approx, evaluat, assess, measur, deduc, calc, extrapolat
- Included Keyword: diagnos
 - Keyword Alternatives: identif, determin, classif, indicat, recogni, verif, check, proce, method, act, operat, step

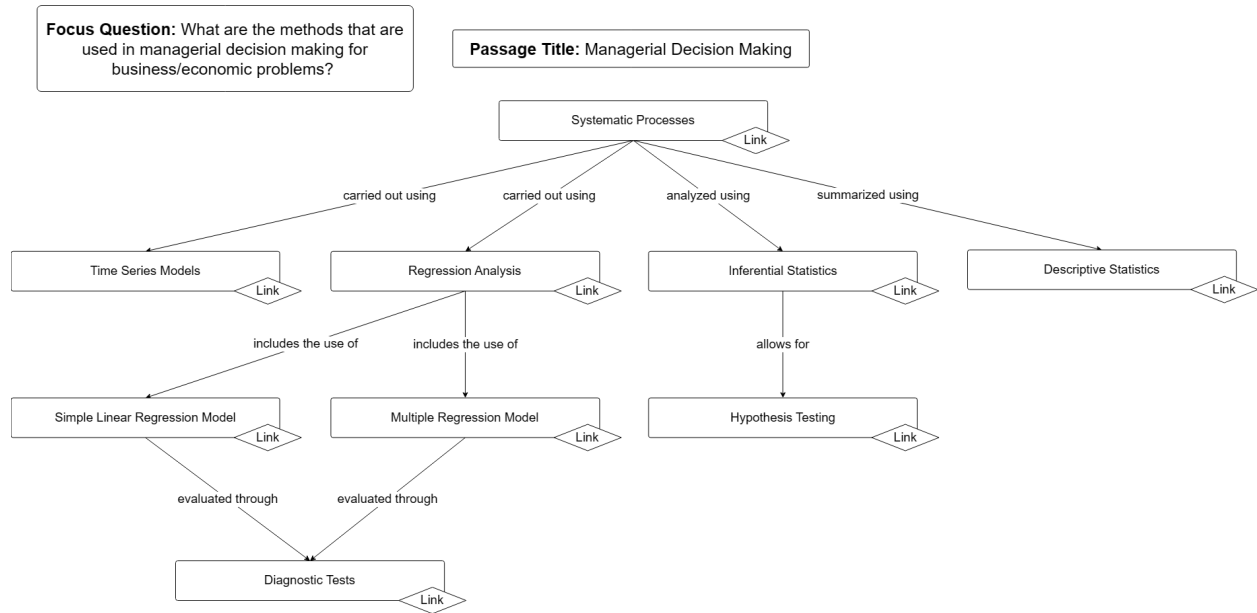


Figure B.64: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - Master-map

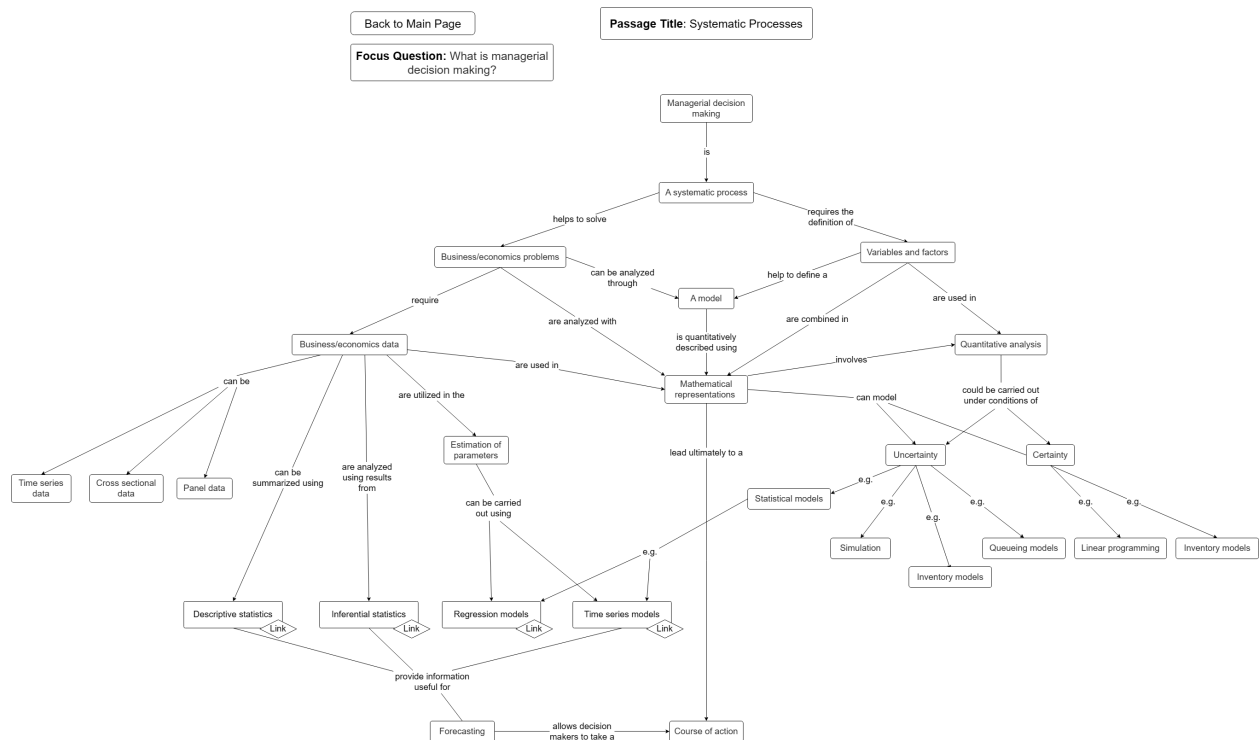


Figure B.65: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map1

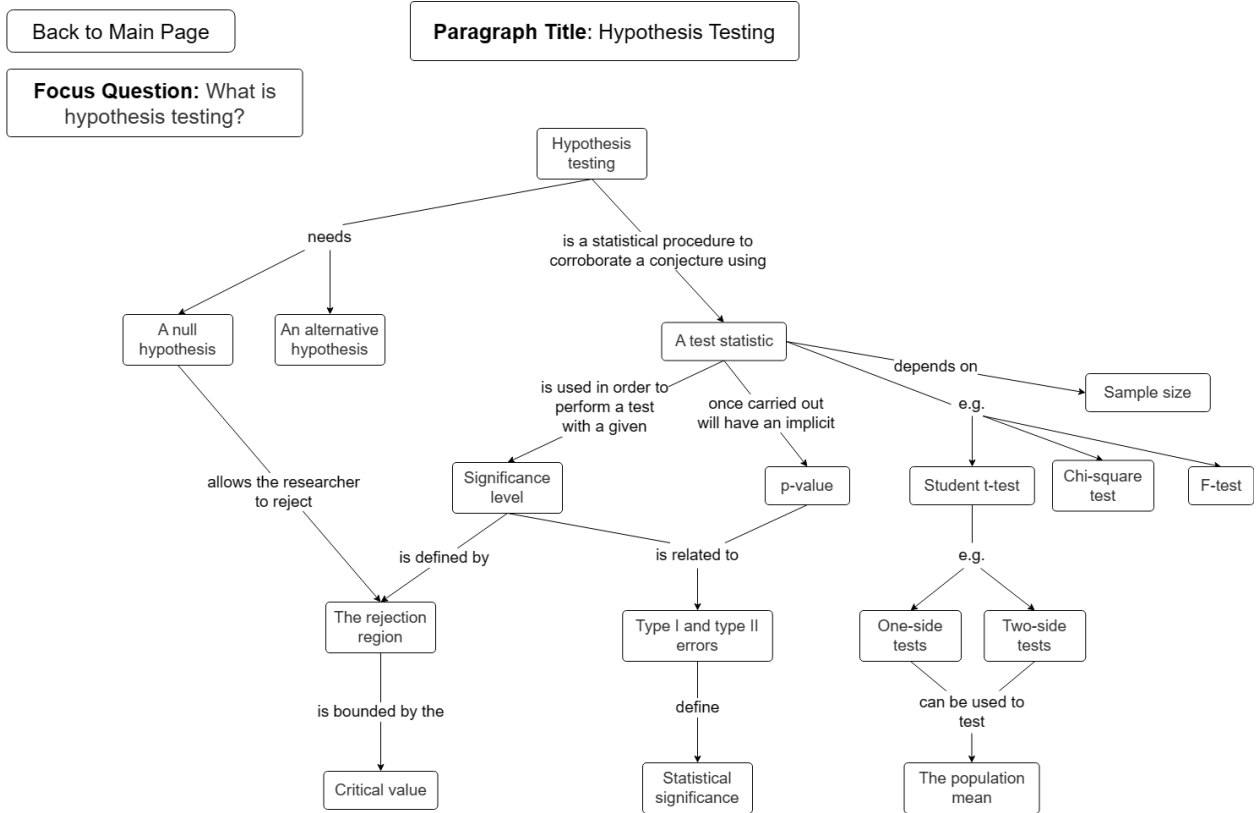


Figure B.67: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map3

Back to Main Page

Paragraph Title: Descriptive Statistics

Focus Question: What are descriptive statistics?

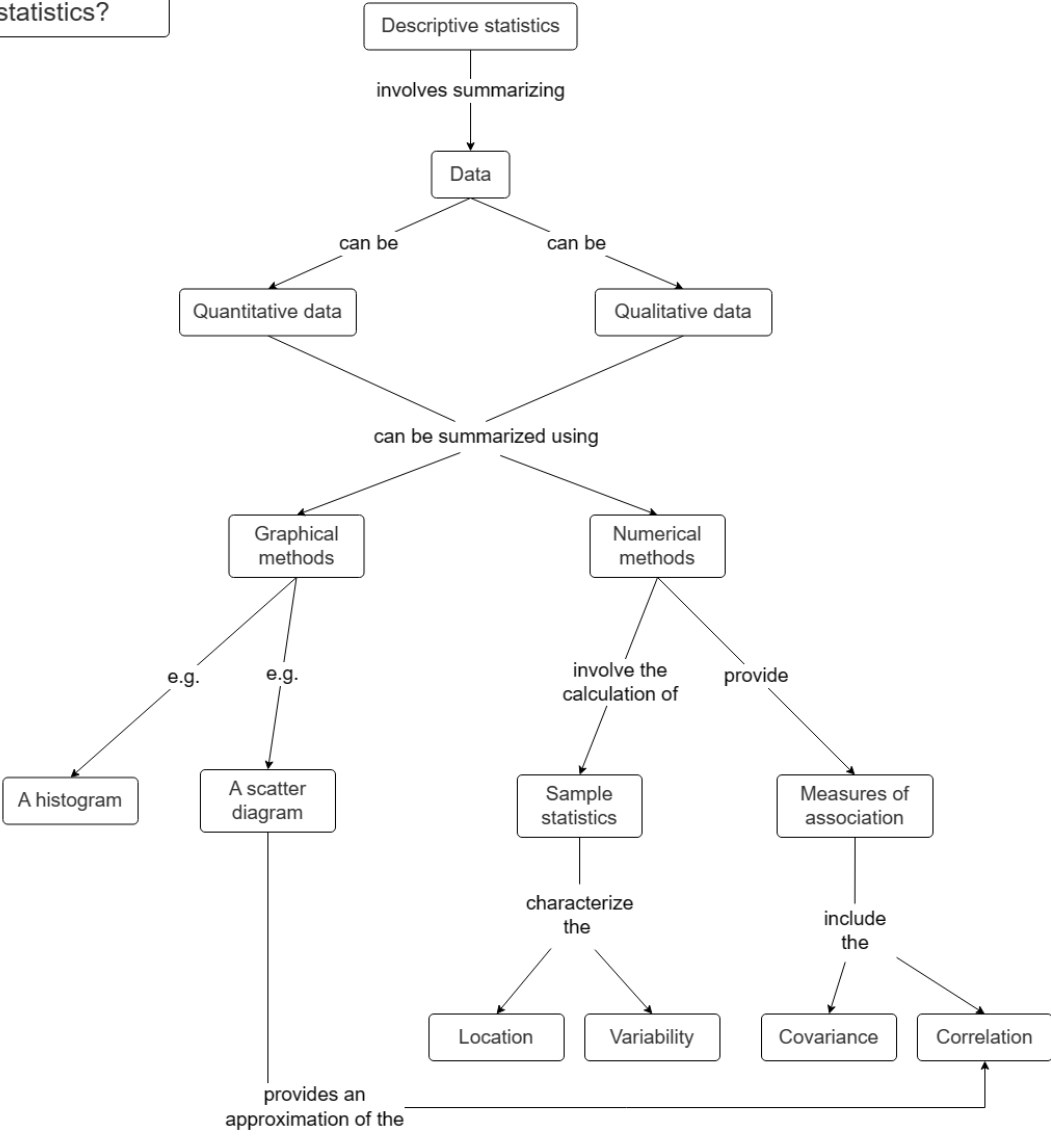


Figure B.68: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map4

Back to Main Page

Paragraph Title: Regression Analysis

Focus Question: What does regression analysis study?

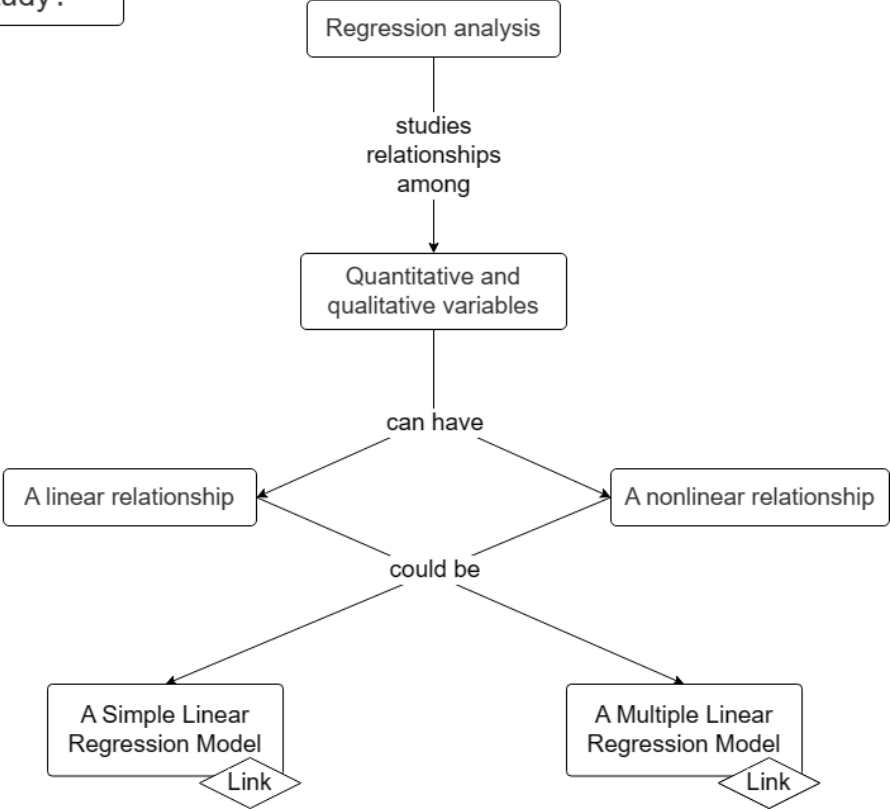


Figure B.69: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map5

Back to Main Page

Paragraph Title: Diagnostic Tests

Focus Question: What is the purpose of diagnostic tests?

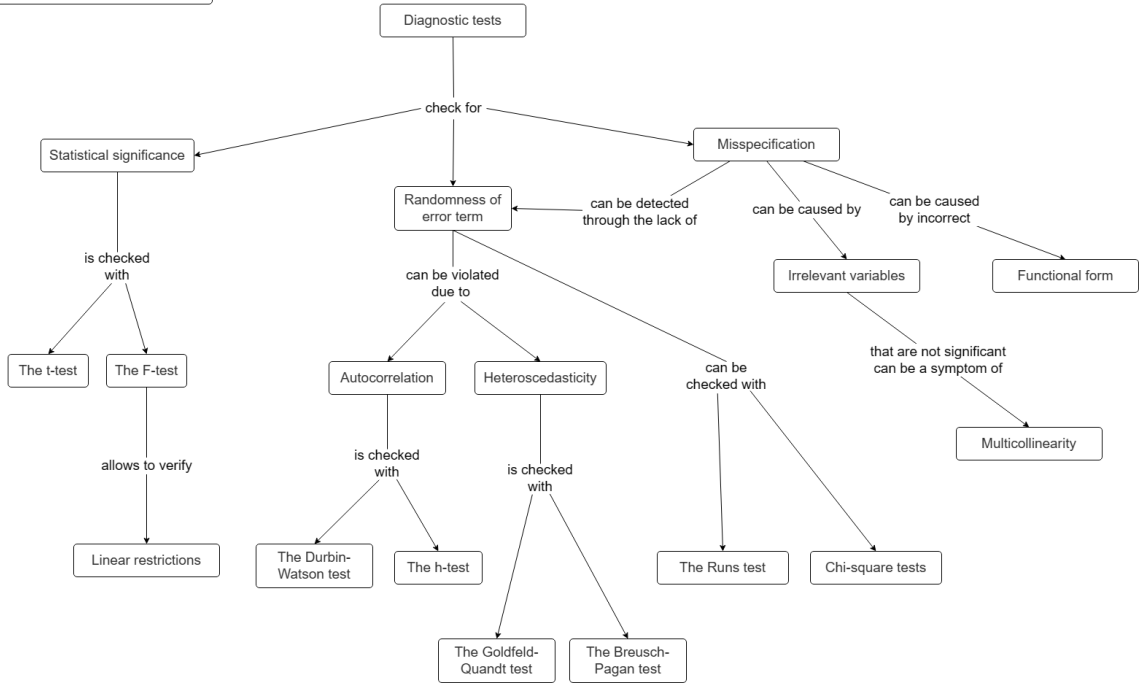


Figure B.70: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map6

Back to Main Page

Paragraph Title: Simple Linear Regression Model

Focus Question: What is the purpose of a simple linear regression model?

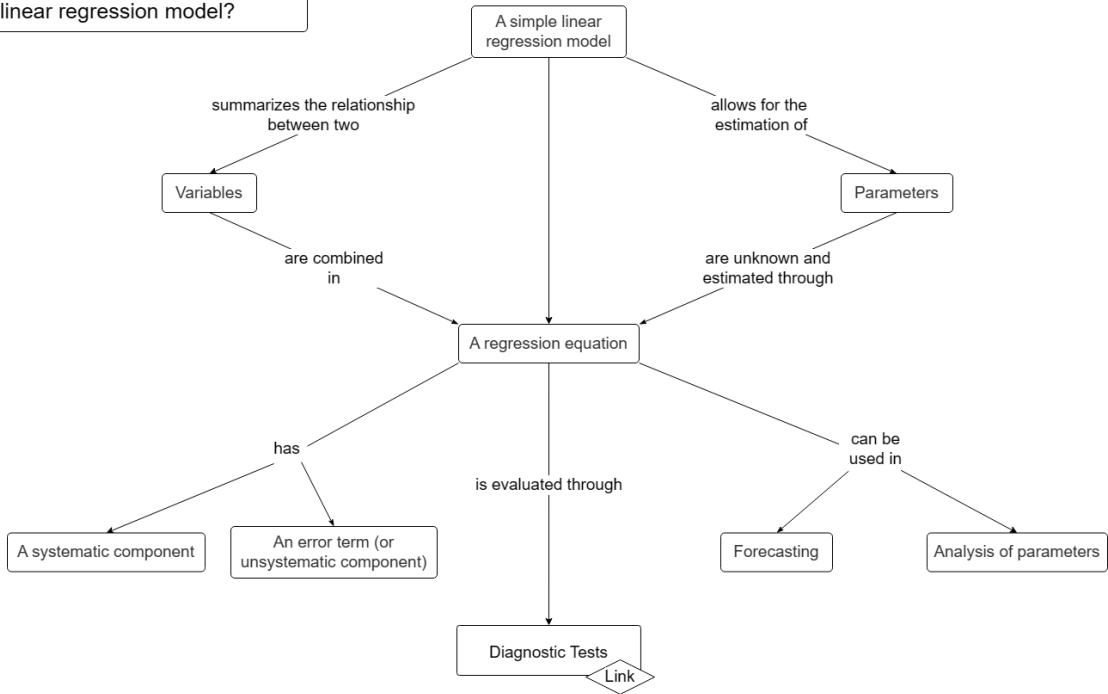


Figure B.71: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map7

Back to Main Page

Paragraph Title: Multiple Regression Model

Focus Question: What is the multiple regression model and how does it work?

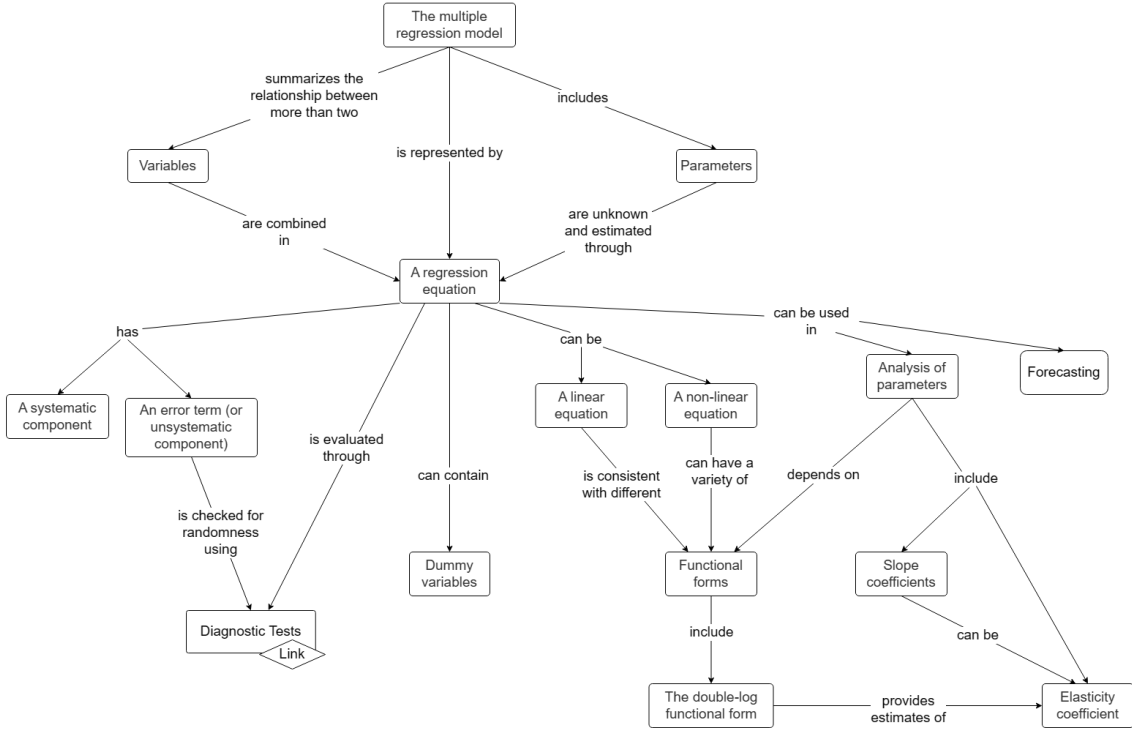


Figure B.72: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map8

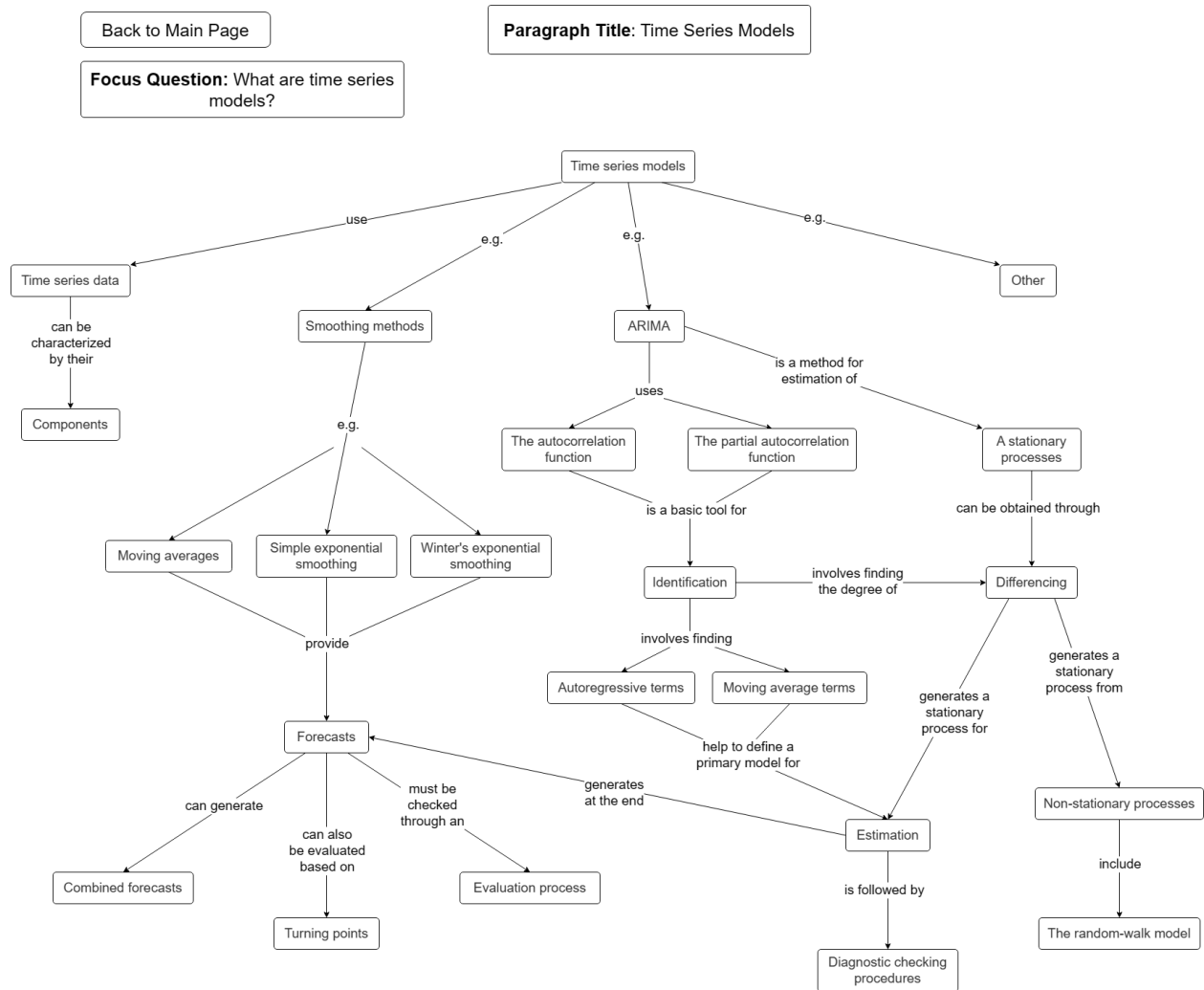


Figure B.73: Passage 8: Managerial Decision Making in Novakian Knowledge Model (K) condition - mini-map9

B.2.9 Passage 9: The Quiet Sideman

The modified multiple-choice questions used for this passage are as follows:

1. Based on the passage, how did Berry's personality affect his career?
 - (a) His ambitious, competitive personality was off-putting to other musicians, who were reluctant to play with him.
 - (b) His genial personality endeared him to other musicians, but his career suffered when he spent more time socializing than practicing.
 - (c) Correct: His modest and easygoing personality kept him out of the spotlight and, consequently, he received less attention as a performer.
 - (d) His shy, introspective personality was misunderstood as snobbish arrogance, so he was offered few recording-session jobs.

2. The author mentions Berry's solo in "Oh, Lady Be Good" primarily in order to:
 - (a) Illustrate why most people haven't heard of Berry.
 - (b) Correct: Provide an example of Berry's musical excellence.
 - (c) Contrast Berry's later work with Berry's early work.
 - (d) Establish that Berry's solo was better than Count Basie's.

3. The author points out that many serious jazz enthusiasts know little about Berry primarily in order to:
 - (a) Criticize scholarship that has provided an unbalanced history of jazz.
 - (b) Demonstrate that the author is more knowledgeable than most jazz scholars.
 - (c) Illustrate the secrecy Berry demanded in order to preserve his family's privacy.
 - (d) Correct: Explain why it's likely that readers would be unfamiliar with Berry.

4. According to the author, Berry's solos as a recording session musician were often very short because he:
 - (a) Wasn't a very good saxophone player until late in his career.
 - (b) Drew more attention playing ensemble passages.
 - (c) Correct: Worked within the recording constraints of the era.
 - (d) Preferred playing many short solos to playing a few long ones.

5. The author indicates that during Berry's time as a musician, swing music was primarily regarded as:
- (a) An opportunity for soloists to show off their skills.
 - (b) A genre to be most appreciated by young people.
 - (c) Musician's music that lacked a popular audience.
 - (d) Correct: Music for dance parties but not music for study.
6. The word "court" most nearly means to:
- (a) Correct: Seek to attract.
 - (b) Romantically pursue.
 - (c) Dangerously provoke.
 - (d) Pass judgment upon.
7. The author compares sidemen to traveling salesmen in order to:
- (a) Make clear how often musicians had to travel.
 - (b) Indicate that musicians often had side jobs.
 - (c) Correct: Illustrate sidemen's supportive role in a band.
 - (d) Show how hard sidemen worked to get hired.
8. The author describes Henderson's "Blues in C Sharp Minor" as:
- (a) Innovative, indulgent, and colorful.
 - (b) Fast-moving, memorable, and eerie.
 - (c) Artful, sublime, and unexpectedly upbeat.
 - (d) Correct: Odd, haunting, and relaxing.
9. According to the author, what is unique about the June 1940 rendition of the song "A Ghost of a Chance"?
- (a) Correct: It's the only recorded piece that features Berry from beginning to end.
 - (b) Berry plays an alto saxophone instead of his usual tenor saxophone.
 - (c) It was the only public performance Berry gave in 1940.
 - (d) Berry showcases his unrivaled ability to play a solo that blends into the background.

10. The author uses the phrase “a cathedral of a solo” most likely to create a sense that Berry’s solo was:
- (a) Correct: An intricate, awe-inspiring masterpiece.
 - (b) A somber, mournful hymn.
 - (c) A crumbling remnant of Berry’s once-great skill.
 - (d) A testament to Calloway’s band leadership.

The following shows the original ACT reading comprehension passage in linear format. This passage in Hyper map (H) format is shown in Figure B.74. The interactive version that the participants studied through is available [here on Draw.io](#). Its equivalent Novakian concept maps (K) are in Figure B.75, Figure B.76, Figure B.77, Figure B.78, Figure B.79, Figure B.80, Figure B.81, Figure B.82, Figure B.83. The interactive version that the participants studied through is available [here on Draw.io](#).

Near the end of his eight years as a recording-session musician, tenor saxophonist Leon “Chu” Berry landed a short-lived spot with Count Basie’s orchestra. Standing in for one of the basie band’s two tenor giants, Berry took a lead solo on “Oh, Lady Be Good,” the 1924 Gershwin song that Basie had played for years. In the 28 seconds that the solo lasted on February 4, 1939, we are treated to no less than the musical personification of mind and body working together in divine tandem. When you hear the recording for the first time, you’re likely to wonder why you’ve never heard of Chu Berry before.

Why you’ve never heard of him is pretty simple: a lot of hard-core jazz buffs don’t know much about him. Berry was a solid session player who turns up on recordings with Basie, Bessie Smith, Fletcher Henderson, and Billie Holiday. But he did not cut many sessions himself as a leader, and when he soloed, he worked within the recording constraints of the era and the swing genre—fast—moving 78s with solos often lasting for a mere 32 beats.

The people who loved Berry were, not surprisingly, other tenor players, a situation leading to the dreaded “musician’s musician” tag. But that’s not nearly praise enough to describe Chu Berry, who, when given opportunity, displayed a musical dexterity that would be envied by future generations of horn men.

Berry faced the lot of other horn players: having to grind it out long and hard until something memorable burst through; the prejudices and expectations of the listening

public; and the accepted wisdom of what is and isn't art in a given medium. In this case, swing was fodder for dance parties, not music worthy of study.

Oddly enough, Berry's geniality might help explain his failure to court history's favor: it wasn't in his nature to call attention to himself or his playing. Born in 1908 into the black middle class in Wheeling, West Virginia, the laid-back, affable Berry attended West Virginia State in Charleston, where he switched from alto sax to tenor and exhibited the willingness to fit in that characterized his presence in so many dance bands. He was the rare artist who refused to put his interests above those of the band, even if that meant playing ensemble passages rather than taking a healthy allotment of solo breaks.

College provided a training ground for Berry the bandsman, as he teamed up with a number of amateur outfits. He never played simply to show off. Instead, he tried to bring out the positive attributes in any given situation or setting. Later, when Berry is performing with the Calloway ensemble, we hear some ragged, out-of-tune playing until Berry's first few solo notes emerge. The other players, no longer languidly blowing through their charts, immediately surge up behind him, all fighting-fit. Once Berry finishes his solo, the shenanigans resume.

After making his way to New York, Berry immediately became a presence and soon was in demand. The great jazz orchestras of the swing era were fronted by musical directors/arrangers—Duke Ellington was preeminent—who drew the acclaim. The sidemen were musical traveling salesmen who sold someone else's wares in the best style they could manage. It was with Fletcher Henderson that Berry began to ditch some of the sideman's subservient trappings. For starters, Henderson wrote in keys that were rare for the jazz orchestras of the day, and his somber, indigo-inflected voicings were ideal for a player of Berry's introspective approach to his instrument: Berry sounds as if he's being swallowed by his sax. "Blues in C Sharp Minor," for instance, is odd, haunting, and ultimately relaxing. A Berry solo in it is slightly off mike, making the listener feel as though he's been playing for some time before we finally hear him. The effect is unnerving, as if we weren't paying close attention.

In June 1940, Cab Calloway granted Berry a showcase piece, "A Ghost of a Chance," the sole recording in Berry's career to feature him from start to finish. It was his "Body and Soul," a response to Coleman Hawkins's famous recording, intended not as a riposte to a rival, but as the other half of a dialogue. Its rubato lines are disembodied from the music meant to accompany it, which is spartan to begin with. This may be Berry's one and only instance of indulgence on a record, a cathedral of a solo in its

flourishes, angles, ornamentations, reflexivity. If sunlight could pass through music, “A Ghost of a Chance” would funnel it out in the broadest spectrum of colors.

B.2.9.1 Key Phrases and their Boolean Expressions for The Quiet Sideman

1. Key Phrase: Berry’s full name is Leon “Chu” Berry.

- Included Keyword: Leon
 - Keyword Alternatives:
- Included Keyword: Chu
 - Keyword Alternatives:
- Included Keyword: Berry
 - Keyword Alternatives: Barry

2. Key Phrase: Berry was a recording-session musician.

- Included Keyword: Berry
 - Keyword Alternatives: Leon, Chu, character, protagonist, Barry
- Included Keyword: record
 - Keyword Alternatives: session, studio, back, support, accompan, auxiliar, side, supplement, assist, subsidiar

3. Key Phrase: Berry worked as a recording-session musician for eight years.

- Included Keyword: Berry
 - Keyword Alternatives: Leon, Chu, character, protagonist, Barry
- Included Keyword: music
 - Keyword Alternatives: sax, art, instument, play, record, session, studio, back, support, accompan, auxiliar, side, supplement, assist, subsidiar
- Included Keyword: 8
 - Keyword Alternatives: eight, some, few, coupl, less, more, several, handful, bunch, num, various, multi, many

4. Key Phrase: Berry was a tenor saxophonist.

- Included Keyword: Berry
 - Keyword Alternatives: Leon, Chu, character, protagonist, Barry
- Included Keyword: tenor
 - Keyword Alternatives:
- Included Keyword: sax
 - Keyword Alternatives:

5. Key Phrase: Berry briefly joined (landed a short-lived spot with) Count Basie's orchestra.

- Included Keyword: Berry
 - Keyword Alternatives: Leon, Chu, character, protagonist, Barry
- Included Keyword: Count
 - Keyword Alternatives: Basie
- Included Keyword: orchestra
 - Keyword Alternatives: ensemble, crew, gang, group, band, philharmonic, troupe, symphon

6. Key Phrase: Berry stood in for one of the Basie band's two tenor giants.

- Included Keyword: stood
 - Keyword Alternatives: sub, tap, fill, replace, stand, cover, locum, hold, alt, tak, second, backup, spar, reserv, extra
- Included Keyword: Count
 - Keyword Alternatives: Basie
- Included Keyword: giant
 - Keyword Alternatives: pro, big, virtu, league, veteran, master, expert, season, ace, adept, prime, premier, star, whiz, hot, lead, heavy, prominen, renown, famous, vip, distinguish, acclaim, head, top, panjandrum, high, tenor, v.i, icon, idol, outstanding, excellent, compar, match, domin, rival, stellar, supreme, major

7. Key Phrase: Berry took a lead solo in Count Basie's orchestra.

- Included Keyword: Berry
 - Keyword Alternatives: Leon, Chu, Protagonist, Character, Barry
- Included Keyword: Count
 - Keyword Alternatives: Basie
- Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, indepedent, exclusive

8. Key Phrase: Berry took a lead solo on "Oh, Lady Be Good" (for Count Basie's orchestra).

- Included Keyword: Berry
 - Keyword Alternatives: Leon, Chu, Protagonist, Character, Barry
- Included Keyword: lady
 - Keyword Alternatives:
- Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, indepedent, exclusive

9. Key Phrase: "Oh, Lady Be Good" is a 1924 Gershwin song.

- Included Keyword: lady
 - Keyword Alternatives:
- Included Keyword: 1924
 - Keyword Alternatives: Gershwin, ninteen, twenty, four, 1920s, 1920's

10. Key Phrase: Basie had played “Oh, Lady Be Good” for years.

- Included Keyword: Count
 - Keyword Alternatives: Basie
- Included Keyword: lady
 - Keyword Alternatives: song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk
- Included Keyword: year
 - Keyword Alternatives: age, time, long, period, decade, span, duration, count, moment, interval, life, exist, stag, phas, season, cycle, instance, event, era, generation, occurence, frame

11. Key Phrase: The solo (“Oh, Lady Be Good”) lasted 28 seconds.

- Included Keyword: 28
 - Keyword Alternatives: twenty, 30, thirty, half, 20, 21, 22, 23, 24, 25, 26, 27, 29, third
- Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, indepdent, exclusive, lady
- Included Keyword: sec
 - Keyword Alternatives: min

12. Key Phrase: The solo (“Oh, Lady Be Good”) was on February 4, 1939.

- Included Keyword: Feb
 - Keyword Alternatives: 1939, ninteen, thirty, nine, 2/, 2., 2-, /2, .2, -2, four
- Included Keyword: solo

- Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, inpedent, exclusive, lady

13. Key Phrase: The solo (“Oh, Lady Be Good”) was the musical personification of mind and body.

- Included Keyword: bod
 - Keyword Alternatives: physi, anatomy, figure, form, frame, shape, mind, brain, psyche, wits, thought, state, mental, cogni, conscious, process, think, perce, aware, soul, spirit, intelligen, understand, reason
- Included Keyword: lady
 - Keyword Alternatives:
- Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, inpedent, exclusive

14. Key Phrase: The solo (“Oh, Lady Be Good”) was like mind and body working together in divine musical tandem.

- Included Keyword: lady
 - Keyword Alternatives:
- Included Keyword: bod
 - Keyword Alternatives: physi, anatomy, figure, form, frame, shape, mind, brain, psyche, wits, thought, state, mental, cogni, conscious, process, think, perce, aware, soul, spirit, intelligen, understand, reason
- Included Keyword: together

- Keyword Alternatives: collectively, concert, alliance, hand, tandem, side, whole, team, join, assist, support, aid, help, partner, align, engage, league, coact, interact, band, uni, cooperat, collab, simultaneous, harmon, coordinat, cahoot, participat, contribut, mutual, combin, cohesive, cocurrent, bond, bind, link, bridg, integrat, connect, intertwine, blend, weav, complement, merg, fus
- Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, independent, exclusive
15. Key Phrase: When listeners hear the recording (“Oh, Lady Be Good”) for the first time, they’re likely to wonder why they have not heard of Berry before.
- Included Keyword: lady
 - Keyword Alternatives:
 - Included Keyword: hear
 - Keyword Alternatives: listen, detect, catch, heed, grasp, understand, ascertain, gather, pick, take, absorb, discover, note, detect, learn, aware, perceiv, atten, notic, register, recog, sens, acquir, encounter, confront, experienc, stumble, across, know, knew, tune, tuning
 - Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, independent, exclusive
16. Key Phrase: There is a lack of recognition regarding Berry (Why people never heard of him is pretty simple).
- Included Keyword: recogni

- Keyword Alternatives: know, lack, pop, mem, recall, recollect, familiar, aware, attent, regard, reput, public, cover, expos, status, prestig, obscur, anon, merit, famous, appreciat, accept, validat, realiz, understand, perception, perceiv, notice, acclaim, tribute, praise, approval, respect, honor, fame, credit, distinct, accolade, notab, identi

17. Key Phrase: Many hard-core jazz buffs don't know about Berry.

- Included Keyword: buff
 - Keyword Alternatives: jazz, expert, enthusiast, fan, music, connoisseur, pro, listener, critic, devot, aficionado, follower, cognoscenti, maven, adept, disciple, zealot, admirer, nerd, guru, specialist, collector, scholar, lover
- Included Keyword: know
 - Keyword Alternatives: recogni, popular, famous, mem, lack, mem, recall, recollect, familiar, aware, attent, regard, public, obscur, anon, merit, fame, famous, appreciat, accept, identif, validat, realiz, understand, perception, perceiv, notice, acclaim, tribute, praise, respect, honor, fame, credit, distinct, approv, hear

18. Key Phrase: Berry has shown up on recordings with Basie.

- Included Keyword: Basie
 - Keyword Alternatives:
- Included Keyword: record
 - Keyword Alternatives: track, session, tape, audio, album, disc, file, playback, sample, perform, captur, broadcast, product, video, platter, vinyl, cassette, clip, collection, composition, score, release, piece, tune, song, discograph, playlist, music, melod, sound, rendition, document, copy, copies, transcript, version, take, notation, archiv

19. Key Phrase: Berry has shown up on recordings with Bessie Smith.

- Included Keyword: Bessie
 - Keyword Alternatives: Smith
- Included Keyword: record

- Keyword Alternatives: track, session, tape, audio, album, disc, file, playback, sample, perform, captur, broadcast, product, video, platter, vinyl, cassette, clip, collection, composition, score, release, piece, tune, song, discograph, playlist, music, melod, sound, rendition, document, copy, copies, transcript, version, take, notation, archiv

20. Key Phrase: Berry has shown up on recordings with Fletcher Henderson.

- Included Keyword: Fletcher
 - Keyword Alternatives: Henderson
- Included Keyword: record
 - Keyword Alternatives: track, session, tape, audio, album, disc, file, playback, sample, perform, captur, broadcast, product, video, platter, vinyl, cassette, clip, collection, composition, score, release, piece, tune, song, discograph, playlist, music, melod, sound, rendition, document, copy, copies, transcript, version, take, notation, archiv

21. Key Phrase: Berry has shown up on recordings with Billie Holiday.

- Included Keyword: Billie
 - Keyword Alternatives: Holiday
- Included Keyword: record
 - Keyword Alternatives: track, session, tape, audio, album, disc, file, playback, sample, perform, captur, broadcast, product, video, platter, vinyl, cassette, clip, collection, composition, score, release, piece, tune, song, discograph, playlist, music, melod, sound, rendition, document, copy, copies, transcript, version, take, notation, archiv

22. Key Phrase: Berry did not cut many sessions himself as a leader.

- Included Keyword: lead
 - Keyword Alternatives: side, back, complement, main, prim, head, foc, charge, support, accompan, auxiliar, side, supplement, assist, subsidiar, Chief, Boss, Director, Manager, Supervisor, Captain, Commander, President, Organizer, Guide, Mentor, Champion, Controller, Conductor, Foreman, Team, Ringleader, Pacesetter, chairman, foreman

- Included Keyword: session
 - Keyword Alternatives: recording, audio, track, perform, play, piece, song
23. Key Phrase: When Berry soloed, he worked within the recording constraints of the era and the swing genre.
- Included Keyword: strain
 - Keyword Alternatives: rule, standard, limit, industr, expect, bound, confin, defin, dictat, inspir, control, inhibit, prevent, narrow, broad, influen, classic, typ, exten, strict, imped, hinder, discourag, stop, recogni, notic, less, more, advanc, epitome, embodi, demand, styl, drawback, barrier, obstacle, handicap, difficult, identi, shackl, hurdl, bottl, ruling
 - Included Keyword: swing
 - Keyword Alternatives: era, jazz, bebop, blues, genre, solo, age, period, generation, histor, span, fram, epoch, time, record
 - Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, exclusive, sole, self, spotlight, indepdent, beat, tempo, bpm, bar, measure, signature, meter
24. Key Phrase: The swing genres' constraints were fast-moving 78s (a specific type of vinyl record that was lower quality).
- Included Keyword: swing
 - Keyword Alternatives: era, jazz, bebop, blues, genre, solo, age, period, generation, histor, span, fram, epoch, time, record
 - Included Keyword: strain
 - Keyword Alternatives: rule, standard, limit, industr, expect, bound, confin, defin, dictat, bottl, inspir, control, inhibit, prevent, narrow, broad, influen, classic, typ, exten, strict, imped, hinder, discourag, stop, identi, recogni, notic, less, more, advanc, epitome, embodi, demand, styl, drawback, shackl, barrier, hurdl, obstacle, handicap, difficult, ruling

- Included Keyword: 78
 - Keyword Alternatives:

25. Key Phrase: The swing genres' constraints were solos (often) lasting for a mere 32 beats.

- Included Keyword: swing
 - Keyword Alternatives: era, jazz, bebop, blues, genre, solo, age, period, generation, histor, span, fram, epoch, time, record
- Included Keyword: strain
 - Keyword Alternatives: rule, standard, limit, industr, expect, bound, confin, defin, dictat, bottl, inspir, control, inhibit, prevent, narrow, broad, influen, classic, typ, exten, strict, imped, hinder, discourag, stop, identi, recogni, notic, less, more, advanc, epitome, embodi, demand, styl, drawback, shackl, barrier, hurdl, obstacle, handicap, difficult, ruling
- Included Keyword: 32
 - Keyword Alternatives: time, little, small, mini, brief, short, fleet, limit, moment, quick, transient, ephemeral, slight, significan, minor, meager, modest, beat, note, pace, count, measure, signature, tiny, micro, paltry, infinitesimal, mere

26. Key Phrase: The people who loved Berry were (not surprisingly) other tenor players.

- Included Keyword: tenor
 - Keyword Alternatives: sax, instrument, peer, horn, colleague, musician, fellow, associate, cohort, coeval, contemporar, mate
- Included Keyword: lov
 - Keyword Alternatives: like, recogni, regard, reput, merit, appreciat, accept, validat, realiz, notice, acclaim, respect, honor, credit, distin, admir, fanc, esteem, prefer, cherish, ador, liking, acknowledg, commend, approv, embrac, favor, favour, applaud, grateful, tribut, prais, valu, treasur

27. Key Phrase: Berry was tagged “musician’s musician.”

- Included Keyword: musician’s musician
 - Keyword Alternatives:

28. Key Phrase: The tag “musician’s musician” was dreaded.

- Included Keyword: musician’s musician
 - Keyword Alternatives:
- Included Keyword: dread
 - Keyword Alternatives: bad, fear, apprehen, terr, concern, desir, fright, shudder, afraid, scar, avoid, away, anxi, haunt, alarm, troub, awful, crap, suck, bum, disast, crum, atrocious, hurt, harm, worr, trembl, hate, hating, welcoming, welcome, miser, horr, mediocre, abysmal, pathetic, dismal, subpar, misgiv, rubbish, suck, stink, blow, crummy, satisf, disappoint, lousy

29. Key Phrase: The tag “musician’s musician” is not nearly enough praise to describe Chu Berry.

- Included Keyword: musician’s musician
 - Keyword Alternatives:
- Included Keyword: enough
 - Keyword Alternatives: adequat, ample, satisf, accept, competen, decen, appropriat, suit, fit, commensura, scratch, suffic, right, fair, okay, meet, grati, fulfill, proper, capab, reason, substan, qualif, mark, job, considerat, genero, kind
- Included Keyword: descri
 - Keyword Alternatives: portray, depict, characteriz, characteris, line, detail, illustrat, present, defin, explain, explan, narrat, outlin, express, forth, recount, paint, pictur, render, chronicl, report, enumerat, sketch, show, comment, convey, specif, constru, label, interpret, state, stating, exemplif, draw, elucidat, distinguish, epitom, explicat, warrant, communicat, disclos, reveal, project, impart, articulat, voic, verbal, declar, convers, constitut, demonstrat, manifest, connot, proclaim, speak, phras, deliver, carry, carri, bear, conduc, bring, emphasi, highlight, stress, underlin, spotlight, focus, promot, magnif, insist, priorit, elevat, strength, amplif, reiterat, height, clear, point, underscor, reinforc, enforc, weigh, strong, power, affirm, assert, indicat, accent, enunciat, headlin, mark, punctuat, emphatic

30. Key Phrase: When given opportunity, Berry displayed great musical dexterity.

- Included Keyword: Berry

- Keyword Alternatives: Leon, Chu, character, protagonist, Barry
 - Included Keyword: dex
 - Keyword Alternatives: skill, finesse, abilit, adept, adapt, pro, apt, capab, expert, master, talent, acu, wit, insight, hand, art, touch, know, forte, smarts, savvy, gift, knack, craft, play, agil, deft, fluen, clever, nimb, competenc, facilit, adroit, qualif, versatil, ingen, efficien, prowess, special, experienc, season, verse, cred, proficien, advanced, accomplish, virtuos, competent, excel, polish, distinguish, eliti, elite, superior, notch, strong, fast, quick, speed, velocity
31. Key Phrase: Berry’s musical dexterity would be envied by future generations of horn men.
- Included Keyword: env
 - Keyword Alternatives: jealous, desir, covet, want, long, wish, yearn, begrud, resent, crav, respect, esteem, appreciat, applaud, valu, ador, idol, rever, regard, prize, commend, glor, prais, venerat, extol, laud, worship
 - Included Keyword: dex
 - Keyword Alternatives: skill, finesse, abilit, adept, adapt, pro, apt, capab, expert, master, talent, acu, wit, insight, hand, art, touch, know, forte, smarts, savvy, gift, knack, craft, play, agil, deft, fluen, clever, nimb, competenc, facilit, adroit, qualif, versatil, ingen, efficien, prowess, special, experienc, season, verse, cred
32. Key Phrase: Berry faced (similar challenges as) the lot of other horn players.
- Included Keyword: face
 - Keyword Alternatives: compet, against, conten, clash, cross, lock, head, wrestl, beat, battl, tangl, confront, dealt, encounter, engag, contest, facing, tussl, handl, address
 - Included Keyword: horn
 - Keyword Alternatives: sax, tenor, instrument, peer, colleague, player, musician, artist, performer, fellow, associate, cohort, coeval, contemporar, mate
33. Key Phrase: Horn players had to work hard (grind it out long and hard) until something memorable burst through.
- Included Keyword: horn

- Keyword Alternatives: sax, tenor, instrument, peer, colleague, fellow, player, musician, artist, performer, associate, cohort, coeval, contemporar, mate
- Included Keyword: work
 - Keyword Alternatives: challenge, push, churn, grind, endeavor, pursuit, engage, labor, dut, commit, driv, mission, undertak, invest, time, chas, hunt, accomplish, achiev, bring, exert, sweat, toil, try, struggl, striv, out, fight, tackl, take, endur, hard, trie, persever, taking, sweat, tear, blood, diligent, persist, carr, stick, hang, soldier, overcom, determin, firm, resolut, relentless, tenac
- Included Keyword: memor
 - Keyword Alternatives: novel, unique, signif, note, event, special, catchy, remark, impress, interest, mean, moment, monument, terrific, forget, critic, distinguish, except, extra, great, compel, convinc, consequen, substan, special, prominen, lasting, mind, forget, note, notab, stand, distinct, resona, indelibl

34. Key Phrase: The listening public had prejudices.

- Included Keyword: public
 - Keyword Alternatives: listen, pop, societ, audience, crowd, viewer, spectator, listener, people, count, number, everyone, folk, person, community, nation, country, world
- Included Keyword: prejudice
 - Keyword Alternatives: bias, discriminat, bigot, tolera, stereo, concept, partial, position, judg, narrow, mind, fair, conceiv, notion, opinion, judicial, attitud, phobia, hate, hatred, avers, animo, animus, ignoran, hostil, possess, enmit, resent, bitter, antagon, malice, rancor, spite, grudg, acrimon, oppos, griev, discord, tens, contempt, alien, detest, disdain, abhorren, pugnan, odium, loath, venom, unjust, equitable, equal, reason, portion, balanc, ethic, warrant, prefer, invidious, favor, justi, scrupl, arbitrar, sided, like, liking

35. Key Phrase: The listening public had expectations.

- Included Keyword: public
 - Keyword Alternatives: listen, pop, societ, audience, crowd, viewer, spectator, listener, people, count, number, everyone, folk, person, community, nation, country, world

- Included Keyword: expect
 - Keyword Alternatives: anticipat, await, predict, foresee, foretell, vision, forecast, project, count, assum, presum, hope, hoping, imagin, visual, plan, prepar, bank, reckon, think, conject, estimat, envisag, calculat, forward, contemp, speculat, ready, readi, guess, figur, foreknow, grant, mind, inten, trust

36. Key Phrase: There was an accepted wisdom of what is and isn't art in a given medium (i.e. swing music).

- Included Keyword: accept
 - Keyword Alternatives: approv, acknowled, affir, respect, admit, endors, submit, uphold, adhere, adjust, defin, know, expect, stay, recogni, agree, cheris, priz, valu, valid, wisdom, convention, permit, custom, standard, welcom, establish, mores, norm
- Included Keyword: art
 - Keyword Alternatives: music
- Included Keyword: medium
 - Keyword Alternatives: instrument, vehicl, channel, method, intermedi, mode, agenc, platform, outlet, venu, mechanism, system, tool, agent, operand, conduit, implement, approach, path, apparatus, resourc, mean

37. Key Phrase: Swing music was fodder for dance parties.

- Included Keyword: swing
 - Keyword Alternatives: jazz, song, music, piece, tune, melody, track, genre, harmon, sing, sang, sung, bebop, blues
- Included Keyword: danc
 - Keyword Alternatives: together, gather, jig, twirl, sway, shuffle, shimmy, waltz, tango, sashay, groov, fun, enjoy, pleasur, amus, delight, lightheart, play, cheer, liv, excit, engag, mirth, jov, festiv, entertain, event, social, shindig, soiree, fiesta, function, bash, reception, fete, affair, rendezvous, jamboree, celebrat, mix, party, parties

38. Key Phrase: Swing music was thought not to be worthy of study.

- Included Keyword: swing
 - Keyword Alternatives: jazz, song, music, piece, tune, melody, track, genre, harmon, sing, sang, sung, bebop, blues
- Included Keyword: worth
 - Keyword Alternatives: respect, accept, admir, deserve, val, good, great, recogni, laud, use, benefit, profit, gain, advantage, stud, serious, learn, research, review, absorb, comprehend, grasp, master, understand, ponder, examin, investigat, explor, analyz, delv, scrutiniz, perus, acquir, contemplat, merit, import, consequence, meaning, estimation, cost, significan, desir, virtu

39. Key Phrase: Berry's geniality might explain his failure to become well-known (court history's favor).

- Included Keyword: genial
 - Keyword Alternatives: nice, friend, cheer, enjoy, agree, kind, grat, warm, good, welcom, pleas, delight, great, awesom, nifty, peach, swell, charm, merry, admir, amiable, attract, wonder, marvel, dandy, consider, grac, polite, thought, respect, sweet, joy, person, heart, tender, bene, altru, self, humbl, affab, cordial, modest, hospital, likab, approacha, openness, benign, gentl, humor, convival, sympath, empath, jovial, companion, compassion, socia, approv, amicable, serene, tranquil, peace, satisf, boast, ego
- Included Keyword: fail
 - Keyword Alternatives: know, recogni, lack, pop, fam, mem, recall, recollect, familiar, aware, celeb, giant, pro, big, virtu, league, veteran, master, expert, season, ace, adept, prime, premier, star, whiz, hot, lead, heavy, prominen, renown, vip, distinguish, acclaim, head, top, panjandrum, high, influ, v.i, import, icon, idol, name, public, light, status, merit, cover, expos, note, notab, legend, establish, regard, recogni, public, reput, respect, like, liking, admir, prestig, well, eminen, shortcoming, misfortun, setback, flaw, error, ruin, weakness, deficien, collaps

40. Key Phrase: It wasn't in Berry's nature to call attention to himself (or his playing).

- Included Keyword: Berry

- Keyword Alternatives: Leon, Chu, nature, person, disposition, tend, inclin, entit, make, demeanor, attitud, habit, being, psych, self, moti, essen, spirit, soul, qualit, practic, custom, belie, manner, style, protagonist, character, Barry, mind, mood, humor, individual, identi, temper, behav, outlook, inclination, tendenc
- Included Keyword: atten
 - Keyword Alternatives: off, modest, aware, regard, scrutin, heed, consider, conscious, curious, surveil, concern, mind, distinct, light, conspicuous, establish, call, draw, distinguish, show, aware, regard, notic, scrutin, heed, consider, conscious, curious, surveil, concern, mind, distinct, light, conspicuous, establish, call, draw, distinguish, flaunt, boast, brag, strut, vaunt, swagger, exhibit, display, present, brand, unveil, reveal, impress, trumpet, tout, showboat, peacock, parad, featur, demonstrat, exaggerat, stand, modest, discreet, low-key, bashful, demure, quiet, earth, simple, genuine, humbl, assum, reserv, effac, pretent, ostentat, understat, depreciat, trovert, restrain, control, withdraw, flash, impos, out

41. Key Phrase: Berry was born in 1908.

- Included Keyword: 1908
 - Keyword Alternatives: twent, 20, eight, nine

42. Key Phrase: Berry was born into the Black middle class.

- Included Keyword: black
 - Keyword Alternatives: African, Afro
- Included Keyword: middle
 - Keyword Alternatives: working, class, bourgeois, income, rich, poor, proletaria, laboring, burgherdom, bracket

43. Key Phrase: Berry was born in Wheeling, West Virginia.

- Included Keyword: Wheeling
 - Keyword Alternatives: West, Virginia, WV, W.V.

44. Key Phrase: Berry was laid-back and affable (easy-going).

- Included Keyword: affable

- Keyword Alternatives: genial, nice, friend, cheer, enjoy, agree, kind, grat, warm, good, welcom, pleas, delight, great, awesom, nifty, peach, swell, charm, merry, admir, amiable, approv, attract, wonder, marvel, dandy, consider, grac, polite, thought, respect, sweet, joy, person, heart, tender, bene, altru, self, humbl, affable, cordial, socia, modest, hospital, likab, approacha, openness, benign, gent, humor, convival, sympath, empath, jovial, companion, compassion, amicable, laid, back, calm, chill, casual, poise, serene, tranquil, nonchalant, mellow, compos, lax, peace, nonplussed, cool, languid, easy, untroubl, undemand, unfaze, leisurely, blithe, satisf, boast, ego

45. Key Phrase: Berry attended West Virginia State in Charleston.

- Included Keyword: West Virginia State
 - Keyword Alternatives: Charleston, university, college, educat, conservatory, institut, school

46. Key Phrase: Berry switched from alto sax to tenor in college.

- Included Keyword: alto
 - Keyword Alternatives:
- Included Keyword: tenor
 - Keyword Alternatives:

47. Key Phrase: Berry exhibited the willingness to fit in (many dance bands).

- Included Keyword: will
 - Keyword Alternatives: read, inclin, prepar, content, along, agree, flex, acquiesce, welcom, eager, open, enthusiastic, keen, voluntary, happy, favorable, prone, amenable, cooperat, oblig, respon, motivat, interest, dispos, compliant, receptiv, accommodating
- Included Keyword: fit
 - Keyword Alternatives: belong, includ, member, part, assoc, accept, affil, recogni, link, connect, interact, communicat, engag, mingl, contact, network, meet, relat, bond, socia, harmon, squar, all, among, bridg, run, swing, ran, plac, group, includ, integrat, assimilat, incorporat, join, involv, partak, blend, conform, adapt, adjust, acclimat, coexist, identi, suit, assort, participat, coordinat, comply, complie, accommodate

48. Key Phrase: Berry participated (played) in many dance bands (characterized his presence in so many dance bands).

- Included Keyword: danc
 - Keyword Alternatives: part, together, gather, jig, twirl, sway, shuffle, shimmy, waltz, tango, sashay, groov, fun, enjoy, pleasur, amus, delight, lightheart, play, cheer, liv, excit, engag, mirth, jov, festiv, entertain, event, social, shindig, soiree, fiesta, function, bash, reception, fete, affair, rendezvous, jamboree, celebrat, mix
- Included Keyword: band
 - Keyword Alternatives: ensemble, crew, gang, group, orchestra, philharmonic, troupe, symphon

49. Key Phrase: Berry (was the rare artist who) refused to put his interests above those of the band.

- Included Keyword: interest
 - Keyword Alternatives: desir, wish, hope, dream, plan, business, matter, affair, endeavo, task, work, pursuit, tim, thing, engagement, dut, responsibilit, commit, obligation, mission, himself, need, prefer, self, sacrific, considerat, help, passion, priorit, first, want, goal, objective, ambition, aspir, before
- Included Keyword: band
 - Keyword Alternatives: ensemble, crew, gang, group, orchestra, philharmonic, troupe, symphon

50. Key Phrase: Berry (was the rare artist who) was willing to play ensemble passages rather than taking a healthy allotment of solo breaks.

- Included Keyword: ensemble
 - Keyword Alternatives: riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, ensemble, background, group, play, act, perform, troupe, part, lineup, compan, set, team, support, other, orchestra, music, rhythm, heal, side
- Included Keyword: solo

- Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, sole, self, spotlight, indepedent, exclusive

51. Key Phrase: College provided (proved) a training ground for Berry.

- Included Keyword: college
 - Keyword Alternatives: Charleston, university, West, Virginia, State, educat, conservatory, institut, school
- Included Keyword: train
 - Keyword Alternatives: coach, tutor, drill, prep, lesson, guidance, instruct, camp, direct, stud, know, exercis, practic, hone, honing, develop, refin, facilitat, fertile, instrument, teach, taught, learn, disciplin, experienc, cultivat, master, nurtur, build

52. Key Phrase: Berry was a bandsman.

- Included Keyword: Berry
 - Keyword Alternatives: Leon, Chu, character, protagonist, Barry
- Included Keyword: bandsman
 - Keyword Alternatives: musician, instrumentalist, player, performer, artist

53. Key Phrase: Berry teamed up with a number of amateur outfits (in bands) at college.

- Included Keyword: amateur
 - Keyword Alternatives: outfit, band, ensemble, crew, gang, group, orchestra, philharmonic, troupe, instrument, peer, colleague, fellow, player, musician, artist, performer, Novice, Beginner, Rookie, Layperson, Dabbler, Enthusiast, Greenhorn, Apprentice, Fledgling, Casual, nonprofessional, experienc, hobb, new, skill, train, expert, dilettante, learn, neophyte, apprentice, practic, qualif, tyro, associate, cohort, coeval, contemporar, mate
- Included Keyword: college
 - Keyword Alternatives: Charleston, university, West, Virginia, State, educat, conservatory, institut, school

54. Key Phrase: Berry never played (simply) to show off.

- Included Keyword: play
 - Keyword Alternatives: perform, acu, wit, hand, touch, know, forte, music, work, passion, craft, invov, jam, abilit, dex, skill, finesse, adept, adapt, pro, apt, capab, expert, master, talent, insight, art, passion, craft, touch, know, smarts, savvy, gift, knack, music, work
- Included Keyword: show
 - Keyword Alternatives: off, attent, modest, aware, regard, notic, scrutin, heed, consider, conscious, curious, surveil, concern, mind, distinct, light, conspicuous, establish, call, draw, distinguish, show, aware, regard, notic, scrutin, heed, consider, conscious, curious, surveil, concern, mind, distinct, light, conspicuous, establish, call, draw, distinguish, flaunt, boast, brag, strut, vaunt, swagger, exhibit, display, present, brand, unveil, reveal, impress, trumpet, tout, showboat, peacock, parad, featur, demonstrat, exaggerat, stand, modest, discreet, low-key, bashful, demure, quiet, earth, simple, genuine, humbl, assum, reserv, effac, pretent, ostentat, understat, depreciat, trovert, restrain, control, withdraw, flash, impos, out, nota

55. Key Phrase: Berry tried to bring out the positive attributes in any given situation (or setting).

- Included Keyword: positiv
 - Keyword Alternatives: optimis, hope, zeal, assur, cheer, bright, progress, help, sun, jovial, pleas, joy, good, friend, amiable, cordial, heart, happ, glee, satisf, light, jolly, spark, chirp, elat, sweet, agree, genial, affable, gentl, kind, nice, irie, grac, amus, constructive, promising, fruitful, successful, effective, efficient, excellent, valuable, remarkable, extraordinary, outstanding, superior, exceptional, confident, upbeat, buoyant, bright, sunny, enthusiastic, idealistic, encouraging, happy, content, assured, sanguine, expectant, radiant, elated, high-spirited, assured, lively, spirited, rosy, favorable, benifi, lift, advantag, power, merr

56. Key Phrase: Berry performed with the Calloway ensemble.

- Included Keyword: Calloway
 - Keyword Alternatives:
- Included Keyword: ensemble

- Keyword Alternatives: band, crew, gang, group, orchestra, philharmonic, troupe, symphon
- Included Keyword: perform
 - Keyword Alternatives: participat, collaborat, contribut, play, acu, wit, hand, touch, know, forte, music, work, passion, craft, invov, jam, abilit, dex, skill, finesse, adept, adapt, pro, apt, capab, expert, master, talent, insight, art, passion, craft, touch, know, smarts, savvy, gift, knack, music, work, cooperat, team, partner, join, engag, associat, liais, synerg

57. Key Phrase: The Calloway ensemble plays ragged and out-of-tune before Berry's first solo notes emerge.

- Included Keyword: rag
 - Keyword Alternatives: out, off, jar, discord, dissonant, music, not, harmon, melod, harsh, grat, phon, sound, flat, sharp, screech, jangl, strid, clang, pierc, racket, sour, squeak, ratchet, rug, uneven, hear, squawk, bitter, bleak, bad, sound, play, listen, tuning, tune, pitch, key, refin, order, coordinat, precis, organiz, organis, sync, balanc, haphazard, random, plan, system, method, chao, higgles, regular, mess, jumbl, muddl, confus, haywire, erratic, crazy, rupt, control, cooperat, defian
- Included Keyword: Calloway
 - Keyword Alternatives:
- Included Keyword: band
 - Keyword Alternatives: ensemble, crew, gang, group, orchestra, philharmonic, troupe, symphon, background, accompan, backing

58. Key Phrase: The other players (of the Calloway ensemble) no longer languidly blow through their charts.

- Included Keyword: languid
 - Keyword Alternatives: laz, lack, droop, tir, indfferent, inactive, sleep, snooz, weak, slug, slack, slo, sloth, energ, feebl, lethargic, life, dope, out, fatigu, drows, pass, wimp, indolent, leisure, passive, nonchalant, listless, easygoing, apathetic, languor, dull, torpid, laid, back, calm, chill, casual, poise, serene, tranquil, nonchalant, mellow, compos, lax, peace, nonplussed, cool, easy, untroubl, undemand, unfaze, leisurely, blithe

- Included Keyword: player
 - Keyword Alternatives: other, musician, sidemen, people, band, orchestra, ensemble, instrument, entertainer, performer, artist, member, group, team, crew, troupe, symphon, accompan, backing, background

59. Key Phrase: The other players (of the Calloway ensemble) immediately surge up behind Berry.

- Included Keyword: player
 - Keyword Alternatives: other, musician, sidemen, members, people, band, orchestra, ensemble, instrument, entertainer, performer, artist, member, group, team, crew, troupe, symphon, accompan, background, backing
- Included Keyword: surg
 - Keyword Alternatives: swell, jump, breakthrough, rush, flood, ris, expan, rall, avanc, charg, push, propel, spur, energiz, inspir, motivat, ignit, galvaniz, incit, stimulat, driv, mobiliz, escalat, swung, swing, turn, develop, flourish, floruish, thrive, prosper, soar, rocket, vigor, lift, spark, propel, fire, firing, emulat, mimic, adher, abid, tail, follow, heed, copy, copie

60. Key Phrase: The shenanigans (of the Calloway ensemble) resume once Berry finishes his solo.

- Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genr, harmon, rendition, single, one, exclusive, sole, self, spotlight, independent
- Included Keyword: shenanigans
 - Keyword Alternatives: antics, nonsens, mischief, behav, fool, wild, rowd, chicane, escapade, conduct, jinks, around, business, clown, sill, ruckus, malarkey, absurd, craz, mad, stupid, ridiculous, goof, act, buffoon, order, chao, havoc, anarch, mayhem, pandemonium, commotion, racket, discord, disarray, shambl, lunacy, insan, fren, turmoil, gimmick, trick, caper, rascal, monkey, hors, gambol

61. Key Phrase: Berry made his way to New York.

- Included Keyword: New York
 - Keyword Alternatives: apple, jungle, concrete, NY

62. Key Phrase: In New York, Berry immediately became a presence (as a jazz musician).

- Included Keyword: New York
 - Keyword Alternatives: apple, jungle, concrete
- Included Keyword: presenc
 - Keyword Alternatives: exist, appear, real, attend, occur, manifest, subsist, compan, incarnat, habit, dwell, residen, incorpor, incumbe, compan, abid, present, occupan, embod, figure, notic, domin, evolv, signif, command, transform, prominen, establish, force, impact, impress, recogni, compel, emerg, mark, influen, visib, note, pop, fame, famous, notor, reput, celeb, acclaim, esteem, renown, known, stature, eminen, distinct, stand, prestig, stat, importan, notab, glor, applaus, lime-light, honor, luster, cachet, name, regard, respect, star, venerat, public, prevalen, approbat, foot, clout, admir, relevan, appreciat

63. Key Phrase: In New York, Berry was soon in demand (as a jazz musician).

- Included Keyword: New York
 - Keyword Alternatives: apple, jungle, concrete, NY
- Included Keyword: demand
 - Keyword Alternatives: want, popular, desir, ask, sought, seek, covet, commodit, request, need, favor, favour, prefer, single, valu, die, vogue, worth, look, long, asset, important, fought, fight, compet, contend, vie, presence, rag, thing, trend, sensation, hit, talk, hype, catch, hot, priorit, prominen, visib, recogni, noto, fame, famous, reputa, stand, stood, influen, status, prestige, stature, wish, attract, hot-cake, market, sell, buzz, high, list, dying, priz, hyping, receive, hip, craz, happen, prevalen

64. Key Phrase: Great jazz orchestras of the swing era were headed (fronted) by musical directors/arrangers.

- Included Keyword: direct

- Keyword Alternatives: arrang, head, lead, manag, administrat, organiz, produc, supervis, overseer, exec, coordinat, design, develop, promot, facilitat, conduct, virtuoso, maestr, impresairo, maven

- Included Keyword: swing

- Keyword Alternatives: jazz, bebop, blues, orchestra, ensemble, band

65. Key Phrase: Duke Ellington (of the swing era) was preeminent.

- Included Keyword: Duke

- Keyword Alternatives: Ellington

- Included Keyword: eminent

- Keyword Alternatives: giant, pro, big, virtu, league, veteran, master, expert, season, ace, adept, prime, premier, star, whiz, hot, lead, heavy, prominen, renown, famous, vip, distinguish, acclaim, head, top, panjandrum, high, tenor, v.i, icon, idol, outstanding, excellent, one, 1, compar, match, domin, rival, stellar, supreme, major, notable, note, prestigious, superior, celeb, respect, except, prodig, ordinar, remark, influen, reput, honor, esteem, illustrious, applau

66. Key Phrase: The musical directors/arrangers (in the great jazz orchestras of the swing era) drew acclaim.

- Included Keyword: direct

- Keyword Alternatives: arrang, head, lead, manag, administrat, organiz, produc, supervis, overseer, exec, person, people, coordinat, design, develop, promot, facilitat, conduct, virtuoso, maestr, impresairo, maven

- Included Keyword: acclaim

- Keyword Alternatives: eminent, notable, note, prestigious, superior, celeb, respect, except, prodig, ordinar, remark, influen, reput, honor, esteem, illustrious, giant, pro, big, virtu, league, veteran, master, expert, season, ace, adept, prime, premier, star, whiz, hot, lead, heavy, prominen, renown, famous, vip, distinguish, head, top, panjandrum, high, v.i, icon, idol, outstanding, excellent, one, 1, compar, match, domin, rival, stellar, supreme, major, success, recogn, prais, distinct, commend, know, admir, applau, appreciat, plaudit, kudo, accolad, ovation, approbat, laudat, tribut, glor, fame, famous, reveren, cheer

67. Key Phrase: Sidemen were musical traveling salesmen (who sold someone else's wares).

- Included Keyword: side
 - Keyword Alternatives: members, people, band, orchestra, ensemble, instrument, entertainer, performer, artist, recording, session, studio, back, musician, support, accompan, auxiliar, supplement, assist, subsidiar
- Included Keyword: sale
 - Keyword Alternatives: sell, deal, trade, bargain, transact, advert, market, merch, vend, business, retail

68. Key Phrase: Sidemen played others' pieces (in the best style they could manage).

- Included Keyword: sidem
 - Keyword Alternatives: members, people, band, orchestra, ensemble, instrument, entertainer, performer, artist, recording, session, studio, back, musician, back, side, support, accompan, auxiliar, supplement, assist, subsidiar
- Included Keyword: play
 - Keyword Alternatives: work, perform
- Included Keyword: piece
 - Keyword Alternatives: riff, note, measure, song, bit, tune, melod, number, part, portion, segment, chunk, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, music, passage, signature, meter, bar

69. Key Phrase: With Fletcher Henderson, Berry was able to become more than a typical sideman (ditch the sideman's subservient trappings).

- Included Keyword: Fletcher
 - Keyword Alternatives: Henderson
- Included Keyword: more
 - Keyword Alternatives: not, over, beyond, high, exceed, larg, great, extra, add, increase, long, extend, further, advanc, far, past, pass
- Included Keyword: side

- Keyword Alternatives: members, people, band, orchestra, ensemble, instrument, entertainer, performer, artist, recording, session, studio, back, musician, back, support, accompan, auxiliar, supplement, assist, sibsidiar

70. Key Phrase: Fletcher Henderson wrote in keys that were rare for jazz orchestras of the day (in the swing era).

- Included Keyword: key
 - Keyword Alternatives: riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, chunk, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, phrase, role, music, composition, tone, pitch, frequenc, hz, hertz, sharp, flat, octave
- Included Keyword: Fletcher
 - Keyword Alternatives: Henderson
- Included Keyword: rare
 - Keyword Alternatives: memor, novel, unique, signif, note, event, special, hard, impress, interest, mean, moment, monument, terrific, forget, last, critic, mind, break, distinguish, except, extra, great, compel, convinc, consequen, substan, special, prominen, limit, scarc, few, sparse, heard, frequent, ordinary, innovat, invent, creat, pioneer

71. Key Phrase: Henderson’s voicings (arrangement) were an ideal match to Berry.

- Included Keyword: Fletcher
 - Keyword Alternatives: Henderson
- Included Keyword: music
 - Keyword Alternatives: key, riff, passage, piece, note, measure, song, bit, perform, play, tune, melod, number, part, portion, segment, chunk, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, phrase, role, composition, voic, arrange, bar, signature, meter, pitch, tone, hz, hertz, octave, phras, inflect, embellish
- Included Keyword: ideal

- Keyword Alternatives: match, same, similar, equ, compar, close, near, analogous, ident, akin, relat, parallel, differ, level, more, less, superior, along, high, align, together, pair, partner, duo, standard, criter, exampl, mirror, fit, optim, represent, counter, relat, suit, like, likable, liking

72. Key Phrase: Henderson's voicings (arrangement) were somber.

- Included Keyword: Fletcher
 - Keyword Alternatives: Henderson
- Included Keyword: somber
 - Keyword Alternatives: gloom, melanchol, sombre, dismal, mourn, sad, depress, grav, serious, solemn, dark, elegiac, lament, dole, pensive, sorrow, heavy, heart, spirit, tear, woe, lugubr, deject, despond, plain, desolat, forlorn, drear, down, cast, wist, morose, funereal, bleak, miser, sullen, shadow, grim, glum, subdu, grief, griev, dusk, dim, shad, twilight, cloud

73. Key Phrase: Henderson's voicings (arrangement) were indigo-inflected.

- Included Keyword: Fletcher
 - Keyword Alternatives: Henderson
- Included Keyword: indigo
 - Keyword Alternatives: inflect, seren, introspect, contemplat, calm, peace, tranquil, melachol, thought, depth, spirit, wisdom, reflect, solitud, meditat, fantas, dream, enigma, rever, myster, aware, digni, profound, still, insight, perce, subtl, eternit, timing, balanc, sincer, eleganc, compass, intuit, mysti, surrender, enchant, nostalgi, reminisc, violet, purple, lavender, amethyst, eggplant, plum, periwinkle, mauve, lilac, mulberr, iris, orchid, heather, grape, damson, thistle, acai, elderberr, hyacinth, wisteria, sloe, blackberr, magenta, flex, bend, modif, alter, vary, vari, chang, transform, adapt, adjust, shift, morph, modulac, amend, mutat, conver, revis, tune, tuningdistort, configur, construct, arrang, organiz, organis, transmut, evolv, transition, figur, edit, shap

74. Key Phrase: Berry had an introspective approach to his instrument.

- Included Keyword: spect

- Keyword Alternatives: thought, reflect, contemplat, meditat, reason, speculat, self, mus, ruminat, pensiv, brood, stud, analy, examin, observ, scrutiniz, insight, deep
- Included Keyword: instrument
 - Keyword Alternatives: tenor, sax, horn, music
- Included Keyword: approach
 - Keyword Alternatives: method, technique, strat, style, manner, tactic, means, process, way, direct, focus

75. Key Phrase: Berry sounds like he is being swallowed by his sax.

- Included Keyword: swallow
 - Keyword Alternatives: over, consume, engulf, drown, envelop, devour, gorge, lost, bur, possess, floating, marr, unite, one, tune, harmony, unison
- Included Keyword: sax
 - Keyword Alternatives: instrument, tenor, horn

76. Key Phrase: “Blues in C Sharp Minor” is odd

- Included Keyword: Blues
 - Keyword Alternatives: Sharp, minor, piece, track, song, arrang, compos, cover, rendition, passage, key, tune, melod, harmon, recital, sang, sung, excerpt
- Included Keyword: odd
 - Keyword Alternatives: peculiar, usual, strange, quirk, centric, curious, weird, outland, unique, singl, singu, normal, beat, common, rare, ordinar, differ, syncretic, anomal, convention, orthodox, diverg, typical, bizarr, quiz, curious, distinct, except, regular

77. Key Phrase: “Blues in C Sharp Minor” is haunting

- Included Keyword: Blues
 - Keyword Alternatives: Sharp, Minor, song, piece, tune, compos, track, arrang, cover, rendition, passage, key, melod, harmon, recital, sang, sung, excerpt
- Included Keyword: haunt

- Keyword Alternatives: eerie, spook, ghost, creep, chill, settl, macabre, myster, canny, world, natur, enigma, phantas, spectr, curs, terrif, witch, mesmer, captivat, fascinat, hypno, forget, spell, bind, earth, evocat, poignant, stir, grip, allur, ominous, mystic, fright, disturb, rais, sinister, shallow, wraith, clandestine, shadow, cimmerician, lament, impos, wist

78. Key Phrase: “Blues in C Sharp Minor” is (ultimately) relaxing

- Included Keyword: Blues
 - Keyword Alternatives: Sharp, Minor, song, piece, track, arrang, compos, cover, rendition, passage, key, tune, melod, harmon, recital, sang, sung, excerpt
- Included Keyword: lax
 - Keyword Alternatives: calm, seren, peace, sooth, wind, juvenat, rest, leisur, pleas, comfort, mellow, laid, easy, easi, gentl, fresh, placid, chill, hush, disturb, reliev, care, caring, creati, quiet, light, content, demand, repos, tens, meditat, soft, effort, hassl, compress, stress, satisf, pain, therap, fill, vital, vigor, energ, restor, generat, reviv, rest, plenish, charg, stimulat, spirit, live, living, brac, bold, fort, power, lift, kind, animat, wake, waking, recuperat, build, bracing, repair

79. Key Phrase: A Berry solo in “Blues in C Sharp Minor” is slightly off mike.

- Included Keyword: Blues
 - Keyword Alternatives: minor, song, piece, sharp, track, arrang, compos, cover, rendition, passage, key, tune, melod, harmon, recital, sang, sung, excerpt
- Included Keyword: off-mike
 - Keyword Alternatives: off-mic, mike, mic, slight

80. Key Phrase: The off mike solo (in “Blues in C Sharp Minor”) gives the impression that Berry has been playing unnoticed for some time (before listeners finally hear him).

- Included Keyword: off-mike
 - Keyword Alternatives: off-mic, mic, mike, solo
- Included Keyword: notic

- Keyword Alternatives: overlook, disregard, seen, recogni, discover, neglect, heed, heard, percieve, remark, hidden, consider, conspicuous, pass, gloss, miss, key, profile, subtl, key, profile, known, conceal, seclu, private, covert, shadow, observ, aware, atten, percep, acknowledg, noting, detect, alert, mindful, scrutin, cognizan
 - Included Keyword: play
 - Keyword Alternatives: perform, acu, wit, hand, touch, know, forte, music, work, passion, craft, invov, jam, abilit, dex, skill, finesse, adept, adapt, pro, apt, capab, expert, master, talent, insight, art, passion, craft, touch, know, smarts, savvy, gift, knack, music, work, blow, horn, air, sax, tenor
81. Key Phrase: The effect (of Berry’s off mike solo in “Blues in C Sharp Minor”) is unnerving, as if listeners weren’t paying close attention.
- Included Keyword: effect
 - Keyword Alternatives: impact, consequen, result, outcome, influen, impress, signif, weight, importan, ramif, produc, aftermath, react, payoff, output, yield, efficac, achiev, attain, reali, event, develop, success, mark, accomplish, emanat, upshot, conclu, implicat
 - Included Keyword: nerv
 - Keyword Alternatives: fright, alarm, daunt, scar, startl, terrify, terrifie, chill, creep, intimidat, settl, quiet, comfort, spine, hair, raise, raising, rise, rising, petrif, harrow, curl, disconcert, perturb, disturb, shock, rack, pleas, horrif, upset, troubl
 - Included Keyword: atten
 - Keyword Alternatives: focus, concentrat, aware, observ, listen, consider, regard, notic, heed, think, thought, mind, scrutin, vigilan, recogni, care, caring, contemplat, watch, absor, examin, engag, note, noting, eye, devot, interest, alert, direct, fix, center, zero, respon, present, diligen, inten, cognizant
82. Key Phrase: Cab Calloway granted Berry a showcase piece called “A Ghost of a Chance.”
- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo

- Included Keyword: Cab
 - Keyword Alternatives: Calloway
- Included Keyword: grant
 - Keyword Alternatives: give, giving, gave, bestow, award, offer, allow, present, permit, approv, endow, accord, yield, hand, authori, sanction, consent, permiss, gift, provid, allocat, assign, enabl, trust, admit, licens, confer, indulg, ratif, warrant

83. Key Phrase: Berry performed “A Ghost of a Chance” in June 1940.

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
- Included Keyword: 194
 - Keyword Alternatives: forty, forties, June, nine

84. Key Phrase: “A Ghost of a Chance” is the sole recording (in Berry’s career) to feature Berry from start to finish.

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
- Included Keyword: sole
 - Keyword Alternatives: only, one, sing, exclusive, rare, lone, unique, special, one, 1, solitary, individual, record, signature, distinct, start, finish, through, entire, thorough, complet, full, all, conclu, commenc, open, clos, begin, end, outset, initia, incept, term, kick, wrap, squar, final, intro

85. Key Phrase: “A Ghost of a Chance” was Berry’s “Body and Soul.”

- Included Keyword: Ghost

- Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
 - Included Keyword: body
 - Keyword Alternatives: soul, coleman, hawkin
86. Key Phrase: “A Ghost of a Chance” is a response to Coleman Hawkin’s famous recording (“Body and Soul”).
- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
 - Included Keyword: respon
 - Keyword Alternatives: answer, repl, react, riposte, retaliat, retort, rejoinder, acknowledged, homage, complement, sequel, follow, compliment, Hawkin, Body, Soul, Coleman, feedback, tribut, commenda, plaudit, prais, honor, exten, respect, adoration, reverenc, commemorat, gratitud, encomium, paeon, bravo, applau, kudo, appreciat
87. Key Phrase: “A Ghost of a Chance” is not meant to be a rival of Hawkin’s famous recording (“Body and Soul”).
- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
 - Included Keyword: rival
 - Keyword Alternatives: compet, oppo, vie, against, anti, threat, contrast, confront, def, face, conflict, odds, antagoni, contend, contes, foe, peer, vying, combat, challeng, enem, nemesis, Body, Soul, counter, adversar, foil, oppugn, battl, wrestl, match, fight, outdo, outmatch, outplay, rebuk, contra, object, deny, denie, hinder, thwart, hamper, imped, obstruct, against, repel, outperform

- Included Keyword: Coleman
 - Keyword Alternatives: Hawkin

88. Key Phrase: “A Ghost of a Chance” is the other half of a dialogue to Hawkin’s recording (“Body and Soul”).

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
- Included Keyword: half
 - Keyword Alternatives: part, piece, portion, section, segment, bit, chunk, cut, set, fragment, slice, fraction, element, component, unit, moiet
- Included Keyword: dialog
 - Keyword Alternatives: discourse, conv, exchang, talk, interchang, chat, communicat, Body, Soul, discuss, colloquy, interact, rapport, consult, negotiat
- Included Keyword: Coleman
 - Keyword Alternatives: Hawkin

89. Key Phrase: “A Ghost of a Chance’s” rubato lines are disembodied from the music meant to accompany it.

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
- Included Keyword: rubato
 - Keyword Alternatives: time, timing, express, flex, tempo, rhythm, free, elastic, fluct, libert, stretch, bend, varia, alter, modif, manipulatur, deviat, nuanc, stead, modulatur, flow, ebb, libitum, interpret, fluid, constrain, artistic, pace, pacing

- Included Keyword: embod
 - Keyword Alternatives: unbod, corporeal, ghost, spect, ether, spirit, material, real, phantom, natur, world, transcend, seen, visibl, astral, apparition, physic, shadow, dimension, tangibl, substan, ephemer, shadow, faint, vague, connect, separat, tach, engag, unite, link, hook, sever, fasten, ssoctiat, plug, hitch, tangl, isolat, bind, coupl, divid, join, break, tether, remov, withdraw, frag, yoke, yoking, moor, clasp, ravel, combin, disband, mantl, articulat, untie, untying, apart, abstract, extract, releas, loos, snap, stick, mount, assembl, thread, latch, split, partition, sequester, twine

90. Key Phrase: “A Ghost of a Chance’s” music (background accompaniment) is spartan (not standing out) to begin with.

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
- Included Keyword: spartan
 - Keyword Alternatives: austere, frugal, embellish, orna, adorn, bare, stark, plain, straight, complex, complicat, basic, strip, elaborate, minim, vanilla, ostentatious, show, pretentious, stand, modest, humble, reserved, frill, flash, face, primitive, refine, sophisticated, rudimentary, elementary, mundane, ordinary, mild, gentle, extravagant, bland, pop, airs, grand, flamboyant, theatric, over, dramatic, opulen, fancy, posh, gaudy, homely, ascetic, strict, rigor, harsh, disciplin, puritan, temperate, essen, severe, simpl, decor, economical, moderat, strain, hard, tough, luxur, furnish, function, compromis, fussy, fussi, frill

91. Key Phrase: “A Ghost of a Chance” may be Berry’s one and only instance of indulgence on a record.

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melod, track, genr, harmon, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo

- Included Keyword: record
 - Keyword Alternatives: audio, track, perform, play, piece, song, session, vinyl, 78, disc
- Included Keyword: instance
 - Keyword Alternatives: example, occasion, case, manifestation, prototype, illustrate, represent, evidence, sample, occur, situation, cite, mention, incident, time, point, one, only, sole, single, individual, lone

92. Key Phrase: “A Ghost of a Chance” is a cathedral of a solo (due to its flourishes, angles, ornamentations, reflexivity).

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melody, track, genre, harmony, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
- Included Keyword: solo
 - Keyword Alternatives: individual, himself, alone, own, riff, passage, piece, note, measure, song, bit, perform, play, tune, melody, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, composition, key, music, chunk, track, genre, harmony, rendition, single, one, sole, self, spotlight, independent, exclusive

93. Key Phrase: If sunlight could pass through music, “A Ghost of a Chance,” would funnel it out in the broadest spectrum of colors (“A Ghost of a Chance is very beautiful”).

- Included Keyword: Ghost
 - Keyword Alternatives: Chance, song, piece, tune, composition, melody, track, genre, harmony, sing, sang, sung, riff, passage, note, measure, bit, perform, play, number, part, portion, segment, recital, component, stanza, excerpt, snippet, verse, slice, section, line, cut, fragment, blurb, phrase, role, key, music, chunk, solo
- Included Keyword: broad

- Keyword Alternatives: spec, layer, mult, many, complex, vast, kaleid, prism, streak, deep, expan, immen, volum, spac, comp, uni, limit, far, tier, strat, full, found, abyss, bottom, feat, fathom, arcane, face, heavy, view, angl, element, acute, trait, look, position, defin, direct, rep, character, copious, set, scope, hue, rainbow, span, scal, extent, bang, depth, rang, board, conti, sphere, color, series, cours, exhaus, thorough, reach, line, ray, beam, categor, grad, string, key, synop, tail, less, immortal, channel, filter, trans, ject, con, mov, reflect, pass, reson, reverb, echo, mirror, shine, gamut, field, distin, monu, mom, diff, not, chunk, piece, sect, branch, stem, root, lea, spic, bit, ingred, divi, domain, environ, med, clim, habit, funnel

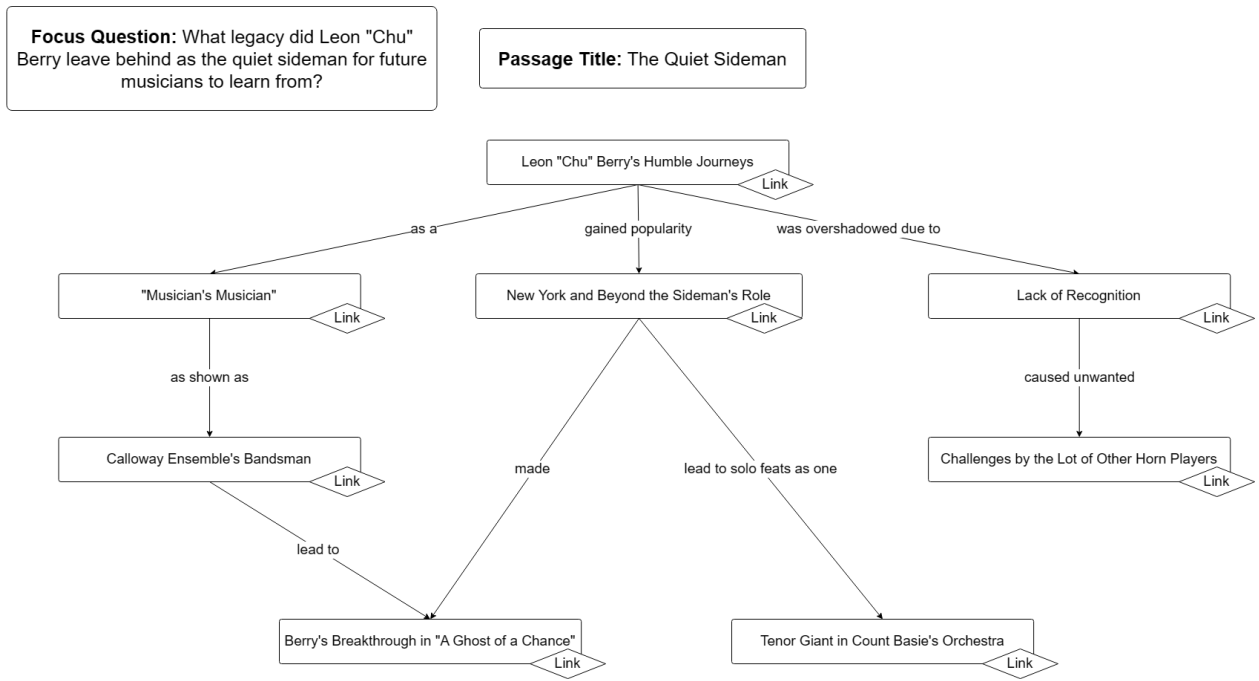


Figure B.75: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - Master-map

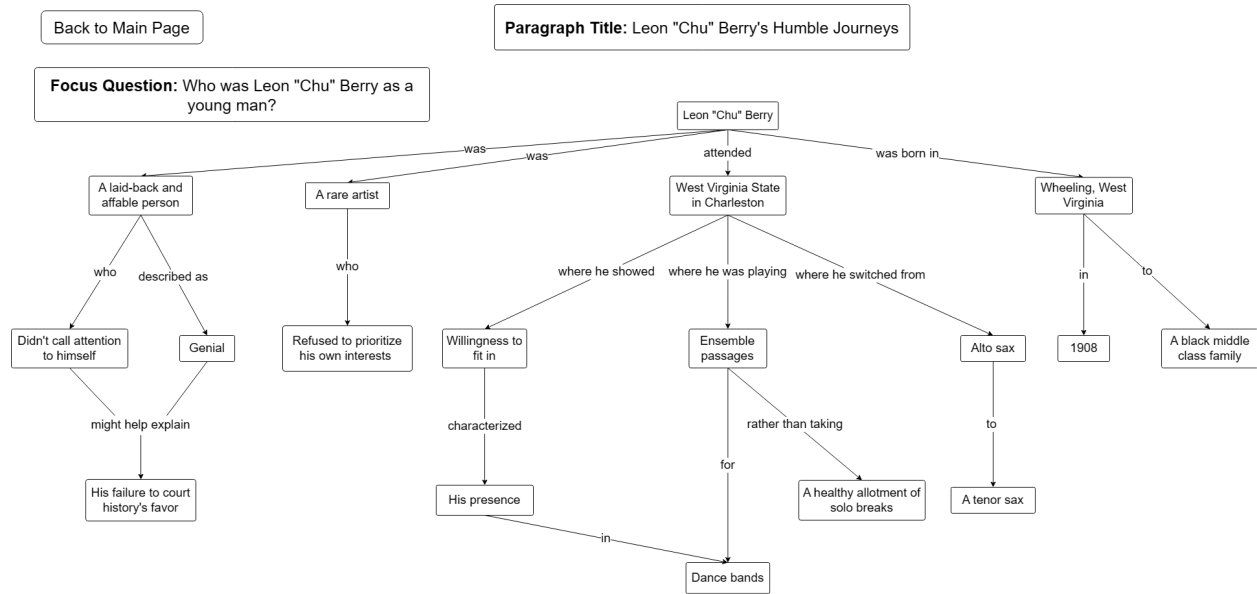


Figure B.76: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map1

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Focus Question: What was so significant about New York for Berry as a musician and sideman?

Paragraph Title: New York and Beyond the Sideman's Role

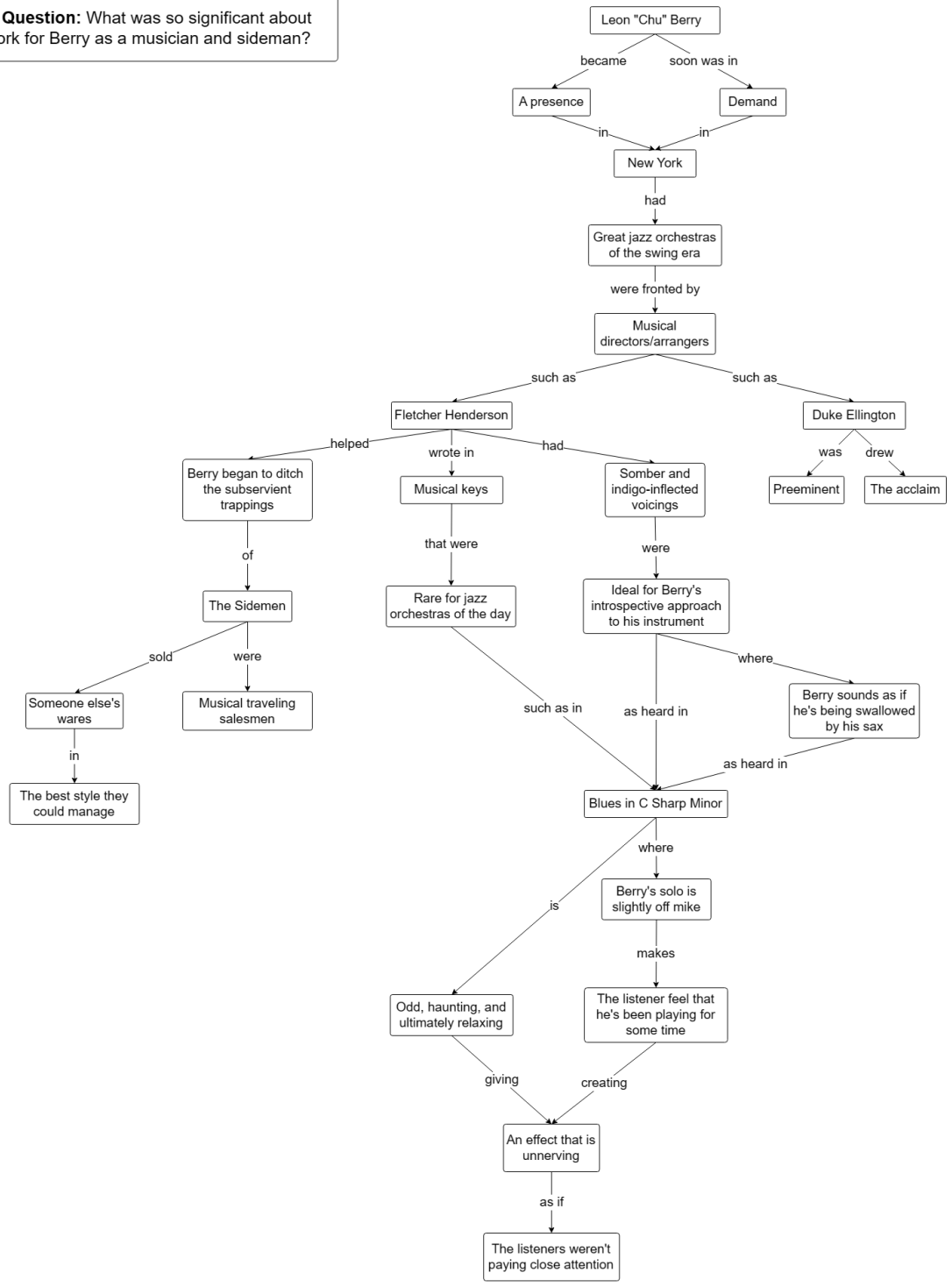


Figure B.77: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map2

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Paragraph Title: "Musician's Musician"

Focus Question: Why was Berry called "musician's musician"?

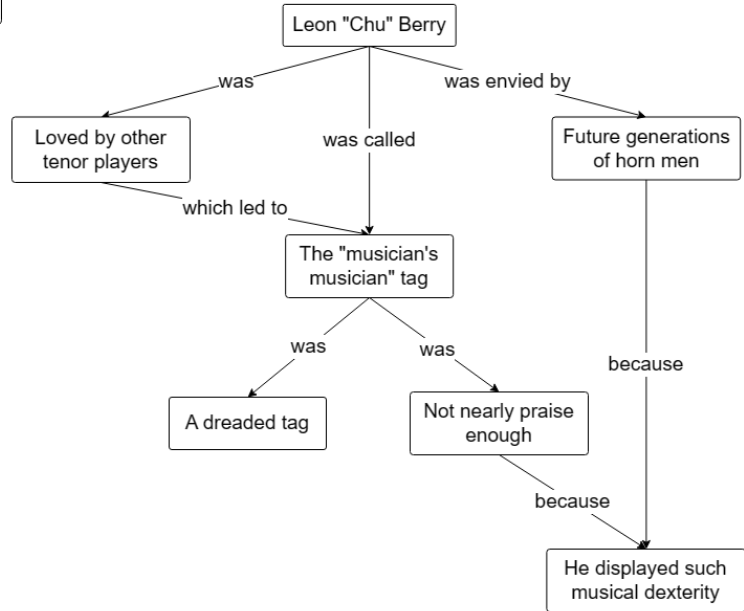


Figure B.78: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map3

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Paragraph Title: Tenor Giant in Count Basie's Orchestra

Focus Question: What were Leon "Chu" Berry's experiences standing in for one of the tenor giants in Count Basie's orchestra?

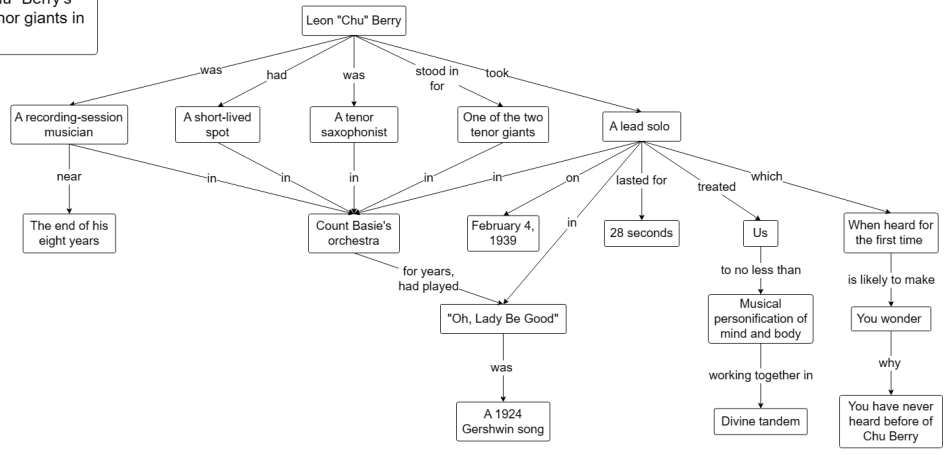


Figure B.79: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map4

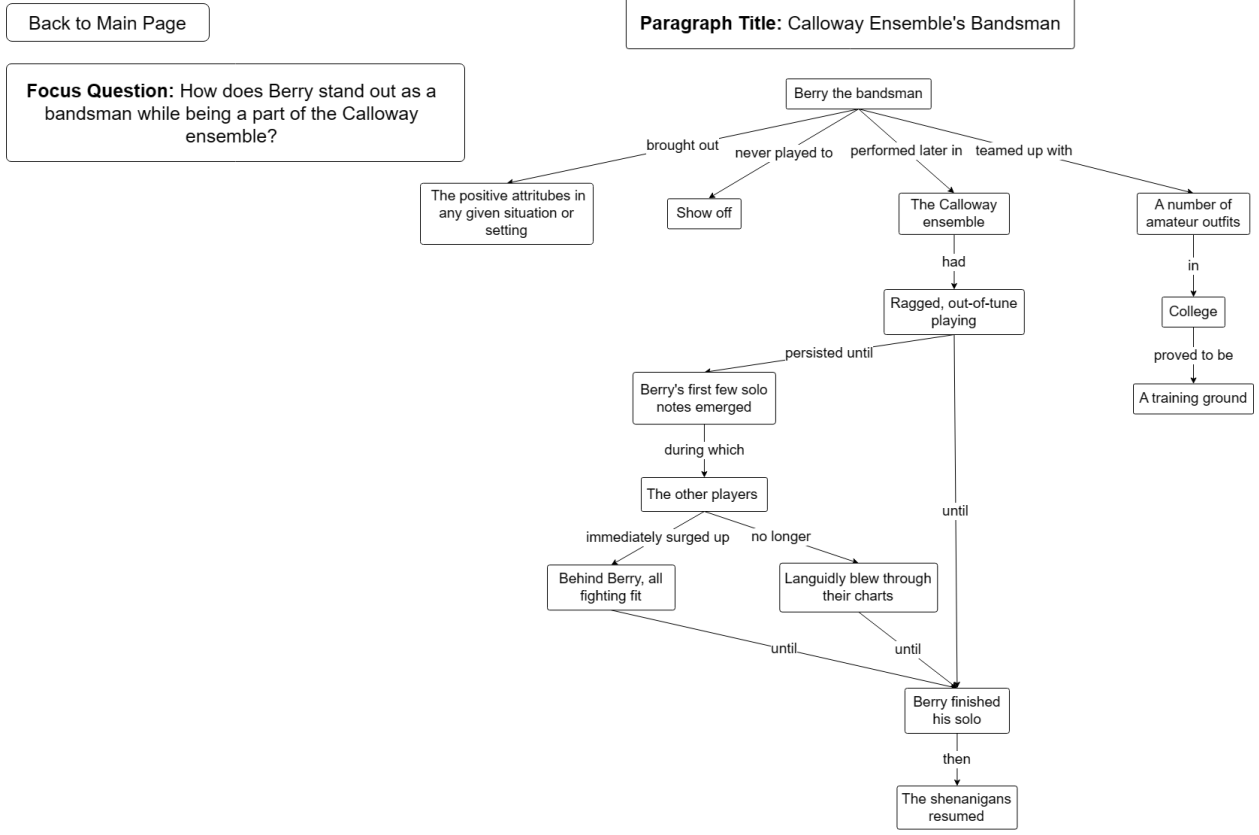


Figure B.80: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map5

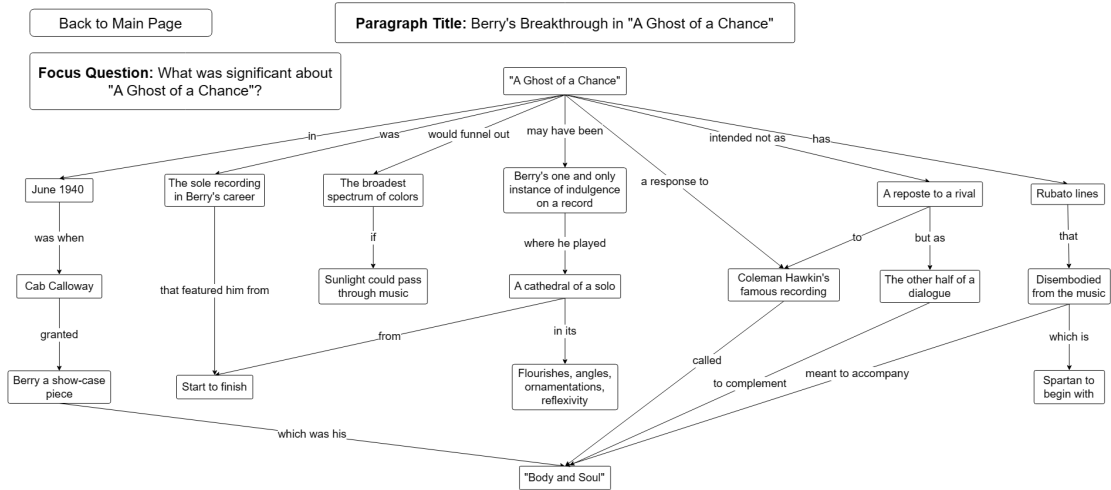


Figure B.81: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map6

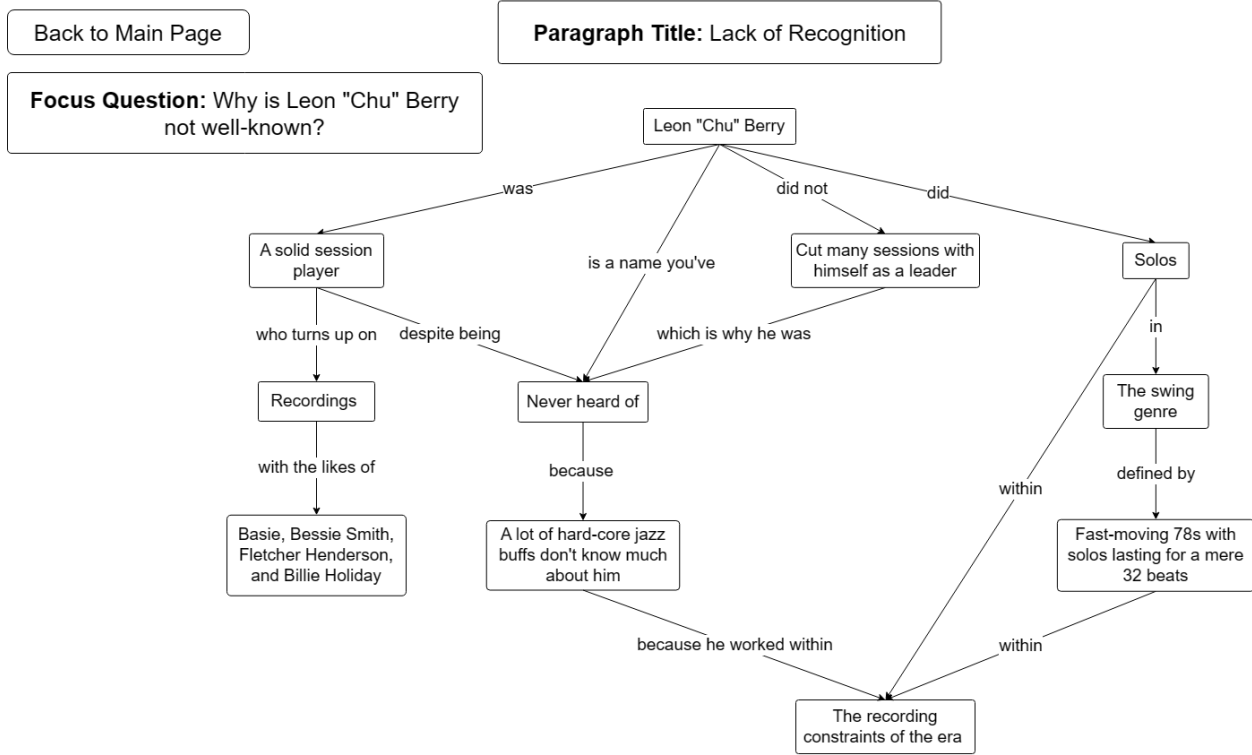


Figure B.82: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map7

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Paragraph Title: Challenges by the Lot of Other Horn Players

Focus Question: What were the difficulties that Leon "Chu" Berry had to overcome as a tenor saxophonist?

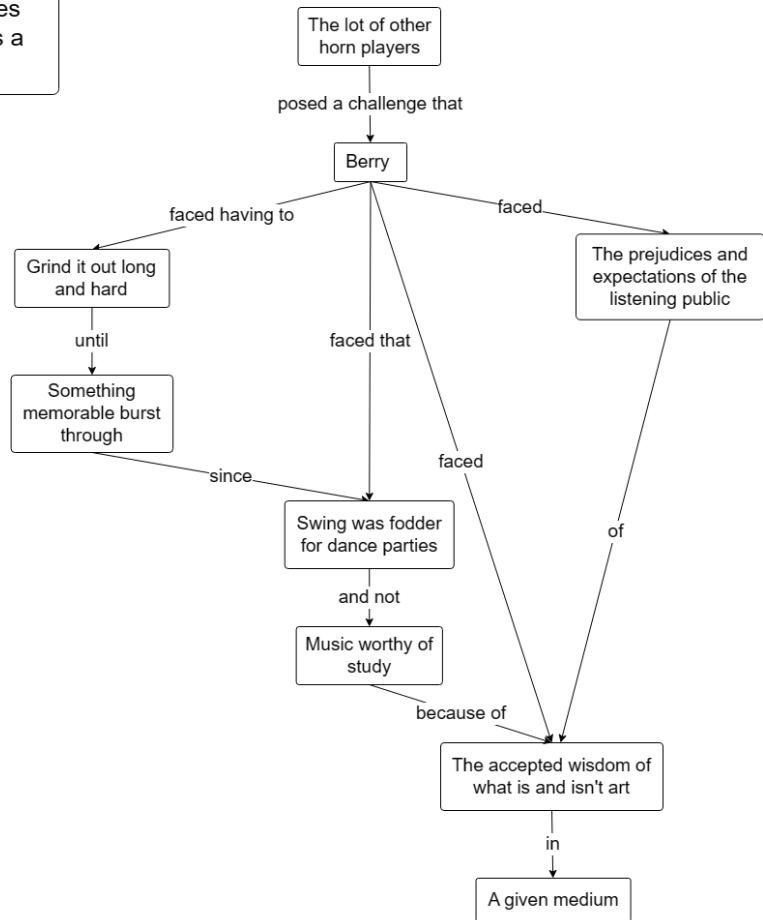


Figure B.83: Passage 9: The Quiet Sideman in Novakian Knowledge Model (K) condition - mini-map8

APPENDIX C

Chapter 4 Appendix - 1Cademy: Social Note-Taking in a Knowledge Graph of Micro-topics with their Learning Pathways (KGMLP)

C.1 Appendix

We have included complimentary explanations, data, and visualizations of the course usage study throughout the appendix.

- We review our theoretical motivations for our causal diagram in subsection C.1.1.
- Summary statistics are displayed in subsection C.1.2.
- Multiple data visualizations and the corresponding analysis of activity are located in subsection C.1.3
- SEM results and statistics are in subsection C.1.4

C.1.1 Causal relationships in the course usage study

We review our theoretical rationale for each relationship in the causal diagram.

- **UniqueCollaborators** → **NetVotes (a)**: This is one of the primary causal relationships in this study. We hypothesized that the more students who collaborate on a node, the more helpful the node would be to students' learning. By testing this hypothesis, we will show whether students found collaboration on the nodes evolution helpful to their learning. Every student has a different way of thinking and came into the class with different background knowledge. Because of this, not every student has the same way of improving the content of a node. Some students may be good at organizing information while others may be good

at explaining concepts. Additionally, not every student will catch the same errors. Some students may have a propensity to make grammar fixes and spelling edits while another might be good at correcting. The more students collaborating, the larger the range of potential improvements to be made, as opposed to if fewer student were generating the ideas for proposals.

- **UniqueCollaborators** → **ProposalsNum (i)**: The same student often makes multiple proposals on a single node. If a students who would've made multiple proposals on a node decides to never become a collaborator, those proposals will never exist. Now take a slightly different scenario, there is still a collaborator on a node who makes multiple proposals. This time however, the collaborator decides to not make one of those proposals. Despite the loss of a proposal they are still a collaborator on the node. This is why the causal arrow exists in the direction it does. Without the collaborator there can be no proposals, but without the proposal there can still be a collaborator.
- **ProposalsNum** → **NetVotes (d)**: Proposals are made by students when they see ways to improve the map. Improvements are made to improve the quality of a node and help students' learning. The more improvements there are, the less reasons there are likely to be to find a node unhelpful. This was seen in the students' evaluations, as they generally shared that they downvoted nodes for the same reasons they proposed improvements, and that they upvoted for reasons that were created by improvements.
- **LinksNum** → **NetVotes (k)** We hypothesize that the more links a node has, the more students will find it helpful. Links between related concepts is part of what helps students to learn. Visualizing and navigating through links provides students with valuable context and prerequisite information to understanding content. Because of this better connected nodes should be more helpful to students learning.
- **LinksNum** → **UniqueStudents (f)** One of the two ways students navigated through the map was through parent/child links (the second being the search function). The more links a node has, the more routes of access a student has to navigate to that node, and the greater chance they will come across it.
- **UniqueStudents** → **NetVotes (b)**: The more people that are introduced to a node, the more people that can vote on it. Nodes that are unhelpful will be removed from the map as soon as there are more downvotes than upvotes. The nodes that are left are nodes that are more likely to be upvoted than downvoted. If a student who would've voted on the node never interacts with it, they will have no opportunity to make their vote. To be able to vote on a

node (and reason to how to vote), the student must first be introduced and interact with the node in order to read its content.

- **CollaboratorsMeanScore** → **LinksNum (h)**: A group of more competent students will find more connections between nodes.
- **CollaboratorsMeanScore** → **NetVotes (e)**: *CollaboratorsMeanScore* is a proxy for the average “performance” of the collaborators involved in creating a version of a node. Certain students make more valuable contributions than others as denoted by the average upvotes they received for proposals. In addition to making better links, more competent collaborators will make better edits to the contents of the node, and thus receive high NetVotes.
- **AvailableTime** → **UniqueCollaborators (g)**: The more time a node has existed for, the more opportunities for different people to notice it and make proposals on it.
- **AvailableTime** → **ProposalsNum (j)**: Similarly to the causal relationship *AvailableTime* → *UniqueCollaborators*, the more time a node has existed for, the more opportunities for proposals to be made.
- **TotalInteractions** → **UniqueCollaborators (n)**: A student is more likely to become a collaborator on a node if they have interacted with it many times. Each interaction provides another opportunity for the student to evaluate its contents and possibly come up with an idea for a proposal.
- **TotalInteractions** → **ProposalsNum (m)**: The more a student interacts with a node, the more likely they are to make a proposal on it. If a student collaborates on a node once, but never interacts with it again, they will never have another chance to make a proposal. Only after interacting with it again, will the collaborator possibly come up with another proposal.
- **TotalInteractions** → **UniqueStudents (p)**: Nodes with more total interactions, are more likely to be revisited after its final modification because students who interact with a node consistently, will not change their habit drastically without at least first reviewing the node.
- **AvailableTime** → **TotalInteractions (l)**: The more time there is, the more opportunity there is to interact with a node.
- **Topic Importance** → **TotalInteractions**: Students were allowed to read and generate content from whatever references they chose throughout the semester. If a student wanted, they could have not used either of the course textbooks the entire semester and still received a

passing grade. The students did not have to worry about studying specific important concepts for a midterm or final. Since a topics importance was subjective based on the students, the causal effect of Topic Importance on the diagram is mediated by *TotalInteraction*.

C.1.2 Summary statistics in the course usage study

Table C.1: Summary statistics of the different types of proposals created per node during the study period.

Statistic	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
AcceptedProposals	2.068	1.367	0	1	2	3	9
ImprovementProposals	0.769	1.254	0	0	0	1	8
LinkRevisionProposals	1.499	2.118	0	0	1	2	21

Table C.2: Summary statistics of the variables. Each data point (the unit of study) represents one unique node on 1Cademy. Every variable other than NetVotes (outcome variable) is normalized to [0, 1] range for the purpose of Structural Equation Modeling (SEM).

Statistic	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
NetVotesPositive	0.799	1.145	0	0	1	7
UniqueCollaborators	0.289	0.153	0.200	0.200	0.400	1.000
ProposalsNum	0.231	0.152	0.000	0.111	0.333	1.000
UniqueStudents	0.129	0.168	0.000	0.000	0.192	1.000
LinksNum	0.153	0.138	0.071	0.071	0.214	1.000
CollaboratorsMeanScore	0.396	0.161	0.000	0.185	0.529	1.000
AvailableTime	0.473	0.262	0.032	0.260	0.678	1.000
TotalInteractions	0.103	0.116	0.000	0.016	0.141	1.000

C.1.3 Visualizations of collaborative activity logs in the course usage study

In this section, we analyze different visualizations of collaborative activity logs.

We present a series of figures to show inter-student interactions and personalization on 1Cademy throughout the semester. Figure C.1 shows who different students collaborated with when making their proposals. Students are arrayed as chords around the circle, each with their own color. Each student proposal on a node that affects a node last updated by another student contributes to the width of the arc connecting the two students; each pair of students can have two arcs, each colored by the student making the proposal.

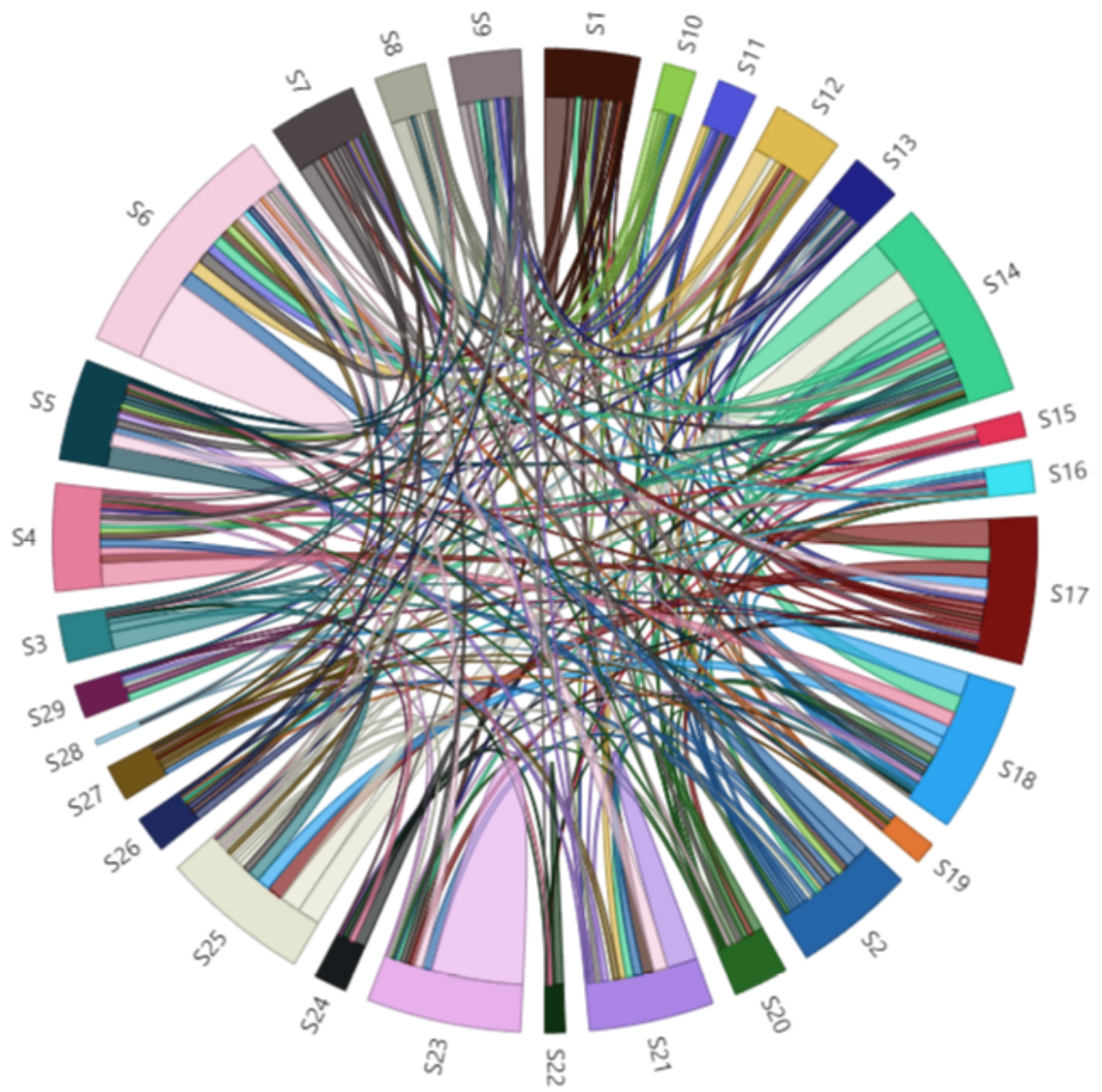


Figure C.1: Proposals Collaboration: connections indicate proposals by each student on nodes that other students contributed to. The wider the connection, the more proposals a student made on nodes collaborated on by the other student.

Students differed in their proposal behaviors relating to other students. For example, S23 (light purple) made many proposals, mostly on their own nodes (the wide, light purple shape from their section). S17 (maroon), by contrast, made proposals more often on nodes that others had edited.

While the extent of each student's collaboration with one another varied, it is apparent that most of the students collaborated with a diversity of others when proposing content (creating and improving nodes). It is also clear that most students received proposals from many other students on the content that they created.

Figure C.2 shows interactions *other than proposing edits*. To measure interactions, for each node, we counted the number of times each student took any of the following actions: show; hide; expand; collapse; upvote; downvote. Here again, students differed considerably. For example, the nodes of S6 (pink) had the most interactions by other students. However, every student interacted with several other students' nodes and most had many different students interact with their own.

Students personalized their views of the knowledge map by choosing which nodes were visible and expanded. As the semester continued, the number of nodes on the map grew, which made this feature increasingly useful to help people organize the added information. Figure C.3 shows a diagram of the nodes students had visible (either expanded or collapsed) at the end of class. Nodes are color coded green if they were last edited by someone else, orange for students' own nodes. Most students had hidden more than half the nodes, though S12 and S27 left most nodes visible. A few students, such as S21 and S23, showed a strong preference for keeping visible the nodes they themselves had last edited (shown by many orange dots) but most students mostly had visible nodes that were contributed by others. These differences showcase that students customized their views of the map with different nodes and in different amounts, and that most students found content contributed by others students to be useful enough to keep visible.

C.1.4 SEM Statistics in the course usage study

We have included the resulting statistics from our SEM analysis for further review.

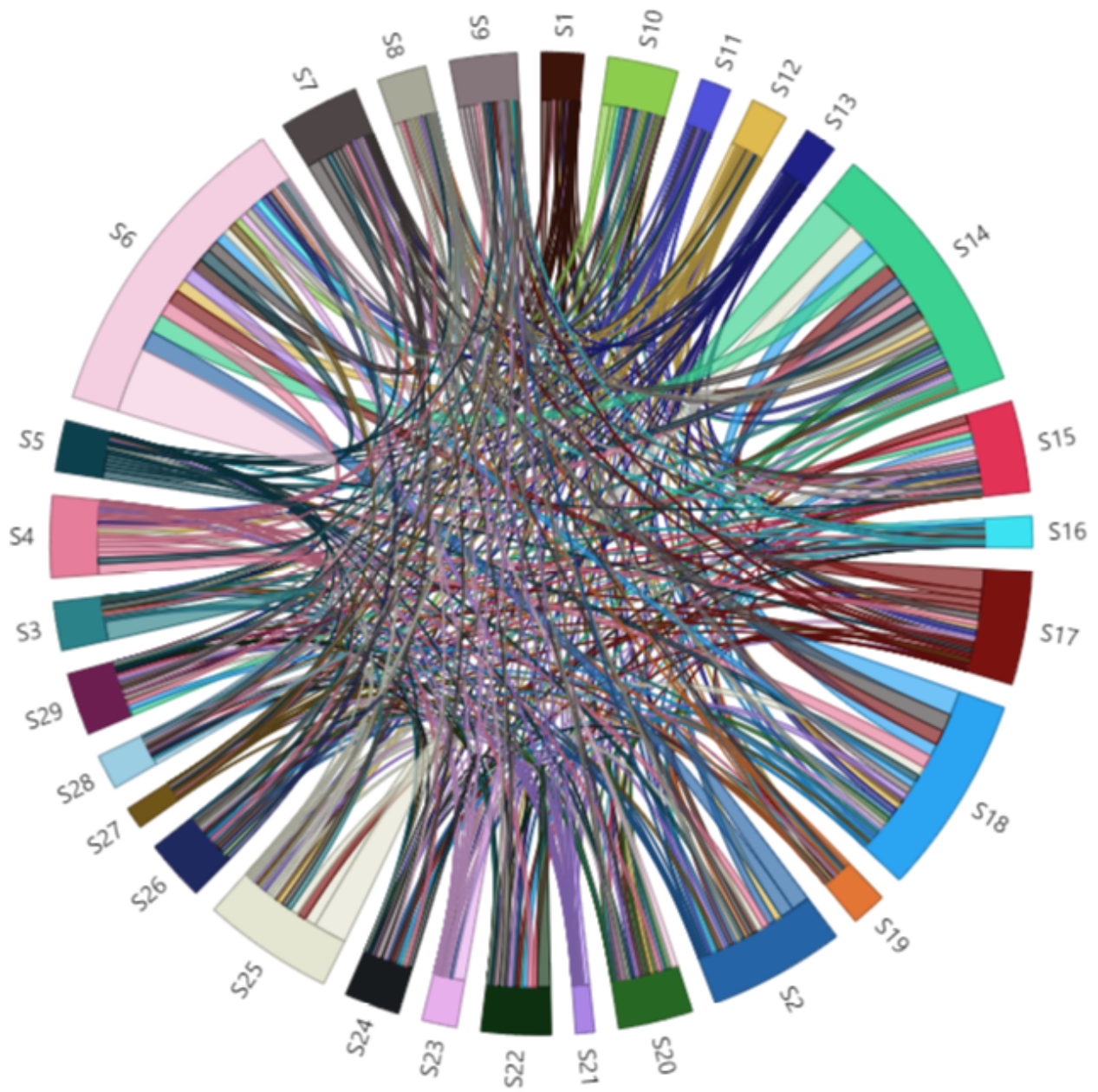


Figure C.2: Interactions: connections indicate interactions by each student on nodes that other students contributed to. The wider the connection, the more interactions a student had with nodes the other collaborated on.

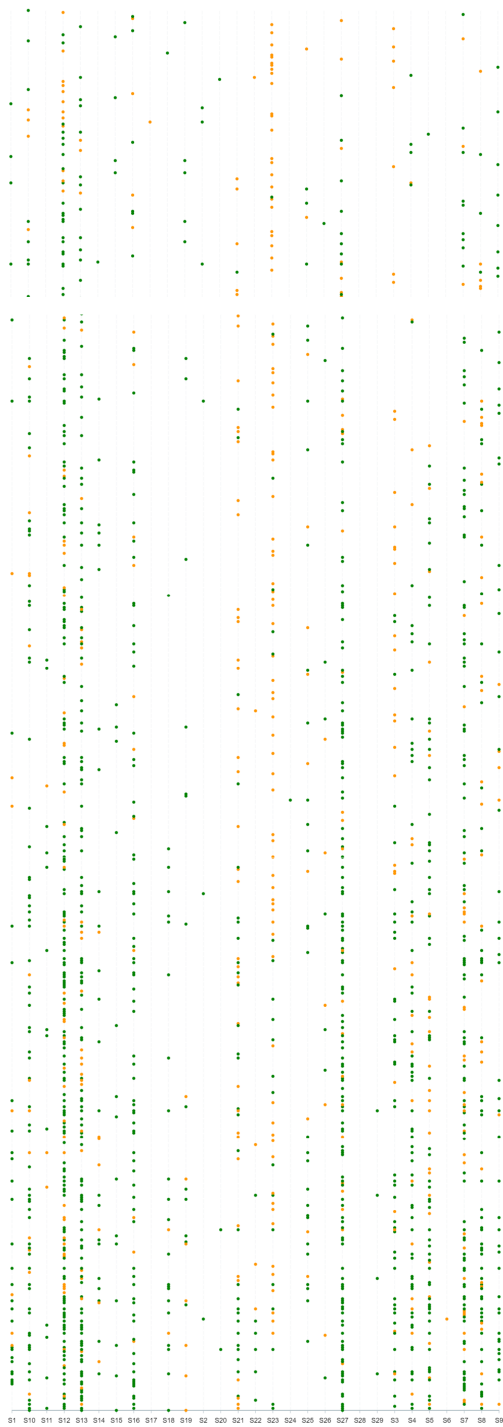


Figure C.3: Visible nodes on each student’s personalized map view at the end of the semester. Each column (X-axis) represents one of the participating students. Each row (Y-axis) indicates a node generated by students of the course. Each dot shows that the corresponding student has kept the corresponding node expand in their map view by the end of the semester. This plot depicts the differences between students’ personalized map views. In addition, green dots indicate nodes contributed by others and orange dots are those the student collaborated on. Many green dots indicate students had more nodes that were contributed by others expanded in their map view up until the last days of the semester.

Table C.3: Results of the Structural Equation Modeling (SEM). The regression model corresponding to each table is written on top of it.

NetVotes \sim a \times UniqueCollaborators + b \times UniqueStudents + d \times ProposalsNum + c \times LinksNum + e \times UollaboratorsMeanScore + o \times TotalInteractions + Intercept						
<i>Variable</i>	<i>Estimate</i>	<i>Std.Err</i>	<i>Low - CI</i>	<i>Up - CI</i>	<i>z - value</i>	<i>P(> z)</i>
UniqueCollaborators (a)	0.597	0.220	0.377	0.817	2.708	6.76e - 03
UniqueStudents (b)	3.367	0.254	3.113	3.621	13.250	< 2e - 16
ProposalsNum (d)	0.297	0.228	0.069	0.525	1.305	0.192
LinksNum (c)	0.388	0.191	0.147	0.529	2.039	0.0415
CollaboratorsMeanScore (e)	1.135	0.163	0.972	1.298	6.958	3.45e - 12
TotalInteractions (o)	1.209	0.391	0.818	1.600	3.092	1.99e - 03
Intercept	-0.509	0.077	-0.586	-0.432	-6.641	3.11e - 11
UniqueCollaborators \sim g \times AvailableTime + n \times TotalInteractions + Intercept						
<i>Variable</i>	<i>Estimate</i>	<i>Std.Err</i>	<i>Low - CI</i>	<i>Up - CI</i>	<i>z - value</i>	<i>P(> z)</i>
AvailableTime (g)	0.115	0.020	0.095	0.135	5.653	1.58e - 08
TotalInteractions (n)	0.449	0.046	0.403	0.495	9.760	< 2e - 16
Intercept	0.188	0.009	0.179	0.197	20.733	< 2e - 16
UniqueStudents \sim f \times LinksNum + p \times TotalInteractions + Intercept						
<i>Variable</i>	<i>Estimate</i>	<i>Std.Err</i>	<i>Low - CI</i>	<i>Up - CI</i>	<i>z - value</i>	<i>P(> z)</i>
LinksNum (f)	0.016	0.023	-0.007	0.039	0.690	0.490
TotalInteractions (p)	1.170	0.028	1.142	1.198	41.896	< 2e - 16
Intercept	0.005	0.005	0.000	0.010	1.045	0.296
ProposalsNum \sim i \times UniqueCollaborators + j \times AvailableTime + m \times TotalInteractions + Intercept						
<i>Variable</i>	<i>Estimate</i>	<i>Std.Err</i>	<i>Low - CI</i>	<i>Up - CI</i>	<i>z - value</i>	<i>P(> z)</i>
UniqueCollaborators (i)	0.561	0.027	0.534	0.588	20.479	< 2e - 16
AvailableTime (j)	-0.011	0.017	-0.028	0.006	-0.655	0.512
TotalInteractions (m)	0.271	0.040	0.231	0.311	6.695	2.16e - 11
Intercept	0.046	0.009	0.037	0.055	5.007	5.54e - 07
LinksNum \sim k \times ProposalsNum + h \times CollaboratorsMeanScore + Intercept						
<i>Variable</i>	<i>Estimate</i>	<i>Std.Err</i>	<i>Low - CI</i>	<i>Up - CI</i>	<i>z - value</i>	<i>P(> z)</i>
ProposalsNum (k)	0.293	0.028	0.265	0.321	10.305	< 2e - 16
CollaboratorsMeanScore (h)	0.084	0.027	0.057	0.111	3.114	1.85e - 03
Intercept	0.052	0.012	0.040	0.064	4.244	2.20e - 05
TotalInteractions \sim l \times AvailableTime + Intercept						
<i>Variable</i>	<i>Estimate</i>	<i>Std.Err</i>	<i>Low - CI</i>	<i>Up - CI</i>	<i>z - value</i>	<i>P(> z)</i>
AvailableTime (l)	0.253	0.012	0.241	0.265	21.347	< 2e - 16
Intercept	-0.017	0.006	-0.023	0.011	-2.582	9.84e - 03
Indirect Effects						
<i>Variable</i>	<i>Estimate</i>	<i>Std.Err</i>	<i>Low - CI</i>	<i>Up - CI</i>	<i>z - value</i>	<i>P(> z)</i>
$i \times d$	0.167	0.128	0.039	0.295	1.302	0.193
$i \times k \times c$	0.064	0.032	0.032	0.096	1.990	0.0465
$i \times k \times f \times b$	0.009	0.013	-0.004	0.022	0.687	0.492
$a + i \times d + i \times k \times c + i \times k \times f \times b$	0.837	0.184	0.653	1.021	4.557	5.18e - 06
$f \times b$	0.054	0.079	-0.025	0.133	0.689	4.911
$c + f \times b$	0.443	0.206	0.237	0.649	2.148	0.0317

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