PROCESSING COORDINATED VERB PHRASES: THE RELEVANCE OF LEXICAL-SEMANTIC, CONCEPTUAL, AND CONTEXTUAL INFORMATION TOWARDS ESTABLISHING VERBAL PARALLELISM.

by

Damon A.Tutunjian

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Linguistics)
in The University of Michigan
2010

Doctoral Committee:

Professor Julie E. Boland, Chair
Professor Samuel D. Epstein
Professor Richard L. Lewis
Assistant Professor Ezra R. Keshet

For Josefin

Acknowledgments

I would like to thank the members of my committee, Julie Boland, Rick Lewis, Samuel Epstein, and Ezra Keshet, for their advice and support while conducting this research. I would especially like to thank Julie Boland, my chair. Without her exceptional mentorship (and patience) throughout each stage of my studies, I would not be where I am today. I feel honored to have had the opportunity to work alongside her.

Additional thanks go to Kevin McGowan and Mason Smith for their unfailing willingness to help out with last minute coding issues, and to Lauren Squires for her statistical expertise and encouragement. I would also like to thank Sylvia Suttor for all of the administrative assistance she has provided me over the years and all of the past and present members of the Psycholinguistics Lab that assisted with my experiments.

I would also like to thank my friends Matthew Sheppeck, Andrew Bernick, and Jack Bucky for always being there for me when I needed friendship, assistance, and advice.

Finally, and most importantly, I would like to thank my wife Josefin Ekström, my parents Ara Tutunjian and Veronica Tutunjian, and my sister Kara Tutunjian for their love and support.

Table of Contents

List of Figures

List of Tables

List of Appendices

Abstract

This dissertation examines the influence of lexical-semantic representations, conceptual similarity, and contextual fit on the processing of coordinated verb phrases. The study integrates information gleaned from current linguistic theory with current psycholinguistic approaches to examining the processing of coordinated verb phrases.

It has been claimed that in coordinated phrases, one conjunct may influence the processing of a second conjunct if they are sufficiently similar. For example, The likelihood of adopting an intransitive analysis for the optionally transitive verb of a subordinated clause in sentences like *Although the pirate ship sank the nearby British vessel did not send out lifeboats* may be increased if the ambiguous verb (*sank)* is coordinated with a preceding, intransitively biased verb (*halted and sank*). Similarly, processing of the second conjunct may be facilitated when coordinated with a similar first conjunct. Such effects, and others in this vein have often been designated "parallelism effects."

However, notions of similarity underlying such effects have long been ill-defined. Many existing studies rely on relatively shallow features like syntactic category information or argument structure generalizations, such as transitive or intransitive, as a basis for structural comparison. But it may be that deeper levels of lexical-semantic representation and more varied, semantic or conceptual sources of information are also relevant to establishing similarity between conjuncts. In addition, little has been done to integrate parallelism effects to theories of the processing architecture underlying such effects, particularly for studies involving syntactic ambiguity resolution.

Using two word-by-word reading and three eyetracking while reading experiments, I investigate what contribution detailed lexical-semantic representations, as well as conceptual and contextual information make towards establishing parallel coordination in the online processing of coordinated verb phrases. The five studies demonstrate that parallelism effects are indeed sensitive to deeper representational information, conceptual similarity, and contextual fit. Furthermore, by controlling for deeper representational information, it is demonstrated that expected facilitatory patterns arising from coordination of similar conjuncts may be disrupted. Implications for the architecture of the processing system are discussed, and it is argued that constraint-based/competition models of processing best accommodate the pattern of results.

Chapter 1

INTRODUCTION

1.1 Parallelism effects in coordinated structures

Coordination is widespread in natural language. Almost all of the syntactic categories - nouns, verbs, adjectives, adverbs, etc., as well as maximal projections such as CP, IP, etc. - may combine recursively to form coordinated phrases. Coordination appears to also be somewhat special, and the behavior of conjuncts has proven rather difficult to explain without proposing independent descriptive rules. Early work conducted by Ross (1967) identified coordinate structures as having distinct syntactic properties. Consider the sentence in (1a), which contains two conjoined verb phrases (VPs). Ross claimed that NP-extraction from a single object position is constrained; it cannot occur out of simply one conjunct, as in (1b), but must apply "across the board" to all conjuncts in parallel, as in (1c).

(1) a. *The boy kissed <u>the girl</u> and pushed <u>his friend</u>.*

b. **Who did the boy kiss the girl and push___*

c. *Who did the boy kiss___ and push___*

In lieu of an independent explanation, Ross (1967) designated this constraint on movement out of a coordinated phrase as the Across the Board (ATB) exception. ATB and a second constraint, the Coordinate Structure Constraint (CSC), a special case of ATB that prohibits movement out of a coordinated clause, provided a descriptive, first explanation of this seemingly unique behavior of coordinated structures. A further observation by Williams (1981) highlighted yet another peculiar quality of coordinated constructions, that they tend to preferentially include conjuncts that are categorically similar. This observation was cast as the Law of Coordination of Likes (LCL) and was considered to limit coordination to constituents that were of the same syntactic category.

It was later argued that the LCL and the CSC do not simply reference general category information, but are based instead on the presence or absence of similar syntactic features. For example, according to Sag, Gadara, Wasow, and Weisler (1985), coordination of two unlike categories, an adverb and prepositional phrase (PP), in a sentence like (2a) is felicitous because the conjoined heads both bear a syntactic [+PRD] (predicate) feature.

(2) a. *John is <u>sick</u> and in a <u>foul mood</u>*

b. **John is <u>sick</u> and <u>in the park</u>*

Munn (1993) however questioned the syntactic basis of this alignment, arguing that coordination of unlike syntactic categories is freely possible only if semantic identity is aligned. In (2a) two unlike categories, an adverb and a prepositional phrase have been coordinated, and coordination is felicitous because each imparts a similar feature upon John. Yet, as can be seen, in (2b) where in the park fails to coordinate with sick, it is not enough that the feature is simply [+PRD], rather, the conjuncts must bear similar semantic features (e.g., [+MANNER]), as well. In (2a) this is the case, but the same cannot be said for (2b), since in the park designates location, not manner. Munn argues that there is thus no independent motivation for postulating the syntactic [+PRD].

In the processing literature, researchers have also been intrigued by the idea that there exists some form of LCL. A number of studies have shown that structural and/or semantic similarity between conjuncts has a facilitatory effect on processing (e.g., Frazier, 1978; Frazier, Munn, & Clifton, 2000; Frazier, Taft, Roeper, Clifton, & Ehrlich, 1984; Staub, 2007). For example Frazier et al. (2000) showed that processing of a second conjunct is faster if it is preceded by a similarly structured conjunct. Thus processing of the NP *tall woman* is faster in sentences like *Hilda noticed a strange man and a tall woman* (where both NPs are modified by adjectives) than in sentences like *Hilda noticed a man and a tall woman* (where the first conjunct has no modification). Such facilitation, as well as facilitatory patterns occurring further downstream in a sentence have been referred to as the "parallel structure effect" (Frazier et al., 1984), the "parallelism preference of coordinated structures" (Staub, 2007), and the "parallelism hypothesis" (Carlson, 2002), among others. For the purposes of this thesis, I will use the term "parallelism" to identify instances of coordination where the conjuncts are assumed to be highly similar in some way. Likewise, I will use the terms "parallelism effect" as an umbrella term for any pattern of facilitation that arises from coordination involving highly parallel (i.e., similar in some way) conjuncts. It should be noted however that not all instances of parallel coordination result in facilitatory patterns, such as when parallelism causes greater competition between structural analyses. Thus "parallelism effect" will also be used to identify cases where a high degree of parallelism between conjuncts has modulated processing in some way.

While the studies that have examined parallelism effects are informative and intriguing, the processing picture is far from complete. In particular, very little is known in regard to verbal coordination, as most studies have opted to focus on coordinated modifiers and noun phrases. In addition, the focus of many processing studies has typically been on identifying to what degree structural and/or semantic similarity between conjuncts can be shown to have a facilitatory effect on processing, with much less time given to questioning the nature of the similarity itself (but see Dubey, Keller, and Sturt, 2008 for some progress along these lines). For example, in Staub (2007) only a rough metric of intransitivity (transitive vs. intransitive) is used as a basis for similarity between conjuncts, yet it is well known that intransitivity is not monolithic phenomenon. For example, verbs like *arrive*, *march*, and *eat* may all be referred to as intransitive, as they have similar morpho-syntactic representations, but each verb bears a markedly different lexical-semantic representation from the others (Levin & Rappaport, 1995; Perlmutter, 1978; Reinhart, 2000). Without understanding what precisely is being coordinated, it becomes difficult to say whether we truly have coordination of likes or unlikes.

Despite this caveat, there is a great deal of support that some facilitation may arise from coordinated structures, and that it is attributable to some measure of similarity between conjuncts. But apart from evidence supporting that facilitatory parallelism effects are dependent upon some form of similarity, a number of questions are still not clear. Are the relevant points of similarity based primarily on semantic or syntactic features, and if so, how exactly we are to define what counts as a semantic or syntactic feature? If the features are syntactic, which syntactic information matters? Is it somewhat "shallow" representational information like the presence or absence of a verbal object or modifier in a linear string and/or general, phrasal-category level information, such as noun phrase (NP) or verb phrase (VP) that is relevant? Alternatively, parallelism effects could be traced to representations that are "deeper," less distanced from the non-linguistic system of concepts, and potentially more detailed, such as lexical relational structure (Hale & Keyser, 1993; 2003), lexical-semantic representations (Levin & Rapport, 1995), or some other means of interfacing the system of concepts to language as well as linking lexical or semantic representations to surface structure (e.g., Baker, 1997; Reinhart, 2000; among others)? How well, for example, do verbs like *eat* that can appear to be structurally intransitive, but that are semantically transitive, behave in coordinate structures when paired with non-alternating intransitives like the unaccusative *arrive*? And how well does *arrive* coordinate in comparison to an alternating unaccusative like *sink* or an alternating unergative like *march*, all of which have arguably different lexical representations (but cf. Levin & Rappaport, 1995 for a different view on unaccusatives). Is the underlying representation and all it entails important, or just the relatively "shallow" linearized, surface representation?

The current thesis addresses exactly these types of questions. Specifically, I test the following hypothesis, which is best stated in two parts: 1) processing difficulty at a garden path will be reduced if the ultimately correct interpretation is highly activated at the second conjunct in a preceding, coordinated verb phrase) and 2) this higher activation will be dependent on the degree of alignment of deep representational information (e.g., lexical-semantic representations) as well as conceptual information between conjuncts in that coordinated phrase. The strongest parallelism effects are thus predicted to occur for conjuncts that are well-matched both in terms of lexical-semantic representations and conceptual information. If such a pattern were found, it would rule out the hypothesis that parallelism effects arise *solely* from superficial syntactic parallelism (e.g., both VPs are superficially intransitive).

The current study thus strives to provide a more detailed view of the depth and type of representational information is relevant to the establishment of parallel coordinated structures. The local implications will be in regard to the processing of coordinated structures, but more broadly, the current research may be seen as a first step in examining how the detailed fruits of linguistic research may be used to inform processing studies for various phenomena. For example, linguists have long sought to identify how best to characterize the representational status of verbs in a way that comports with what is known about the syntactic realization of their arguments. Yet, meeting this challenge has been far from trivial. In their survey of approaches to argument structure realization, Levin and Rappaport (2005) stress that, to be complete, a study of argument structure must address the question of argument structure and argument realization on at least five dimensions, paraphrased in (3) below:

(3) a. The facets of the meanings of verbs relevant for the mapping from lexical-semantics to syntax.
b. The nature of lexical-semantic representations that encompass these components of meaning.
c. The nature of the algorithm that derives the syntactic expression of arguments.

d. The extent that non-semantic factors such as information structure and heaviness govern argument realization?
e. The extent that the semantic determinants of argument realization are lexical/non-lexical?

The first three aspects (3a-c) essentially capture the long debated question of whether the mapping from lexical representations to surface syntax relates various lexical representation to one syntactic forms (many-to-one) or one form to one form (one-to-one), and what the lexical representations must include to support either path. The last two pertain to whether argument structure is modulated by contextual information (3d) and how lexical-semantic information acts to bridge the system of concepts to the linguistic system (3e).

This inventory, arising from a body of research spanning over 40 years, demonstrates that any notion of simplicity in the lexical-semantic representational state is unlikely. Thus, while the question of which account best captures verb representation and behavior remains open, one thing seems clear: a good deal of complexity underlies verbal representations, and while verbs may resemble one another in a linear output, it is by no means obvious that the relation of that output to their representation is one-to-one, and many different forms potentially underly a seemingly monolithic surface representation. The question then arises whether this same complexity is relevant not only to the representational state of verbs, but also to how verbs are accessed and utilized in online processing. In fact, this same question could be asked for the knowledge obtained from each subfield of theoretical linguistics. And while it may be the case that such information is not relevant to online studies of processing, to ignore its existence is to draw a boundary between two potentially similar lines of research without reason.

Because the materials used in the current study will involve structure building and ambiguity resolution, it will not suffice to consider the relation between the two conjuncts without also considering the relevance of various parsing models to any observed parallelism effects. Thus, in the process of determining the accuracy of the two predictions mentioned above, the goodness-of-fit of the data to processing models will also be considered. In Chapter 2, two broad classes of parsing models: two-stage models (e.g., Frazier, 1987; Frazier & Clifton, 1996) and constraint-based models will be discussed, with special emphasis directed to two types of constraint-based models: constraint-based/competition models and qualified constraint-based models. Ultimately, it will be argued that constraint-based/competition models that allow for long-lasting effects best accommodate the experimental results.

1.2 Summary of experiments

I begin in Chapter 2 with a review of two-stage and constraint-based models, which, while only a secondary goal in this study, will necessarily set the stage for further discussion. I then detail recent studies that have examined the processing of coordinate structures. In Chapter 3, I present a new series of experiments that focus on identifying the role of "deep" lexical representations towards establishing the parallelism effect. A general discussion of the relevance of the findings is provided in Chapter 4.

Staub (2007) expected to see facilitation at the disambiguating main clause verb, but effects were only in later regions of his sentences. In Experiments 1-3, I first seek to replicate this late parallelism effect. I then attempt to elicit earlier evidence of the effect by eliminating lexical-semantic differences between and within experimental items as well as by attempting to broadly control for semantic similarity within items. In doing so, I test the hypothesis that syntactic and semantic similarity between conjuncts at a deep representational level will establish stronger parallelism between conjuncts and thus elicit earlier and stronger parallelism effects. In Experiments 4 and 5, I again test for earlier facilitation, this time via a more fine-grained manipulation of lexical-semantic representations, using specific verb classes to differentiate between conditions. The same hypotheses are tested, but unlike the first set of experiments where differences were removed, the second set of experiments accentuates representational differences to provide more room to demonstrate any potential facilitation. In addition, the hypothesis that the conceptual fit of a subject to a verb fit may act as a processing constraint on ambiguity resolution, thereby modulating any effects of parallel coordination is also examined. Experiments 1-5 are summarized below:

Experiment 1 examines whether lexical-semantic parallelism may affect the analysis of an ambiguous second conjunct in a coordinated phrase. Using a moving window paradigm, I compared coordinated and non-coordinated sentences from Staub (2007: Experiment 2) (e.g., *Because the Senator (lied and) stole the money is no longer available*) with a new set of coordinated and non-coordinated items (e.g., *Although the pirate ship (halted suddenly and) sank the British ship did not send out lifeboats*). The new items differed in the following ways: they only appeared in the simple past tense, they were all alternating unaccusatives (Levin & Rappaport, 1995), and each utilized an adverb after the first conjunct to rule out a transitive analysis of the first conjunct. Surprisingly, the parallel coordination advantage noted in Staub, whereby recovery from a garden path in the final region was facilitated on account of higher intransitive V2 activation was not replicated, even for his own materials – though this may be attributable to an unavoidable difference in experimental design. A subsequent normative study examined verb transitivity biases from both sets of materials, using a different approach from the normative study presented in Staub's study. The new materials were shown to have a higher intransitive bias than the materials from Staub, which vary in their degree of transitivity. This finding is contrary to the results of the normative study presented in Staub, which showed his verbs to be highly transitive. Together, the results of these two studies suggest that lexical-semantic information may indeed be relevant to the establishment of similarity-based parallelism.

Experiment 2 uses a moving window paradigm to test the hypothesis that coordinated, semantically related, and thus semantically parallel verbs (e.g., *capsized* and *sank*) engender higher activation of the intransitive analysis in the second conjunct than both coordinated, non-semantically related verbs (e.g., *halted* and *sank*) and non-coordinated controls. A facilitatory pattern in the final region provides limited support that parallel conceptual/semantic coordination does bolster the intransitive analysis at the second conjunct. In addition, reading time differences at the V2 and NP regions suggest that the presence of coordination may strengthen the intransitive V2 analysis and facilitate processing later processing at the ambiguous NP.

Experiment 3 uses the materials from Experiment 2 in an eye-tracking paradigm. A similar pattern of differences to that seen in Experiment 2 at the ambiguous NP region was found. However the results suggest that a new approach is needed to determine whether the early effects seen in both Experiments 2 and 3 actually represent facilitation arising from parallelism.

Experiment 4 introduces a new approach to engendering facilitation by accentuating, rather than minimizing the representational differences between verbal conjuncts. A mismatch/match comparison was enlisted to allow more experimental room for any potentially facilitatory effect of intransitive parallel lexical-semantic coordination. This additionally provided a useful contrast by which to assess early facilitatory effects. Facilitation was found at the second verbal conjunct and the ambiguous NP region, but not at the disambiguating region. The results implicate representational similarity as playing a limited role in parallel coordination. In addition, competition effects at the first conjunct and ambiguous NP regions provide novel evidence in support of constraint-based/competition models of processing that allow for long-lasting effects.

Finally, Experiment 5 again tests for an effect of coordination, and examines how the goodness-of-fit of a subject to the event denoted by a V2 verb may further influence selection of that verb's intransitive analysis. A facilitatory effect of coordination at the ambiguous NP region supports the conclusion from Experiment 4 that coordinated parallelism between the matched conditions may result in longer activation of structural alternatives. In addition, a number of measures in the final region showed a processing advantage for the coordinated conditions over NoCoord, demonstrating that early coordination may ease or head off processing difficulty at a later garden path. The subject/verb relation was also found to be relevant to coordination. It was found that while the presence of parallel coordination heightens competition at a V2, when the intransitive analysis is given more contextual support, less competition ensues, and thus the competing transitive parse is less available at a following NP region to head off any processing difficulty. This finding is shown to be consistent with constraint-based/competition models of processing.

Chapter 2

BACKGROUND

2.1 Introduction

In the section that follows, I present a number of studies that examine the processing of coordinated phrases. In addition, because this thesis involves, to a large degree, an examination of the relevance of detailed lexical-semantic representations to the processing of coordinated verb phrases, it will be necessary to present the formal system of classifying lexical-semantic information that provides a theoretical basis for my experimental approach. In addition, since the materials in the current study involve structural analysis and reanalysis, it will also be beneficial to provide a summary of processing models that have received much attention and support in the literature.

I begin by outlining Levin and Rappaport's (1995) system of verbal representation and argument realization, then proceed with a discussion of processing models of analysis and reanalysis. Finally, I present a number of studies that represent what is currently known regarding the processing of the coordinated phrases, emphasizing, when possible, data that is relevant to the processing of coordinated verb phrases.

2.2 Lexical-semantic representations and argument realization

Levin and Rappaport (1995) present a highly developed system of argument structure (i.e., lexical semantic representations) and argument realization, comprising one of the most extensive and complete systems currently available for English. Many of the basic premises are similar to those found in other available systems (e.g., Perlmutter, 1978; Reinhart, 2000), and there are numerous points of intersect with other extant studies (e.g., Dowty, 1991; Jackendoff, 1990). Furthermore, the high degree of overlap between these different approaches, be it in approach or goals, demonstrates that the need for a systematic, detailed approach is a genuine concern. However, unlike other available systems, the Levin and Rappaport system covers a wide selection of verbs and presents clearly stated criteria by which to inform verb selection, particularly in regard to intransitivity. These advantages provide a measure of not only theoretical validity, but also experimental practicality, and thus this system is a natural best choice for the purposes of the current study. A brief introduction to the Levin and Rappaport system follows. Particular emphasis is placed on the components of their theory relevant to verb selection as used in the upcoming experiments.

Levin and Rappaport (1995) take a predicate-centered, as opposed to semantic role-centered (e.g., Filmore, 1968; Gruber, 1965) approach to lexical-semantic representation. Whereas semantic-role centered approaches use thematic roles to represent verb meaning, predicate-centered approaches (e.g., Jackendoff, 1987; Pinker, 1989) typically use some form of predicate decomposition to mediate conceptual knowledge with linguistic knowledge. In the Levin and Rappaport approach predicate decompositions reveal two fundamental types of primitives. The first, called constants, are idiosyncratic “roots” such as *break*. The constants function together with the second type, a finite class of primitive predicates (e.g., BECOME), to encode the structure of an event and thereby determine argument realization. This is exemplified by the decomposition of *break* in (4) below from Levin and Rappaport (1995:94, (25)), in which DO-SOMETHING, CAUSE, and BECOME represent primitive predicates; BROKEN represents the constant; and x and y represent the two syntactic arguments that are required by this particular configuration of primitives.

(4) *FedEx broke my Arp Odyssey synthesizer.*

break: [[*x* DO-SOMETHING] CAUSE [*y* BECOME *BROKEN*]]

The decomposition in (4) represents one of the permissible lexical-semantic templates (the arguments in configuration with both the constants and the root) available to the verb *break* - here it is the causative template. Templates encode representational properties of the lexicon that may be semantically predictable (and thus conveniently grouped and described in terms of semantic classes), but which are crucially assumed to be syntactic in nature. Each verb is assumed to have one basic underlying lexical-semantic template that may reduce or append as a function of the particular semantic restrictions of the constant involved and that constants relation to the other primitives in the template.

The current study makes use of both alternating and non-alternating unaccusative verbs selected primarily from Levin and Rappaport (1995). Following Chierchia (1989), Levin and Rappaport propose that alternating unaccusative verbs (e.g., *break*) are underlyingly causative and thus dyadic (having two arguments), whereas non-alternating unaccusative verbs (e.g., *arrive*) are basically monadic (having one internal argument). Thus, while a verb like *break* may decausativize to have only one argument (e.g., [y

BECOME *BROKEN*]), its basic lexical-semantic representation will always be dyadic as in (5) below. Non-alternating verbs like *arrive* however, have a monadic, single argument lexical-semantic representation (6), and are thus representationally distinct in the lexicon from their alternating cousins, despite the apparent superficial similarity.

(5) *My Arp 2600 synthesizer broke.*

break: [[*x* DO-SOMETHING] CAUSE [*y* BECOME *BROKEN*]] → [y BECOME *BROKEN*]

(6) *The new transistors arrived.*

arrive: [*ARRIVE y*]

The Levin and Rappaport classification is determined in a large part by a invoking a semantic distinction between "internally" and "externally" caused eventualities. In brief, the basic adicity of a verb is taken to relate to a distinction between internal and external causation inherent in the way humans conceive events. For events that are conceptually stable in terms of causation, there will be one basic argument structure realization. For events that can be construed as either internally or externally caused, their account predicts variation.

2.3 Processing models of analysis and reanalysis

There are currently two general classes of approaches to modeling analysis and reanalysis as they relate to the language processing architecture, both of which are based primarily on evidence garnered from online studies of ambiguity resolution. The first approach comprises what have commonly been referred to as two-stage or fixed choice models, for example the Garden Path model (Frazier, 1987) and its successor, the Construal model (Frazier & Clifton, 1996), The second approach comprises what have been referred to as variable choice, constraint-based, or competition-based models (e.g., McRae, Spivey-Knowlton, & Tanenhaus, 1998; Spivey-Knowlton & Tanenhaus, 1998; Traxler, Pickering, & Clifton, 1998; Van Gompel, Pickering, & Traxler, 2001). The terminology used to describe these classes is somewhat problematic. To some degree, all of the models listed above are two-stage in that they claim one analysis is ultimately selected at each word in the sentence and that when evidence shows that choice to be incorrect, reanalysis is required. This is markedly different from another class of constraint-based/competition models, ranked parallel models (e.g., Gibson, 1991), in which multiple syntactic analyses, ranked in accordance with various supporting constraints, may be retained over the course of a number of words. That is, the parser does not necessarily choose one analysis over another at any given point. Rather, analyses may be re-ranked, but still remain active over multiple regions. Such models are thus sometimes referred to as "long lasting" (Van Gompel, Pickering, Pearson, & Liversedge, 2005). Such models allow for competition effects, but predict little or no cost from the re-ranking of alternatives when disambiguating material conflicts with the current parse. Yet another class of constraint-based/competition models, dynamic self-organizing (DSO) models (e.g., Tabor & Hutchins, 2004; Tabor & Tanenhaus; Tabor, Tanenhaus, & Juliano, 1997), also allows for long-lasting effects arising from competition.

In the discussion that follows, I will use the terms two-stage model and constraint-based models to differentiate between models that prohibit (two-stage) or allow (constraint-based) various non-syntactic constraints to influence the earliest stages of a parse. In addition, I will use the terms long-lasting and short-lasting to distinguish between constraint-based models that prohibit (short-lasting) or allow (long-lasting) for multiple analyses to extend over multiple word regions. Deviations from these generalizations will be noted as necessary.

Two staged models typically posit some form of modularity in the language processing system (Fodor, 1983). Standard components of language (syntax, phonology, semantics) are held to each be informationally encapsulated from one another, and individual tasks are serially handled by one module and then passed on to the next for additional processing. For such models, syntax is often considered to precede semantics in the processing chain. During a parse, a single representation is built up. When an ambiguity is reached, an initial analysis is constructed based solely on built-in structural heuristics. Because this initial stage references global structural heuristics that result in predictable structural choices, and because the process is blind to other potential constraints on the parse, the process is often considered to be deterministic in nature, in that it always makes a selection based on the structural heuristics. Should this deterministic analysis prove to be incorrect or even unlikely at a later region, as would be the case if the incorrect structure was initially chosen or if pragmatics deemed a parse to be unlikely, a second stage of reanalysis would occur in which additional information, such as plausibility, would have the ability to affect the new selection. Two stage models thus often posit that processing difficulty will be observed at a point of disambiguation, where the original analysis is discovered to be incorrect. At the point of ambiguity however, no difficulty would be observed as the parser would simply choose one analysis in accordance with a global, syntactic/structural heuristic (e.g., attach incoming material low to the current constituent, not to a higher point in the tree).

The Garden Path and Construal models are relatively strict in assuming that even for those instances where additional constraints are available, ambiguity resolution will reference only structural information to inform the parse; additional constraints may only influence the parse after structural preferences have been enacted. In this way, modularity is retained. In contrast, constraint-based models, (e.g., MacDonald, Pearlmutter & Seidenberg, 1994; McRae et al., 1998; Spivey-Knowlton & Tanenhaus, 1998; Traxler et al., 1998; Trueswell & Tanenhaus, 1994) propose that ambiguity resolution may be influenced not only by general structural heuristics, but also by any given number of additional constraints, such as semantic and probabilistic lexical information, at the earliest stages of a parse. Thus, while only one representation is ultimately built up at any given word, that selection may be influenced by a greater number of constraints than are available in the fixed-choice models.

Constraint-based models can be divided further into three subclasses. The first comprises what will be referred to here as constraint-based/competition models, represented by such models as the constraint-based lexicalist approach (e.g., MacDonald et al., 1994; Trueswell & Tanenhaus, 1994) or the competition-integration model (e.g., Elman, Hare, & McRae, 2005; Spivey-Knowlton, 1996; Spivey-Knowlton & Tanenhaus, 1998; McRae et al., 1998) in which constraints from multiple levels of representation may always affect the earliest stages of a parse, and in which analyses compete for activation, with the one having the one with the most constraints in its favor ultimately becoming the one that is activated. For the models listed above, competition is relatively short-lasting. That is, at each word, one analysis is ultimately adopted. The analysis at this point then acts on a constraint for the next region.

A second subclass of the constraint-based models (Gibson, 1991; Tabor & Hutchins, 2004; Tabor, Tanenhaus, & Julianao, 1997) allows for competition to be longer lasting. Such models either implicitly or explicitly include some form of ranked parallelism. For example, Tabor and Hutchins (2004) explicitly proposes that at each new word potential analyses are maintained in parallel, competing primarily via the use of lexically specified syntactic knowledge until one analysis reaches a steady state. This steady state need not be attained at the ambiguous word, but may extend over a number of words, though at each new word additional constraints will come into play that would likely, additionally modulate the level of activation/ranking. Such models thus predict long-lasting effects related to the parse that is ranked highest at the point of ambiguity, but do not allow for significant cost associated with re-ranking at a point of disambiguation (as both analyses are maintained to some degree in parallel).

The third subclass, which I will refer to as qualified constraint-based models also makes use of or permits the use of constraints from multiple levels of representation at early stages, but with some restrictions. For example the unrestricted race model (Traxler et al., 1998; Van Gompel et al., 2001; Van Gompel et al., 2005) limits the type of constraint-based information that becomes newly available at the point of ambiguity to structural information. In addition, analyses are held not to compete, but to race to activation – the difference being that the presence of analyses with equibiased support never causes a processing slowdown; whereas competition involves interaction, in a "race" the analyses proceed independently. A second example, the concurrent model (Boland, 1997a) allows syntactic and semantic processing to proceed in parallel but limits when certain constraint-based information (sentence-level, contextual/pragmatic constraints) can affect syntactic ambiguity resolution to instances when two or more lexically available structural forms are grammatical and thus are also available for selection.

For the constraint-based/competition models, like the competition-integration model, that allow a broad range of information to affect processing at all stages, it is generally maintained that at a point of ambiguity multiple analyses may become active simultaneously. Each analysis has an initial activation level that is set by and updated via cyclical backward and forward activation. Differences in initial activation levels cause the different analyses to have an inherent preference ranking. In the course of a parse, the available constraints can push one of these activation levels to some selection threshold, at which point the processor moves on to the next word. In this way, only one representation is built up at each word. Crucially, all forms of linguistic and probabilistic information are available at each stage of the parse to inform which analysis will receive the highest level of support. Because the processing system is construed as a general all-purpose mechanism, analyses must compete to reach the highest level of activation. Thus, these models predict that for instances when there are multiple analyses receiving similar levels of constraint-based support, processing difficulty will ensue. For those instances where one analysis has more support than another, competition will be reduced and the parse will show little processing cost.

The predictions of the constraint-based/competition models have been borne out in experimental results. For example McRae et al.'s, (1998) first word-by-word reading experiment used agent biased (7a) and patient-biased (7b) sentences to show that multiple types of constraints do play an early role in ambiguity resolution. The agent-biased condition had an equal number of constraints supporting both analyses at the point of ambiguity (*arrested*), while the patient-biased condition more strongly supported the incorrect past participle analysis (as computed over the relative weights of multiple constraints).

(7) a. *The cop arrested by the detective was guilty of taking bribes.*

b. *The crook arrested by the detective was guilty of taking bribes.*

It was found that processing difficulty did indeed arise at the point of ambiguity for (7a) but not for (7b) supporting the prediction that a greater number of constraints would lead to greater competition and thus greater processing difficulty would ensue at the point of ambiguity.

Qualified constraint-based models also allow constraints to affect a parse at the earliest stages, but impose some limitations on when and where this can occur. The unrestricted race model, for example, imposes certain restrictions on the availability of information allowed prior to and at the point of ambiguity. For example, there are no restrictions on the types of constraints that can influence the selection of a particular analysis at the ambiguous region (hence the unrestricted part of the model's name), provided that this information has become available prior to the ambiguity. However, at the actual point of ambiguity, the only new information that can influence this initial selection is major category information - major category information presumably includes a limited form of argument structure that involves syntactic placeholders but not semantic information or information about lexical biases. The logic behind the model is that semantic information can only be accessed once a structural form has been made active (but c.f. Boland 1997a for an alternative view). Given the inability of two stage models to explain certain early effects of non-linguistic constraints (e.g., McRae et al., 1998), models like unrestricted race currently are a more favored way of preserving some of the core notions of modularity and syntactic primacy while still allowing for additional types of information to influence the parse.

Yet another difference between qualified models like unrestricted race and the comparatively less-limited constraint-based counterparts is in how the models handle competition. In the unrestricted race model, at a point of ambiguity where multiple analyses are available, there will never be reanalysis or processing cost. As mentioned above, in unrestricted race, analyses do not compete per-say, rather they “race” towards activation. For those cases where one analysis is heavily biased prior to and at the point of ambiguity, there will be greater support for that analysis at the ambiguity, and it will complete the race to activation fastest, independently of the slower analysis. For those instances where two analyses have equal support prior to and at the point of ambiguity, the processor will still race, and one analysis will be adopted at chance. Crucially, there will still be no processing slowdown, as the analyses make use of independent resources.

Long-lasting vs. short-lasting versions of the constraint-based/competition models also make different predictions. If effects are long-lasting, whatever analysis was ranked highest at the point of ambiguity will persist until contradictory material is encountered, and potentially even in spite of that contradictory material (Tabor and Hutchins, 2004; Ferreria & Henderson, 1991b). Furthermore, in contrast to constraint-based models positing short-lasting effects, very little if any cost should be accrued on account of the re-ranking of alternatives.

Results have been found supporting the predictions of each of the models, making it difficult to rule any one model out. Currently, the largest arena of debate is between the constraint-based/competition models and the qualified constraint-based models. Further confounding the issue is the more recent claim regarding the additional discrepancy of long-lasting vs. short-lasting effects. Still, one way of distinguishing between the models might involve identifying an effect that is necessarily dependent on information that one of the models excludes. In this study, a difference in eye fixation durations in sentences containing coordinated verb phrases will be shown to serve as just this type of distinguishing information, providing support for constraint-based models that allow for long-lasting activation of structural alternatives over both qualified and non-restricted constraint-based models that do not, as well as two stage models like the Garden Path theory.

2.4 Processing Coordination

I now turn to an examination of some noteworthy studies from the processing literature that have examined parallelism effects in coordinated structures – the general finding that structural and/or semantic similarity between coordinated phrases has a facilitatory effect on processing. Perhaps one of the most extensive studies of various parallelism effects can be found in Frazier et al. (2000). Discussion thus begins with this study.

Frazier et al. (2000) made the general claim that the processing of a syntactic structure can be facilitated if a like syntactic structure has just been processed. Their hypothesis was tested in a series of four experiments, two of which are detailed here. In their Experiment 1, an eyetracking while reading task, they tested sentences like those in (8) which differ in the syntactic category of the modifier conjuncts. In both first pass and total reading times, facilitation was found at the second conjunct region for like syntactic categories (8a) over both unlike categories (8b) and two non-coordinated control conditions.

(8) a. *John walked slowly and carefully, avoiding the broken glass.*

b. *John walked slowly and with great care, avoiding the broken glass.*

A parallelism effect was also found in their third experiment, this time for conjuncts that contained similar internal structure. Using eyetracking while reading, facilitation was found at the second NP for an internally parallel condition (9a) but not for a non-parallel variant (9b). In contrast, no difference was found between the control conditions (9c-d) which contrast in NP-constituent weight but are not simultaneously parallel in internal structure (as neither is parallel, one should not perform faster than the other, even if constituent weight differs).

(9) a. *Hilda noticed a strange man and a tall woman when she entered the house.*

b. *Hilda noticed a man and a tall woman when she entered the house*

c. *Hilda noticed a strange man and a woman with a dog when she entered the house.*

d. *Hilda noticed a man and a woman with a dog when she entered the house.*

Frazier et al. (2000) concluded that the matching or mismatching of "internal structure" is relevant, respectively, to the presence or absence of the parallelism effect. This finding is interesting because it implicates internal constituent structure, and not just categorical information or constituent weight (as demonstrated by the lack of difference between 9c and 9d) in establishing the parallelism effect. But their Experiment 3 raises an interesting question: whether the differences noted arose on account of differences in the deeper structural representations of the modifiers being conjoined, or because of differences in the positional, linear location of the modification (i.e., before or after the noun). The first case naturally includes the second, but the second case does not necessarily include the first. That is, would the same effects be obtained using positionally different, but structurally similar conjuncts (at least within the modifying clause). Take for example the adverbial modification of conjoined verbs as in *The kite plunged suddenly and rose quickly.* Should we expect to see facilitation in this first example over the following variant: *The kite plunged suddenly and quickly rose* in which the internal structure of the modifier was matched, but for which the linear order was not? In addition, two other details obscure the relevance of their finding. Verb bias (confirmed by a rating study) was for low attachment of the PP modifier (*with a dog*) to the second conjunct. This was important as it demonstrated that the PP's in (9c and 9d) were indeed parsed as modifying the second conjunct. Yet while the experiment was online, the normative study was conducted offline, via a questionnaire, which only tests how the sentence was ultimately resolved. It still remains possible that differences could be seen between the two conditions in an online measure, which could potentially mask differences at the second conjuncts.

The Frazier et al. (2000) study remained neutral in regard to the actual processing architecture that would underlie just such a facilitation effect. In addition, the study focused primarily on noun phrase and modifier coordination, and does not consider verbal coordination, perhaps on account of the numerous thorny issues that verbal representations raise. Staub (2007) however, addresses both of these points, extending the investigation to include verbal coordination as well as a consideration of the processing implications underlying coordination. The key manipulation involves a coordinated verb phrase situated in an introductory, subordinate clause. Numerous researchers have noted that in sentences containing a subordinate clause object/main clause subject ambiguity, the direct object reading is more frequently adopted at the ambiguous NP (e.g., Clifton, 1993; Ferreira & Henderson, 1991; Frazier & Rayner, 1982; Kjelgaard & Speer, 1999; Sturt, Pickering, & Crocker, 1999). As an example, consider (10a) where *mopped* is an optionally transitive verb and where *the floor* could serve as either the direct object of *mopped* or as the subject of the upcoming main clause. This attachment preference is so strong that it has been claimed to exist even when a verb's subcategorization frame expressly prohibits such attachment, as with intransitive verbs like *imply* (Cuetos & Mitchell, 1988; but cf. Staub, 2007b and Trueswell, Tanenhaus, & Kello, 1993). On account of this bias, and because of the ambiguous role of the NP in such structures, the parser might be expected to adopt and discard various analyses, eventually settling on the correct one when the structure is disambiguated at the main clause verb (e.g., *is*). This disambiguation would then be associated with reanalysis and thus processing cost for the instances when the prior analyses were incorrect.

(10) a. *Though the maid mopped the floor would not get clean.*

b. *Though the maid arrived and mopped the floor would not get clean.*

Staub (2007) hypothesized that the difficulty normally encountered at the main verb (*would*) in sentences like (10a) might be lessened if the subordinate clause structure in which the ambiguity originates has some means of bolstering the ultimately correct parse, even if it is temporarily abandoned prior to the disambiguating region. Staub proposed that parallel intransitive verbal coordination could provide this mechanism. For example, (10b) contains a coordinated VP. This includes an intransitively biased verb (*arrived*) that precedes an optionally transitive verb (*mopped*). Staub hypothesized that successful parallel coordination of the first intransitive verb (V1) with a second alternating intransitive verb (V2) would strengthen the initial intransitive activation of the V2 beyond the verb's normal uncoordinated bias. At the subsequent NP region, the intransitive analysis might be temporarily dropped in favor of a transitive analysis (taking the NP as a DO), but given the earlier, bolstered activation, retrieval of that intransitive analysis would be facilitated when it was discovered to be correct at the subsequent disambiguating verb region.

In his Experiment 2, an eyetracking while reading study, just such an effect was found. Coordination in the subordinate clause eased processing difficulty at the later ambiguity. But this facilitation was apparent only in Go-Past times, a somewhat late eyetracking measure that reflects regressive eye movements to earlier regions - and the effect appeared only in the final region (*get clean*), not at the earlier disambiguating verb region, which would have served as a much better measure of online facilitation.

In regard to the implications of Staub's (2007) study for models of the parsing process and processing architecture, he points out that in order for facilitation to occur, the abandoned intransitive analysis that occurs at his second verbal conjunct would need to somehow still be active in the representation that was being built up, which a serial, deterministic model cannot accomplish. Staub thus concluded that models that posit a parallel[1] processing architecture and that have the potential to exhibit long-lasting effects provide the best means of explaining the facilitation noted in the final region. While this conclusion may be correct, the lateness of his noted effects, as well as some potential issues associated with the experimental materials (to be further discussed in Chapter 2), both limit the conclusions that can actually be drawn from his study.

Coordination has also been investigated as part of the broader question of anaphor resolution. For example, Smyth (1994) proposed that for structures that exhibit full morphological (gender and number), syntactic (grammatical function), and semantic (thematic roles) parallelism, the structure of the first conjunct should successfully prime the structure of the second. Anaphoric reference in such cases would then also exhibit full parallelism, with subject anaphors establishing reference with prior subjects, and object

---

[1] Not to be confused with the term “parallel” as in “parallel coordination.”

anaphors establishing reference with prior objects. However, in the absence of such parallelism, Smyth claimed that the probability of an anaphor in a second conjunct referring to a referent occupying the same structural position in a prior conjunct would be significantly decreased. Smyth proposed that in such cases, where a strong match was absent, anaphor objects would default to a *grammatical subject preference* and consequently refer to subjects, not objects. His findings support this claim; in an off-line task in which subjects circled the correct referent, it was found that pronouns and potential antecedents bearing different grammatical roles, like those found in sentences like (11) are less likely to establish coreference than those which bear the same roles (12).

(11) *Jane tickled Diana and Andrew laughed at her.* (non-parallel roles)

(12) *Alfred criticized Bob and Colette praised him.* (parallel roles)

Smyth (1994; see also Chambers & Smyth, 1998) proposed the extended feature match hypothesis (EFMH) to account for his findings. Under his account, a coreference processor handles the detection of matching features between conjuncts; the more features match, the stronger the parallelism will be. The relevance to the current study is noteworthy, as the "deep" representational similarities that are being investigated could also be thought of as featural in this way. Smyth's account relies on an independent mechanism, the coreference processor, to handle similarity detection and to derive whether basic, underlying verbal representations are important in establishing the parallelism effect.

Smyth's (1994) hypothesis has, however, come under close scrutiny. Kehler (2002; Kehler, Kertz, Rohde, & Elman, 2008; also see Hobbs, 1979) argued against the EFMH and grammatical subject preference, claiming that any noted effects may be neutralized when coherence relations are controlled for. Coherence can be thought of in two ways, there is internal coherence: the aspects of the causal relationships essential to interpreting a sentence, and there is external coherence: discourse level or conceptual aspects of an event and the environment it occurs in as they relate to the logical form of a sentence. The coherence approach claims that mechanisms supporting pronoun interpretation are driven predominantly by semantic knowledge, world knowledge, and inference, which are all components involved in establishing the coherence of a discourse. For Kehler, the grammatical role parallelism effect noted by Smyth is epiphenomenal. Its true origin is an independent interaction between other factors - information structure and accent placement for a particular class of coherence relations.

While not directly attributed to coherence theory, a related point nonetheless was made in Hoeks (1999: Chapter 3) regarding the importance of pragmatic fit and context in establishing coordination biases. Context sentences like (13a) in which the information structure is focused on the actions of one topic, *the model*, which creates a simplex-topic context, were predicted to have a different effect on the scope of coordination (as reflected in sentence completions) than context sentences like (13b), in which focus is on both *the model* and *the photographer*, and thus contain duplex-topic contexts.

(13) a. *When she met the fashion designer and the photographer at the party, <u>the model</u> was very enthusiastic.*

b. *When they met the fashion designer at the party, <u>the model</u> and <u>the photographer</u> were very enthusiastic.*

c. *The model embraced the designer and the photographer*______

Using a completion task for sentences like (13c), Hoeks (1999) found that simplex topic contexts were biased more towards one-topic sentential coordinations (and NP coordinations when sentential completions were not possible). In contrast, duplex topic contexts, demonstrated a strong bias towards two-topic sentential coordinations. Similar effects were replicated for self-paced reading and eyetracking. The findings were taken as support for an early effect of information structure on coordination scope and thus also for context-sensitive models over serial, deterministic models.

Another dimension of coordination that has been examined is its relation to priming. In addition to their examination of basic parallelism effects, Frazier et al. (2000) asserted that such effects are special to coordinate structures and are not, as others have claimed just another instance of syntactic priming (Arai, Gompel, & Scheepers, 2007; Branigan, Pickering, & McLean, 2005; Thothathiri & Snedeker, 2008; Traxler, 2008). In their Experiment 4, using sentences like (14), Frazier et al. did not find any difference in reading times for the non-coordinated but similarly weighted NPs in (14a) over the unequally weighted NPs in (14b) (beyond that incurred by the extra word length).

(14) a. *A strange man noticed a tall woman yesterday at Judi's.*

b. *A man noticed a tall woman yesterday at Judi's.*

From these results, Frazier et al. (2000) concluded that parallelism effects are special to coordinate structures. However, this claim has come under recent scrutiny. For example, in three eyetracking experiments, Sturt, Keller, and Dubey (2010), examined whether parallelism effects were special to coordinated structures or whether it can be found in other syntactic environments. Their primary challenge to Frazier et al. (2000) as well as to a similar study conducted in German that corroborated the Frazier findings (Apel, Knoeferle, & Crocker, 2007), was that in addition to issues regarding cross-experimental comparisons (eyetracking vs. self-paced reading) and a reliance on null effects (Frazier et al. concluded that the absence of facilitation in the non-coordinated conditions implied that there was no parallelism effect), the two studies mismatched grammatical functions between the prime and the target. For example, in (14a) from Frazier et al., *a strange man* functions as subject, whereas *a tall woman* is an object. Similarly, in the Apel et al. study, both grammatical function and case was mismatched.

Similar to what is being claimed in the current study, Sturt et al. (2010) suggest that detailed features of representations, for example, grammatical function, case marking, and semantic meaning are relevant and important to achieving or not achieving an overall syntactic parallelism effect. On account of Frazier et al.'s (2000) and Apel et al.'s (2007) inability to control for these factors, Sturt et al. deem the result of both studies inconclusive. In a series of three eyetracking experiments that tested for an effect of parallelism in both coordinated noun phrases and subordinate clauses, Sturt et al. demonstrated that parallelism effects are not limited to coordinated sentences alone, implicating priming as the mechanism that underlies the effects.

In sum, there is good evidence in the coordination literature that parallel coordination is based on a somewhat more complex set of constraints than studies like Frazier et al. (2000) and Staub (2007) have the ability to discern. Despite this drawback, these studies still provide a necessary starting point by which the set of relevant information might be identified. Studies like Sturt et al. (2010) make significant grounds in this regard, and the current study proceeds with similar goals.

Chapter 3

THE CURRENT STUDY: RE-EXAMINING PARALLELISM

3.1 Experiment 1

Staub (2007: Experiment 2) found that early activation of an intransitive analysis helps readers to more easily resolve an incorrect, transitive analysis at a later region. This was evident in faster Go-Past times in the final region of his sentences. What remains unclear is exactly how this was achieved. Staub attributed the late facilitation to intransitive parallelism in his coordinated verb phrases. That is, the intransitivity of a first conjunct influenced the intransitivity of the second conjunct such that the second conjunct was more intransitive than it would have been if uncoordinated. Critical to this manipulation was the assumption that the two coordinated verbs were sufficiently similar to engender a parallel, coordinated relation between them.

However, whether or not a truly parallel relation existed is actually unclear. While Staub attempted to control for transitivity, the study actually made use of a variety of representationally different verb types both within and between conjuncts. The verbs appear structurally similar in that they have no overt direct object in the experimental sentences, but there is much evidence that they still differ in their underlying lexical representations (Levin & Rappaport, 1995; Perlmutter, 1978; Reinhart, 2000; Staub, 2007b). For example in the first conjunct position, the study makes use of a number of superficially intransitive, yet implicitly/conceptually transitive verbs, like *eat*. Regardless of whether the theme for *eat* (e.g., *food*) is explicitly present in the syntax, it is likely that there still exists a conceptual theme. This differs markedly from other verbs that fill the first conjunct slot like *arrive*, a non-alternating unaccusative, for which the positional subject is arguably the sole internal argument of the verb (and for which there is no casual action present on any level of representation), and *travel,* which is unergative verb and has only an external argument.

Such, representational differences have been shown to have consequences on processing. For example, in a paraphrasing study, Patson, Darowski, Moon, and Ferreira (2009), demonstrated that a contrast between semi-reflexive verbs (e.g., *bathe* in 15a) and non-reflexive, transitive verbs that may optionally have their object realized implicitly (e.g., hunt in 15b) can yield differences in the final interpretation of a sentence.

(15) a. *While Anna bathed (,) the baby spit up on the bed.*

b. *While the man hunted (,) the deer ran through the woods.*

Specifically, it was found that, when a comma was present, participant-generated paraphrases showed a higher number of lingering misparses for the conceptually transitive, though superficially intransitive condition than they did for the reflexive verb condition (i.e., more instances of reporting that the man hunted the deer than Anna bathed the baby). However, these differences were no longer present when the comma was absent. While this finding, along with similar research by Christianson, Hollingworth, Halliwell, & Ferreira (2001) is most often invoked as support for partial as opposed to complete processing of garden path sentences (Ferreira, Ferraro, & Bailey, 2002; Ferreira

& Patson, 2007), it also may be taken to support the view that underlying differences between verb types are relevant to processing, and thus also relevant to the processing of coordinated structures.

In Staub (2007), more than half of the verbs used as intransitive V1s were conceptually transitive, and the remainder represented a variety of verb types. To control for this representational variation, Staub selected direct objects that were always highly implausible objects for the V1s. In addition, the V1s were always intransitively biased in the corpus from which they were selected (Gahl, Jurassky, & Roland, 2004). However this is arguably not an ideal approach, as it generates a set of materials in which the intransitive analysis at the V1 position is sometimes reliant on pragmatic/contextual constraints and at other times is reliant, though inadvertently, on the deeper lexical representations of individual verbs.

A number of additional potential issues can be found in his Experiment 2 materials. First, in regard to the implicit object verbs, if a verb's argument structure becomes immediately active upon access (Allopenna, Magnuson, & Tanenhaus, 1998; Altmann & Kamide, 1999; Boland, 2005; Dahan, Magnuson, Tanenhaus, & Hogan, 2001; Kamide, Altmann, & Haywood, 2003), there will be nothing to prevent the object from becoming active in the discourse. To what extent this would count as syntactic transitivity is debatable, but it should be taken into consideration. Second, some (but not all) of the remaining intransitive V1s actually had causative, transitive alternates (e.g., *blossom*, as in *blossom and grow* <u>*their leaves*</u>; and *relax*, as in *relax and rest* <u>*a sprained ankle*</u>), adding further variability into the materials. Third, a number of Staub's sentences used complex predicates for the V1 (e.g., *intends just to stop, tends to congregate* etc.).

This makes it still more difficult to isolate the relative contributions of each verb and further unbalances the materials. Finally, the verbs in both the V1 and V2 positions were unmatched in regard to tense and aspect. This range of variability across multiple parameters undermines Staub's ability to make claims about the relative impact of one verb on another, and it remains unclear whether parallelism was actually established under such diverse conditions or if the late facilitation came about as a result of other factors, such as semantic/pragmatic effects like the goodness-of-fit of the subject to the verb/event.

In addition to the materials-related issues mentioned above, it is important to note that the observed effect showed up only in Go Past times for the final region - a rather late measure in a late region. The absence of facilitation at the earlier disambiguating verb region presents difficulties for any conclusions regarding online facilitation, and does little to distinguish between two-stage and competition-based models of the processing architecture.

In Experiment 1, I adopt the same basic approach used in Staub (2007) to elicit a facilitatory effect of early verbal parallelism on a later garden path region. I use a subset of his sentences as well as a new set of sentences for which differences in the underlying lexical-semantic representations of the coordinated verbs as well as other factors, like tense, have been treated more consistently. The goal is to both replicate Staub's basic findings and to test the hypothesis that matching the underlying representations of the coordinated verbs will enhance parallelism within the coordinated phrase. If lexical-semantic representations do indeed play a role in establishing parallelism, the intransitive analysis at the V2 verb should receive more support, which will in turn facilitate recovery from or eliminate completely any garden path at the disambiguating verb region. Thus there should be earlier or more robust evidence of facilitated recovery at the disambiguating main clause verb when the coordinated verbal representations have similar lexical-semantic representations than when they differ. In addition, it is hoped that by finding an earlier pattern of results, more can be said regarding the processing architecture that might underlie the process of ambiguity resolution, especially at the second verbal conjunct.

3.1.1 Method

3.1.1.1 Participants.

Twenty-four participants from the University of Michigan participated in the experiment to receive credit for an introductory psychology course. Participants were all over 18 years of age with normal to corrected vision. All participants were native speakers of English. Two subjects were removed prior to analysis as they responded incorrectly to over one third of the comprehension questions.

3.1.1.2 Materials.

Twenty items were selected from Staub (2007; Experiment 2). Four of Staub's original items were omitted to eliminate verb redundancy and balance presentation lists. In addition, 20 new coordinated/non-coordinated item pairs were constructed. For the new materials, a number of guidelines were adopted. For verb selection in the current study, only verbs that could be classified as alternating unaccusatives, following the classification criteria outlined in Levin and Rappaport (1995) were utilized. A number of subclasses were avoided on account of their relative indeterminacy in respect to prior classification systems such as that in Perlmutter (1978), which differs from the Levin and Rapport system considerably. For example, verbs of emission (e.g., *beam*) were avoided, as were agentive manner of motion verbs (e.g., *roll*) both of which are classified as unergative in Levin and Rapport, but are unaccusative in Perlmutter (1978). In addition, unaccusative manner of motion verbs that are classified as having both unaccusative and unergative forms in Levin and Rappaport's analysis were also avoided. However, some exceptions were made. For example, the materials contain a number of verbs of spatial configuration (*tilt*, *dangle*, *swing*, *hang*). These verbs, though unaccusative under Levin and Rappaport's analysis, also have potentially non-unaccusative variants. Their inclusion is admittedly non-optimal, though necessary to ensure sufficient items.

In addition to the verb class constraint, an adverbial modifier was added to the first verbal conjunct to ensure that an intransitive analysis is adopted for the first verb. This is a compromise to some degree, as the presence of the adverb will not represent the most basic form of verbal coordination. For example, although a sentence like *When the giant iceberg slowed suddenly and sank*... has a parallel completion (e.g., …and sank quickly…), the structural weight of the first VP conjunct means that a fully parallel completion would have to be equally weighted (i.e., have a post-verbal adverb). However the addition does still allow for a possible parallel completion, and the inclusion of an adverb is necessary, as unlike Staub (2007), the materials are not reliant on pragmatics to encourage the intransitive parse. In addition, the current study does not use non-alternating unaccusatives (*arrived*) in the first conjunct (which Staub uses for roughly half of his items) and thus cannot guarantee that the two conjuncts will not be both taken to be subjects of the same direct object. The trade-off for this compromise is that while some pragmatic control is lost, a fair degree of representational consistency is gained.

Finally, tense was held constant; all new verbs appeared in the simple past tense. This contrasts markedly with Staub's (2007) materials for which a variety of tenses were used. In addition, particle verbs and verbs with complex predicates, all present in the Staub materials, were avoided when constructing the new materials.

There were four conditions: an uncoordinated condition (S-NoCoord) (16a) and a non-semantically related coordinated condition (S-NotSem) (16b) from Staub, and a new non-coordinated (N-NoCoord) (17a) and coordinated condition (N-NotSem) (17b) that adhere to the new constraints detailed above.

(16) a. *The vet said that because the dog /ate /the medicine /had /its effect.*

b. *The vet said that because the dog slept and /ate /the medicine /had /its effect.*

(17) a. *Although the pirate ship /sank /the British vessel /did not /send out lifeboats.*

b. *Although the pirate ship halted suddenly and /sank /the British vessel /did not /send out lifeboats.*

The new coordinated conditions are referred to as NotSem in anticipation of an upcoming semantic/non-semantically related contrast between conjuncts in Experiment 2. Sixty fillers of various types were randomly distributed amongst the critical items to mask the experimental manipulation. Full materials are presented in Appendix D.

3.1.1.3 Procedure and Equipment.

Sentences were presented in a moving window, word-by-word reading paradigm using E-Prime 1.0 and were displayed in 12 pt Courier New font on a 19” widescreen LCD monitor (1680 x 1050). Courier New font was selected for its regularity of character width across characters and spaces. Presentation regions (Table 1) were divided up in a like manner to the analysis regions from Staub (2007). Region boundaries are indicated by “/” in (16) and (17). The unusually long initial region was necessary on account of the high variability of sentential material in Staub’s initial region. This variability precluded the division of the words into standard regions, as could have been done if only the new, more streamlined materials had been used. It is also important to note that Staub used eyetracking and not word-by-word reading, and thus this variability was not problematic for his experiment - though his initial presentation region included a large number of words, readers had the advantage of reading through each section in a measured way. Such measured presentation is not possible in the current experiment.

Table 1. Experiment 1 presentation regions.

Region	Text
1. Intro	Although the pirate ship (halted suddenly and)
2. V2	sank
3. NP	the British vessel
4. DisambV	did not
5. WrapUp	send out lifeboats.

On account of the length of the sentences in relation to the screen size, a carriage return was necessitated after each disambiguating verb region in the presentation materials. Thus, item presentation was split between two lines of text.

Experimental sentences were distributed across two lists. Three practice items preceded the experimental items. In addition to the critical and filler items, 50 percent of all trials, including both critical sentences and fillers, were immediately followed by Yes//No comprehension questions to monitor each subject's attention level. Comprehension questions were fixed to certain items and as such were randomized in a like manner. Subjects were instructed to read at their own pace.

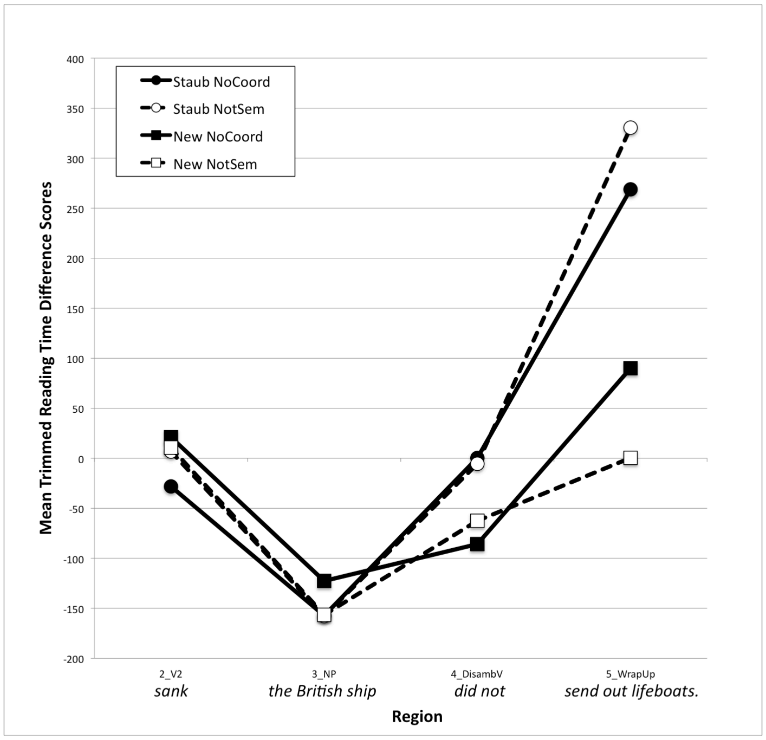
3.1.2 Results

Prior to analysis, raw reading scores falling beyond 2.5 SD from the region mean were trimmed to equal the mean plus or minus 2.5 SD. This occurred for less than three percent of the data. In addition, reading times required normalization to correct for differences in region length between experimental sets. For example, the material in the ambiguous noun phrase region used in the new materials consistently has a modifier present before the head noun, whereas the material in the corresponding region in the materials taken from Staub (2007) does not. Using the technique outlined in Ferriera and Clifton (1986), a linear regression equation was applied to the trimmed reading times. Predicted reading times were then computed as a function of the number of characters in each region for each subject and compared against actual reading times to generate difference scores for each region. The magnitude and direction by which difference scores deviate from a zero point (the expected scores) were then taken to be indicative of the presence or absence of factors which facilitate or hinder processing for each region. For example, negative difference scores would indicate faster than average reading times, whereas positive difference scores would indicate slower than average reading times (when statistically significant).

For item analyses, the adjusted, difference score reading times for each presentation region were submitted to a 2 (item group) X 2 (experiment set) X 2 (coordination) repeated measures ANOVA, with coordination as a within item factor and item group and experiment set as between item factors. Subject analyses utilized a 2 (list) X 2 (experiment set) X 2 (coordination) ANOVAs for each region, with coordination and experiment set as within subject factors and list as a between subject factor.

Analysis focused on the final four regions: the second VP region (V2), the ambiguous NP region (NP), the disambiguating verb region (DisambV), and the final wrap up region (WrapUp), The first region was excluded as the material between experiment sets was not only of different length, but also contained different phrasal material, prohibiting an informative comparison. The pattern of results is presented in Figure 1.

Figure 1. Experiment 1 Mean, trimmed reading time difference scores (trim time - predicted time). NotSem conditions are coordinated, but not semantically related.



At the second verbal conjunct (Region 2), no main effect of coordination was found [*F1*(1,20)=.557, p>.05; *F2*(1, 36)=.502, p>.05]. Experiment set [*F1*(1,20)=2.503, p>.05; *F2*(1,36)=1.662, p>.05] and the interaction [*F1*(1,20)=3.647, p=.07; *F2*(1,36)=1.704, p>.05] were also non-significant.

In Region 3, the ambiguous noun phrase region, also did not show a main effect of coordination [*F1*(1,20)=.411, p>.05; *F2*(1,36)=.653, p>.05]. Experiment set [*F1*(1,20)=.439, p>.05; *F2*(1,36)=.349, p>.05] and the interaction [*F1*(1,20)=.387, p>.05; *F2*(1,36)=.619, p>.05] were both non-significant.

Region 4, the disambiguating verb region, also failed to display an effect of coordination [*F1*(1,20)=.096 p>.05; *F2*(1,36)=.190, p>.05, but there was a main effect of

Experiment Set [$F1(1,20)=8.840$, $p<.05$; $F2(1,36)=4.378$, $p<.05$] whereby the new materials were faster overall than the Staub (2007) materials. This did not, however, interact with coordination [$F1(1,20)=.426$ $p>.05$; $F2(1,36)=.528$, $p>.05$].

A significant experiment set effect (by subjects and items) also showed up in the final wrap up region (Region 5) [$F1(1,20)=28.615$, $p<.001$; $F2(1,36)=9.848$, $p<.05$], trending towards an interaction with coordination by subjects [$F1(1,20)=2.716$, $p=.10$] but not by items [$F2(1,36)=1.752$, $p>.05$]. However, no effect of coordination was found in this region [$F1(1,20)=.139$, $p=.714$; $F2(1,36)=.060$, $p=.808$].

3.1.3 Discussion

The current experimental manipulations failed to reveal a main effect of coordination for any of the critical regions. Thus the current study did not replicate the primary finding from Staub (2007) whereby the presence of coordination facilitated processing in the final wrap up region, and there was no evidence that the new, more highly parallel, coordinated materials were effective. In part, the absence of any coordination effects may be due to the unusually long initial presentation region that was used in the current study but that was not present in the Staub experiment, as discussed above. There was a main effect of experiment set for which the new materials were read faster than the Staub materials at both the disambiguating verb region and in the final wrap up region. This finding suggests that the new set of materials engendered less processing difficulty overall than the Staub materials. As this facilitation occurs both in the presence and absence of coordination, it may be tied to a more highly intransitive selection of verbs in our V2 region. In addition, it is worthwhile noting that there was a trend towards interaction between coordination and experiment set in the subject analysis.

However, this is a crossover interaction, and it is not clear why the Staub materials would show a disadvantage. In sum, the study suggests that the coordination advantage found in Staub may be either spurious or not replicable using the current paradigm, at least with coordinated materials which bear little to no semantic relatedness between conjuncts.

3.2 Normative Study 1

Experiment 1 utilized a moving window paradigm to contrast coordinated and non-coordinated items from Staub (2007: Experiment 2) with a new set of coordinated and non-coordinated items. Unlike the items found in Staub, the new materials appeared in the past tense, were alternating unaccusatives (Levin and Rappaport, 1995), and used an adverb after the first conjunct forces the intransitive reading. Surprisingly, the coordination advantage noted in Staub was not replicated. The normative study will help determine 1) the inherent transitivity biases of the both the new set of verbs and the verbs taken from Staub (2007) and 2) whether the lexical/lexical-semantic properties or biases of the verbs used correlate with reading time differences as noted in Experiment 1. Also, in anticipation of a manipulation in Experiment 2, Normative Study 1 includes a semantically related, coordinated verb condition (Sem) to contrast with the coordinated, but not semantically related verbs (NotSem) and the non-coordinated verbs (NoCoord) from Experiment 1.

The study will also serve to replicate the normative study results from Staub (2007), which was also intended to determine verb biases. For his study, Staub tested two conditions, a coordinated condition containing the first verb followed by *and* (18a) and an uncoordinated condition which omitted both verbs (18b). In both conditions, Staub omitted the critical V2 verb, reasoning that its inclusion would cause participants to too readily interpret the end of the fragment as being the end of the clause.

(18) a. *Though the maid arrived and____*

b. *Though the maid____*

Staub found that there were significantly more intransitive completions in the coordination condition (61%) than in the non-coordinated condition (45%). However, while this finding suggests that an intransitive V1 might prime the use of a second intransitive V2 when in a coordinate structure, it says nothing about the transitivity biases of the V2's that are the critical verbs in his Experiment 2.

The current normative study takes a different approach - maintaining the second verbal conjunct in the sentential materials. As will be seen below, this provides a better picture of how the verbs in the second conjunct are biased in the context of the material that precedes them. Furthermore, it will be seen that it is not necessarily the case, at least for the Staub verbs, that the inclusion of the V2's prematurely closes off interpretation.

3.2.1 Method

3.2.1.1 Participants.

Twenty-seven native English-speaking participants from the University of Michigan took the study in exchange in fulfillment for a requirement of an undergraduate psychology class. Six participants were removed on account of a technical issue (non-functioning backspace button) and one removed for finishing the study in an exceedingly short period of time.

3.2.1.2 Materials.

The study uses six versions of each of the 20 new sentences from Experiment 1, plus one new verb/sentence that will be used in Experiment 2, as well as the 20 sentences selected from Staub that also appeared in Experiment 1. The first and second version consisted of the uncoordinated condition, in both short and long forms, respectively. Long forms consisted of material from the sentence start, up to and including the ambiguous NP as in (19a). Short forms omitted the final NP, as in (19b). The third and fourth versions each contained two semantically related conjuncts. The long version included the ambiguous NP (20a), whereas the short version omitted it (20b). Finally, the fourth and fifth versions consisted of two conjuncts bearing no obvious semantic relation. The long version included the ambiguous NP (21a) whereas the short version omitted it (21b).

(19) a. *Although the pirate ship sank the nearby British vessel*_____

b. *Although the pirate ship sank*_____

(20) a. *Although the pirate ship halted suddenly and sank the nearby British vessel*_____

b. *Although the pirate ship halted suddenly and sank*_____

(21) a. *Although the pirate ship capsized suddenly and sank the nearby British vessel*_____

b. *Although the pirate ship capsized suddenly and sank*_____

This yielded a total of 103 critical sentence items that were then rotated in three blocks across two presentations lists and randomized, with three of the six conditions appearing in each list. In this way, each version of each item was distanced as much as possible without having a predictable placement. No fillers were used. Full materials are presented in Appendix C.

3.2.1.3 Procedure.

Sentences were presented using E-Prime 1.0 and were displayed in 12 pt Courier New font on a 19” widescreen LCD monitor (1680 x 1050). Participants were instructed to type completions for each partial sentence presented on the screen and were allowed to revise completions prior to advancing to the next item.. Participants were encouraged to complete the experiment at their own pace.

3.2.2 Results.

For analysis, the new verbs and the verbs from Staub (2007) were subjected separately to 3 (coord) X 2 (length) ANOVAs. Mean transitive completeions are presented in Table 2, but only the short forms are discussed below, as they appear to best reflect the basic biases of the verbs.

For the new verbs, there was a main effect of coordination [$F2(2,40) = 5.370$ $p < .05$] for which post hoc tests (Bonferroni) revealed that the NoCoord condition was significantly less transitive than NotSem ($p<.05$). For Staub’s verbs, the short, NoCoord forms appear to be equibiased. However, with the addition of coordination the NoCoord condition the bias turned more transitive in comparison to the NotSem condition (44% vs. 28% transitive) [$F2$ $(1,19) = 20.535$ $p < .001$].

Table 2. Normative Study 1 Mean transitive completions.

		Item Length	
Experiment Set	Coordination Condition	Long	Short
New	NoCoord	0.82	0.06
	NotSem	0.85	0.19
	Sem	0.84	0.11
Staub	NoCoord	0.97	0.44
	NotSem	0.94	0.28

3.2.3 Discussion

The general pattern of results indicates that the majority of the new verbs have a basic intransitive bias when they are uncoordinated and are not followed by an NP (the short conditions). Two exceptions are *toughened* and *dangled* which pattern more as equibiased transitive/intransitive verbs (each had a .4 mean transitivity completion rate). Adding coordination reduces this bias somewhat, though the verbs still remain strongly intransitive. Furthermore, the verbs turn highly transitive with the addition of an ambiguous NP after the uncoordinated version of each verb. The non-coordinated verbs from Staub (2007) appear to have a higher transitivity bias overall which may be driven by a subset of items (see Table 3). For example, Staub's *grow*, *restarts*, *rests*, and *left* appear intransitively biased for the Short/NoCoord conditions, while *ate, saved, directs, and plans* pattern in the opposite direction. In sum, the overall biases appear to be much more highly consistent for the new items than for Staub's. Crucially, as demonstrated by the variability in the Staub materials, the manipulation did not create a ceiling effect by which all verbs elicited intransitive responses, demonstrating 1) that the task was sufficiently sensitive to verb biases and 2) that inclusion of the critical V2 verb does not cause participants to too readily interpret the end of the fragment as being the end of the clause.

Table 3. Normative Study 1 Mean transitive completions, NoCoord and NotSem.

	Mean Tran			Mean Tran	
V2 (DT)	NoCoord	NotSem	V2 (Staub)	NoCoord	NotSem
sank	0.00	0.10	*ate*	0.90	0.60
rested	0.00	0.10	*fight*	0.00	0.00
burned	0.20	0.40	*write*	0.40	0.20
exploded	0.00	0.10	*perform*	0.20	0.20
healed	0.00	0.10	*study*	0.20	0.10
corroded	0.00	0.00	*direct*	0.80	0.10
rotated	0.00	0.20	*played*	0.20	0.20
shattered	0.00	0.00	*restarts*	0.00	0.00
shook	0.00	0.20	*advertised*	0.40	0.40
toppled	0.00	0.20	*attack*	0.40	0.20
froze	0.00	0.00	*feed*	0.78	0.40
bent	0.00	0.20	*cooking*	0.10	0.10
developed	0.00	0.10	*leave*	0.20	0.20
solidified	0.00	0.10	*stole*	0.60	0.20
grew	0.00	0.60	*mopped*	0.60	0.50
brightened	0.00	0.10	*contemplate*	0.40	0.40
stopped	0.00	0.30	*plans*	0.78	0.30
polarized	0.00	0.30	*jump*	0.50	0.20
toughened	0.40	0.60	*saved*	0.90	0.80
dangled	0.40	0.10	*summarize*	0.50	0.40
dissolved	0.20	0.20			

3.2.4 Regression Analysis.

To assess the impact of inherent verb transitivity on reading times, the mean transitivity scores for the short, non-coordinated form of each verb were used in a regression equation as predictors for the mean residual reading times for the NoCoord and NotSem conditions from Experiment 1. Residual reading times represent the difference between actual and predicted reading times computed for each subject's average time spent per character, following the procedure outlined in Ferreira and Clifton (1986; see Trueswell, Tanenhaus, & Garnsey, 1994 for discussion). The short non-coordinated transitivity biases were selected for analysis as they most closely reflect the inherent biases of the verbs. As Experiment 1 did not distinguish between semantically related and non-semantically related coordination, the semantically related items from Normative Study 1 (included in anticipation of the upcoming Experiment 2) were excluded from the regression analysis. One additional verb, *dissolved*, which is used in Experiment 2, was also omitted, as there was no data from Experiment 1 on this item.

Figure 2. Experiment 1 mean, predicted reading times for Region 4 (DisambV) for NoCoord/short condition.

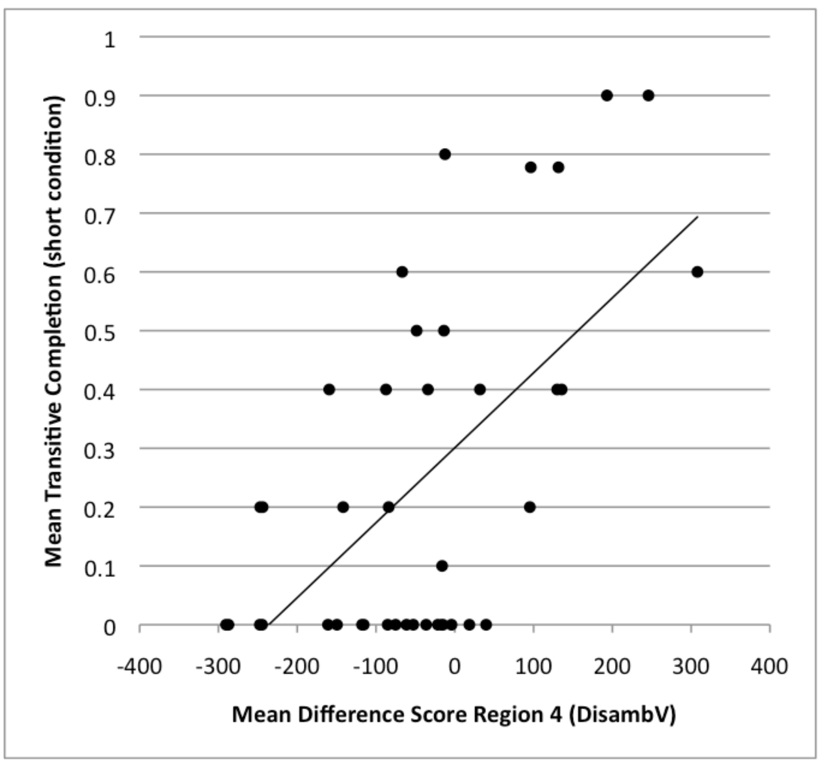


Figure 3. Experiment 1 mean, predicted reading times for Region 4(DisambV) for NotSem/short condition.

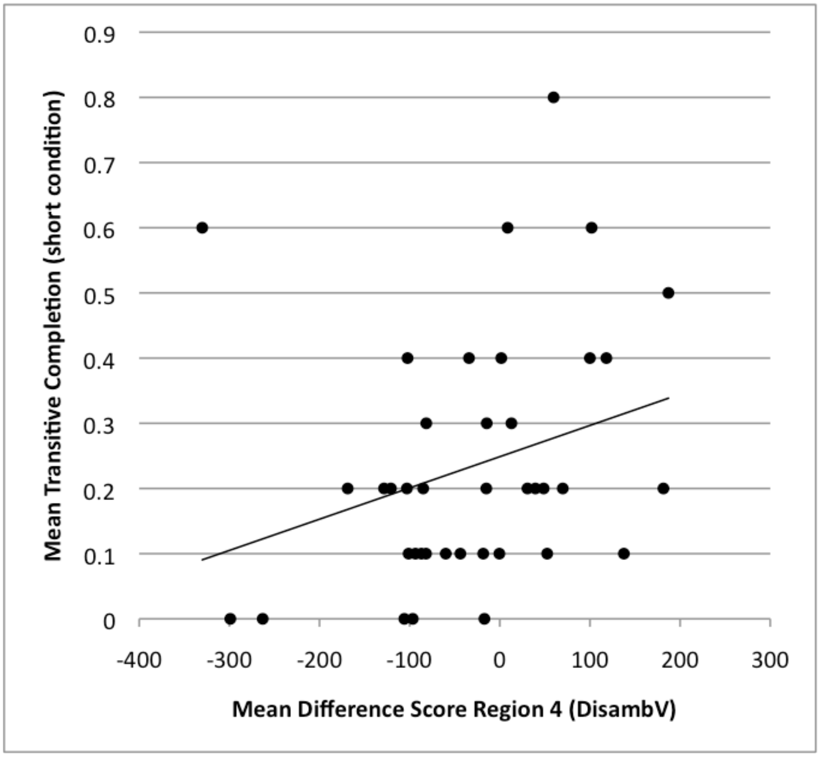
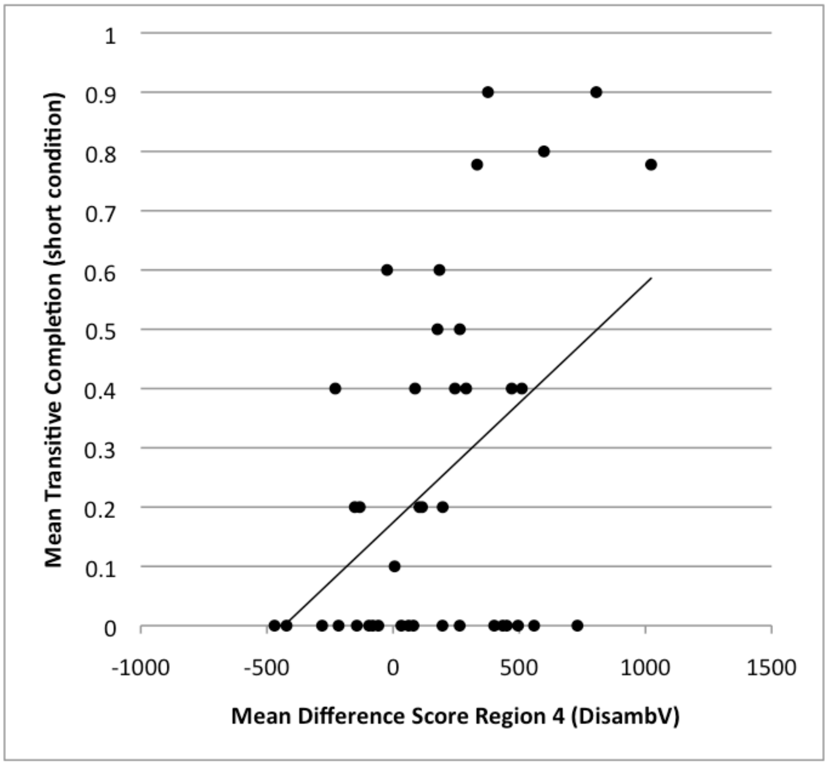


Figure 4. Experiment 1 mean, predicted reading times for Region 5 (WrapUp) for NoCoord/short condition.



At the ambiguous NP region (Region 3), verb transitivity was not a reliable predictor for reading times in either the NoCoord (R^2 = .001, $F(1, 39)$ = .019, p =.891) or the NotSem condition (R^2 = .001, $F(1, 39)$ = .028, p =.891).

However, at the disambiguating verb region (Region 4), higher transitivity scores did significantly predict longer reading times in the NoCoord condition (R^2 = .363, $F(1, 39)$ = 21.692, p < .001) (Figure 2), and higher transitivity scores only marginally predicted longer reading times for the NotSem coordinated condition (R^2= .083, $F(1, 39)$ = 3.462, p =.071) (Figure 3).

In the wrap up region (Region 5), transitivity served as a good predictor of reading time for the NoCoord condition (R^2= .202, $F(1, 39)$ = 9.603, p < .05) (see Figure

4), but this predictive power only trended towards significance when coordination was added, as in the NotSem condition (R^2= .068, $F(1, 39) = 2.761$, p =.105).

3.2.5 Discussion

The results of the normative study indicate that for the short NoCoord condition the new V2s are relatively stable in their basic transitivity. Furthermore, they have a higher intransitive bias than those found in Staub (2007). If transitivity biases can be thought of as lexical constraints, and if lexical constraints can affect the earliest stages of a parse, then transitivity bias might translate into higher or lower activation of a particular parse at the V2 region. That is, in a highly parallel, coordinated phrase, an intransitively biased V2 verb would be similar to a preceding, intransitive V1, and consequently the intransitive form of the V1 would support the bias for an intransitive parse at the V2. In contrast, an intransitive V1 would provide information that conflicts with the biasing information provided at a transitive V2. This would thus more likely lead to postulation of a transitive parse than in the prior case. For the instances where the transitive analysis prevailed or was more highly activated at the V2 region, there would be a greater and less recoverable garden path at the disambiguating verb region, as the intransitive V2 analysis would be less available for retrieval at that garden path.

The NoCoord results from the regression analysis support the predication that the more basically transitive a verb, the more difficulty ensues at the disambiguating verb region. Yet it is still unclear whether the addition of parallel coordination has any further potential to mitigate any later processing difficulty in this same region. As seen in the NotSem results, the addition of coordination diminishes predictive power in the regression analysis; transitive completions are lower, yet reading difficulty does not diminish in a like way. There are at least three possible explanations for the lower correlation in the NotSem condition. The first is that the V1s, for which the transitivity biases remain unknown, likely have some influence on the transitive biases of the V2s. Secondly, the NotSem completions had a good deal more variability than the NoCoord completions (perhaps related to the first point) and thus may not serve as reliable predictors. Finally, some additional factors may come into play with the addition of the coordinated phrase that causes processing difficulty at the NP region. For example, as Staub (2007b) suggests, the absence of the comma may cause processing difficulty at the end of the subordinate clause. This might be evident as longer spillover reading times at the following disambiguating verb region.

3.3 Experiment 2

Experiment 2 uses word-by-word reading to test whether heightening the semantic relatedness of verbal conjuncts will create stronger parallelism in a coordinated clause, resulting in facilitation at the disambiguating verb region and beyond. In Experiment 1, the facilitatory pattern that Staub (2007) found was not replicated. This may be on account of the fact that different paradigms (word-by-word reading vs. eyetracking) were used in the two experiments and the difference in materials presentation that was required, particularly in regard to the initial region. In addition, it is likely that the expected parallelism effect is relatively subtle, and it is possible that additional constraints are needed to enhance parallelism such that the intransitive analysis is sufficiently supported at the V2, especially when using word-by-word reading paradigms. Prior studies have shown that semantics may have an influence on both parallelism (e.g., Smyth, 1994; Stevenson, Nelson, & Stenning, 1995) and on priming

(Cleland & Pickering, 2003). Thus in addition to changing presentation regions, a semantic manipulation may provide further means to obtaining the facilitation effect from Staub (2007) that was not replicated in Experiment 1. Such an addition also carries the benefit of further addressing the question of what type of information is relevant to parallel coordination.

For this experiment, all coordinated verbs are assumed to be parallel in their lexical-semantic representations. The degree to which the intransitive analysis remains active is expected to be a function of the level of semantic/conceptual parallelism achieved between V1 and V2. If semantics plays a role in parallelism, the more semantically similar the conjuncts are, the higher the intransitive parallelism will be. This is expected to be visible as a greater level of facilitation in the disambiguating verb region and beyond.

3.3.1 Method

3.3.1.1 Participants.

Thirty-eight native English-speaking participants from the University of Michigan took the study in exchange in fulfillment for a requirement of an undergraduate psychology class. Two participants were removed on account of technical issues, leaving 36 subjects for analysis.

3.3.1.2 Materials.

Twenty-one critical items were constructed for the study. Twenty were identical to the new items used in Experiment 1. One additional item, present in Normative Study

1, was also used. In addition to the NotSem (22b) and NoCoord (22c) conditions from Experiment 1, a semantically related condition (Sem) (22a) was also included.

(22) a. *Although /the pirate ship /capsized /suddenly /and /sank /the nearby British vessel /did not /send out /lifeboats.*

b. *Although /the pirate ship /halted /suddenly /and /sank /the nearby British vessel /did not /send out /lifeboats.*

c. *Although /the pirate ship /sank /the nearby British vessel /did not /send out /lifeboats.*

In Experiment 1, verbs were held constant in their lexical-semantic representation status in that they were all alternating unaccusatives. For the semantic manipulation in Experiment 2, the standards of classification were further refined such that semantically related pairs were primarily obtained from the same broad lexical subclass, as classified in Levin (1993). Levin and Rappaport (1995) consider their classification system to be syntactically based. However, under their system, similarities in lexical-semantic representations also tend to conveniently fall into semantically distinct groupings (though one verb may be cross-listed between several semantic classes). All but five of the 21 pairs adhere to this constraint. Of the five deviants, three pairs were not analyzed specifically in the Levin and Rappaport materials, but appear to meet the proper criteria. Two others are conceptually similar, but members of different (though related) subclasses. Beyond their lexical-semantic class, the criteria for determining “semantic” relatedness relied primarily on whether the two verbs invoked an intuitively similar conceptual event type. For example, *capsizing* and *sinking* have a good deal of conceptual overlap, at least in regard to the resulting stage of each event. Albeit, this is a rather rough metric, but given the constraints imposed on the materials, it represents a realistic compromise. Semantic pairs are listed in Table 4 below.

In addition to the 21 critical items conditions, 79 filler items bearing a variety of syntactic structures were also used. Full materials are presented in Appendix E.

Table 4. Experiment 2 verb class correspondences between V1 and V2

Item	V1	Verb Class	V2	Verb Class
1	capsized	Other alternating of change of state (45.4)	sank	Other alternating of change of state (45.4)
2	relaxed	undetermined	rested	spatial configuration (47.6): assume position
3	ignited	Other alternating of change of state (45.4)	burned	Other alternating of change of state (45.4)
4	expanded	Other alternating of change of state (45.4)	exploded	Other alternating of change of state (45.4)
5	improved	Other alternating of change of state (45.4)	healed	Other alternating of change of state (45.4)
6	rusted	Internally caused change of state (45.5)	corroded	Internally caused change of state (45.5)
7	spun	Roll (51.3.1) external cause left unexpressed	rotated	Roll (51.3.1) external cause left unexpressed
8	broke	Break verbs (45.1)	shattered	Break verbs (45.1)
9	jiggled	undetermined	shook	undetermined
10	tilted	Other alternating of change of state (45.4)	toppled	Other alternating of change of state (45.4)
11	cooled	Other alternating of change of state (45.4)	froze	Other alternating of change of state (45.4)
12	warped	Other alternating of change of state (45.4)	bent	Bend verbs (45.2)
13	unfolded	Other alternating of change of state (45.4)	developed	appearance (48.1.1)
14	hardened	Other alternating of change of state (45.4)	solidified	Externally caused of change of state L&R 45
15	sprouted	Other alternating of change of state (45.4)	grew	Other alternating of change of state (45.4)
16	lightened	Other alternating of	brightened	Other alternating of change

		change of state (45.4)		of state (45.4)
17	decreased	Other alternating of change of state (45.4)	stopped	undetermined
18	decomposed	Other alternating of change of state (45.4)	dissolved	Other alternating of change of state (45.4)
19	magnetized	Other alternating of change of state (45.4)	polarized	Other alternating of change of state (45.4)
20	strengthened	Other alternating of change of state (45.4)	toughened	Other alternating of change of state (45.4)
21	hung	spatial configuration (47.6): assume position	dangled	spatial configuration (47.6): assume position

3.3.1.3 Procedure.

For the experiment, the three conditions were randomly distributed across 23 presentation lists such that each subject would only see one instance of each item. Sentences were presented in a moving window, word-by-word reading paradigm using E-Prime 1.0 and were displayed in 12 pt Courier New font on a 19” widescreen LCD monitor (1680 x 1050).

Experiment 1 followed the segmentation used for analysis in Staub (2007). This was necessitated by the fact that Staub’s materials were of inconsistent composition within the initial region. While this may not have been an issue for eyetracking (in which sentential regions are used only for analysis and not for presentation), it resulted in an exceedingly lengthy introductory region in the word-by-word reading study, which may have contributed to the inability to replicate his findings. For the current study, which omits the Staub verbs, this large initial region was no longer necessary. Presentation regions were thus divided into nine considerably smaller units, roughly corresponding to individual lexical items or constituents. Exceptions to this include the disambiguating verb region and the wrap up region. Disambiguating verb regions all began with an auxiliary verb and were followed by an adverb, qualifier, or negation. Wrap up regions varied to some degree. Region boundaries are indicated by "/" in (22) above and examples are presented in Table 5 below. A carriage return was again included after each disambiguating verb region in the presentation materials on account of screen space limitations. Thus, item presentation was split between two lines of text.

Table 5. Experiment 2 presentation regions.

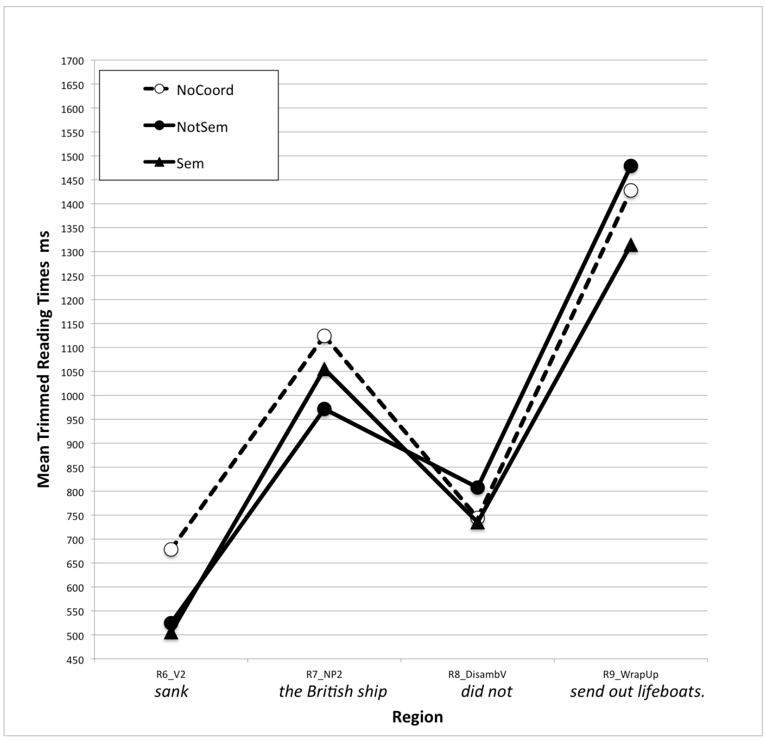
Region	Text
1. Intro	Although
2. NP1	the pirate ship
3. VP1	capsized/ halted
4. Adv	suddenly
5. Con	and
6. VP2	sank
7. NP	the nearby British vessel
8. DisambV	did not
9. WrapUp	send out lifeboats.

Three practice items preceded the experimental items. In addition to the critical and filler items, 50 percent of all trials, including both critical sentences and fillers, were immediately followed by Yes//No comprehension questions to monitor each subject's attention level. Comprehension questions were fixed to certain items and as such were randomized in a like manner. Participants were instructed to read at their own pace.

3.3.2 Results

For analysis, reading scores for 36 participants were first adjusted to normalize reading times that fell 2.5 SD above or below the mean, following the procedure outlined in Experiment 1. Approximately 2% of the data was affected. Adjusted reading times were then analyzed using repeated measures ANOVAs, with coordination used as both a within items and within subjects factor. As in Experiment 1, analysis begins at Region 6 (V2). The pattern of results for Regions 6-9 is presented in Figure 5. As the experiment is not fully balanced, an effect of coordination as presented below may apply to a facilitatory pattern arising from semantic/conceptual parallelism and/or the presence or absence of coordination (here assumed to be parallel in lexical-semantic representations).

Figure 5. Experiment 2 mean, trimmed reading times regions 6-9 (ms).



At Region 6 (V2), there was a main effect of coordination by both subjects and items [*F1*(2,66)=14.294, p<.001; *F2*(2,36)=19.576, p<.001]. Post hoc tests (Bonferroni, α=.05) revealed that reading times for the NoCoord condition were greater than those for NotSem and Sem, both by subjects and items.

There was also an effect of coordination in Region 7 (NP) that was significant only by subjects [$F1(2,66)=11.200$, $p<.001$]. Post hoc tests (Bonferroni, $\alpha=.05$) revealed that NoCoord times were longer than those for NotSem, and that times for Sem were longer than those for NotSem. Coordination was also significant by items [$F2(2,36)=4.986$, $p<.05$], with post hoc tests (Bonferroni; $\alpha=.05$) indicating that NoCoord times were longer than NotSem.

There was no effect of coordination at Region 8 (DisambV) [$F1(2,66)=2.338$ $p=.104$; $F2(2,36)=2.270$ $p=.118$].

At Region 9, the wrap up region, there was a marginally significant effect of coordination by subjects [$F1(2,66)=2.975$, $p=.058$] for which post hoc tests (Bonferroni, $\alpha=.05$) indicated that NotSem was significantly longer than Sem. There was also a significant effect of coordination by items [$F2(2,36)=4.468$ $p<.05$] though post hoc tests (Bonferroni, $\alpha=.05$) were only marginal, with NotSem times patterning longer than Sem.

3.3.3 Discussion

If semantic/conceptual information is relevant to establishing parallel coordination, we should see more effective intransitive priming of V2 in the semantic condition (Sem) than in the non-semantically related coordinated condition. This would be apparent as faster reading at the disambiguating verb region and beyond. In addition, if the presence of coordination (assumed to be parallel in lexical-semantic representations between conjuncts – though this is not tested directly here) affects the intransitive analysis at V2 we should expect equal facilitation at the disambiguating verb region and beyond for both coordinated conditions, but not for the non-coordinated condition. If not, reading times should be equal for all three conditions.

A significant main effect of coordination was found in the final region, for which reading times were significantly faster for Sem than NotSem (by items, marginal by subjects). This could reflect spillover from the earlier disambiguating verb region where a similar effect was not found. The finding suggests the presence of coordination does boost parallelism, and thus activation of the intransitive parse at the V2, at least when there is some measure of conceptual/semantic relatedness between conjuncts. The lack of a difference between NoCoord and NotSem suggests that the mere presence of coordination is not sufficient to establish parallelism between conjuncts, though it is not clear whether this is on account of the NotSem lexical-semantic representations being insufficiently parallel or not.

At the earlier V2 and NP regions, it was not clear what pattern might emerge. An unexpected finding in Staub (2007) was that at his V2 region, the non-coordinated condition had significantly faster first pass times than his coordinated condition, which would seem to contradict facilitation effects arising from structural parallelism, such as those seen in Frazier et al. (2000). Numerically, the difference was small (25ms), and Staub explained the effect as the result of low-level (non-linguistic), saccade landing site differences arising from the presence or absence of the conjunction and, which on account of its length was likely to be skipped, resulting in a greater number of re-fixations. In addition, no effects were found in his ambiguous NP region.

In contrast, the facilitation seen at V2, which matches the numerical, but not statistical pattern seen for the new verbs in Experiment 1, could be taken to indicate that the presence of coordination does have a facilitatory effect on processing of the second conjunct, similar to the effects found for second conjunct NPs in Frazier et al. (2000).

This facilitation would presumably arise because the V1s were sufficiently similar/parallel to the V2s, such that processing of the V2s was facilitated in comparison to other conditions. However, NoCoord is not an ideal point of comparison for the coordinated conditions, as it does not contain the same number of sentential regions. What is really needed to interpret this effect is a contrasting condition within the coordinated items. Just such a contrast will be examined in Experiment 4. Thus, for now, this explanation for the facilitatory effect seen at the V2 region remains speculation.

For the NP region, two stage models would predict a slight garden path for the coordinated conditions, since for such models the previous, intransitive parse at the V2 would be need to be reanalyzed as transitive when the NP was encountered, as this NP would preferentially be attached as an object, given default structural heuristics/preferences. But as was seen above, the NotSem coordinated condition was facilitated, and both coordinated conditions patterned visually faster than NoCoord. Constraint-based/competition models could potentially accommodate this finding. Though coordination may have ultimately resulted in the selection of the intransitive parse at the V2, it is likely that the transitive parse was also active at the V2 region, especially if the two analyses were engaged in competition (which would have been the case if there was in fact no facilitatory effect of parallelism at the V2). If this is the case then the transitive analysis may have remained sufficiently active through the following NP region to preclude any difficulty arising from reanalysis at the ambiguous NP. Likewise, the intransitive analysis from the V2 region may have remained sufficiently active to preclude significant reanalysis cost at the disambiguating verb region. Such long-lasting effects, especially in the absence of any reanalysis effects at the disambiguating verb are allowed in constraint-based/competition models such as those found in Tabor and Hutchins (2004) and Tabor et al. (1997).

The longer reading times at the NP region for the NoCoord condition also require explanation. For the instances where the NoCoord condition had converged on an intransitive analysis at V2, maintaining the intransitive analysis would have far less support at the NP, and costly reanalysis would ensue. This is because the intransitive analysis would have been arrived at without much competition, and activation levels would be lower overall.

To conclude, the results of Experiment 2 suggest that semantics plays some role in establishing or bolstering parallelism. While it is not possible to draw any conclusions regarding lexical-semantic parallelism from this experiment, the results do raise a number of interesting issues regarding the processing architecture and its implications for the deciphering the complex factors underlying facilitatory and potentially non-facilitatory effects of parallelism in coordinated structures. Such issues are addressed in more depth in Experiments 4 and 5. I first modify the current materials to an eyetracking paradigm in an attempt to bring the experiment more in-line with Staub (2007), with which the current study continues to see differing results.

3.4 Experiment 3

Experiment 3 revisits the findings from Experiment 2 using an eyetracking while reading paradigm. The availability of multiple dependent measures from eyetracking may provide a better means of identifying a parallel coordination advantage that reflects advantages for conjuncts that are semantically/conceptually similar. Eyetracking paradigms also have the advantage of allowing for a more natural presentation of sentential items, and using eyetracking sets the current study more in-line with the methodology used in Staub (2007). In addition, by using the same materials as Experiment 2, there will be an opportunity to replicate the pattern of results from Experiment 2, though as stated above, deeper examination of the effects seen in the V2 region can only be adequately addressed via a change in materials, as will be attempted in Experiments 4 and 5.

3.4.1 Method

3.4.1.1 Participants.

Forty-one native English-speaking undergraduates from the University of Michigan participated in the experiment to receive partial credit for an introductory psychology class. Six subjects were excluded from analysis on account of tracking calibration issues, two additional subjects were dropped via random selection to balance the number of participants across presentation lists.

3.4.1.2 Materials.

Critical and filler items were identical to those used in Experiment 2. There were thus 21 critical sentences, each appearing in one of three conditions: NoCoord (23a), NotSem (23b), and Sem (23c), across three lists. Thirty-seven filler items of varying types were included to mask the experimental manipulation. Full materials are presented in Appendix E.

(23) a. *Although /the pirate ship /sank /the nearby British vessel /did not /send out lifeboats.*

b. *Although /the pirate ship /halted /suddenly /and /sank /the nearby British vessel /did not /send out lifeboats.*

c. *Although /the pirate ship /capsized /suddenly /and /sank /the nearby British vessel /did not /send out lifeboats.*

3.4.1.3 Apparatus and display.

The study used an Eyelink2 head-mounted eyetracker running at 250Hz in corneal reflection mode. Nine-point recalibrations were performed at the beginning of the experiment and as necessary throughout the experiment. One-point drift corrections were performed after every trial. Sentences were displayed in 12 pt Courier New font on a 17" CRT monitor (1024 x 768). A carriage return was again included after each disambiguating verb region in the presentation materials on account of screen space limitations - thus, item presentation was split between two lines of text.

3.4.1.4 Procedure.

The experiment proceeded as follows. Participants first read through an introductory screen that presented a set of instructions and a sample sentence. They then completed a practice block consisting of three items and two comprehension questions. The practice block was identical in design and appearance to the experimental block. Both the experimental and practice blocks began with a small fixation cross to the center left of the screen. When participants looked to this cross, an, invisible eye-contingent trigger automatically brought up a blank screen for 500 ms which was then followed by the complete critical sentence. After reading the sentence, participants were required to make a button press to advance to the next item. They were next either presented with a comprehension question or advanced to the next item. Breaks were built into the experimental design, appearing after every 25 trials, during which participants were encouraged to close their eyes for one or two minutes to reduce any possibility of eyestrain or discomfort associated with the lengthy duration of the experiment. In some cases, participants were allowed to remove the headset for a few minutes. A nine-point recalibration (and manual readjustment for cases where the headset was removed) was performed after each break.

3.4.2 Results

For analysis each sentence was divided into nine interest areas, indicated by "/" in (22) above. The words included in each interest area corresponded exactly to those used in each presentation region from Experiment 2. Regions were contiguous on the x-axis and extended 45 pixels above and below the words that they contained.

Five standard eye-movement measures (Rayner, 1998) were computed for the final four regions of interest: First fixation duration, first pass dwell time (gaze duration), regression path duration (go-past time), percent regression out, and total dwell time. First fixation duration is the duration of the first fixation event in an interest area during the first reading pass. First pass dwell time (gaze duration) is the summation of all fixation durations that occur in a region prior to leaving it in the first run for an interest area. Regression path duration (go-past time) is the sum of all fixations from first entering a region during the first pass of reading until leaving it to the right, including regressive fixations. Percentage regression out is the percentage of times that regressions were made from a region to an earlier region prior to leaving the first region in a forward/rightward direction. Total dwell time is the summation of the duration across all fixations within a region.

Mean reading times and standard deviations for each region are presented for each condition in Table 6. For both subject and item analyses, the dependent variables were converted to Log10 values and subjected to repeated measures ANOVAs with coordination (Sem, NotSem, NoCoord) as a within subjects/items variable. Only p-values that reached (or marginally reached) the .05 level are reported. Additional F-scores may be found in Table 7. As the experiment is not fully balanced, an effect of coordination as presented below may apply to a facilitatory pattern arising from semantic/conceptual parallelism and/or lexical-semantic parallelism, as well as the absence of facilitation.

Table 6. Experiment 3 mean reading times (ms) and percent regression out. Standard Deviations in parentheses.

	Region 1 (Intro)	Region 2 (SubjNP)	Region 3 (V1)	Region 4 (Adverb)	Region 5 (Conj)
First fixation duration					
NoCoord	400(243)	240(153)	N/A	N/A	N/A
NotSem	420(273)	227(120)	277(110)	261(91)	204(73)
Sem	442(313)	248(146)	272(105)	266(109)	209(67)
First pass dwell time					
NoCoord	465(259)	628(467)	N/A	N/A	N/A
NotSem	494(277)	633(418)	329(155)	304(122)	210(77)
Sem	513(322)	636(429)	332(147)	323(161)	222(78)
Regression path dur.					
NoCoord	465(259)	1041(507)	N/A	N/A	N/A
NotSem	494(277)	981(461)	494(470)	446(411)	350(404)
Sem	515(323)	974(447)	483(402)	477(438)	295(302)
Total dwell time					
NoCoord	517(351)	1412(682)	N/A	N/A	N/A
NotSem	518(356)	1229(595)	584(378)	516(305)	167(196)
Sem	537(403)	1228(610)	559(335)	515(358)	153(186)
Percent regression out					

NoCoord		41%	N/A	N/A	N/A
NotSem		30%	15%	23%	16%
Sem		38%	17%	23%	6%
	Region 6 (V2)	Region 7 (AmbNP)	Region 8 (DisambV)	Region 9 (WrapUp)	
First fixation duration					
NoCoord	266(112)	255(96)	248(110)	188(92)	
NotSem	265(105)	257(91)	239(118)	174(64)	
Sem	259(92)	248(86)	249(123)	185(103)	
First pass dwell time					
NoCoord	319(152)	708(358)	380(223)	993(534)	
NotSem	337(167)	730(376)	344(197)	1001(565)	
Sem	321(150)	726(342)	394(277)	972(495)	
Regression path dur.					
NoCoord	431(348)	1095(667)	682(728)	2451(1846)	
NotSem	416(275)	943(481)	592(795)	2413(1837)	
Sem	431(355)	890(506)	636(707)	2416(2158)	
Total dwell time					
NoCoord	647(404)	1353(696)	574(378)	1342(706)	
NotSem	578(356)	1218(630)	490(355)	1272(627)	
Sem	536(389)	1210(775)	549(405)	1251(611)	
Percent regression out					
NoCoord	16%	31%	28%	95%	
NotSem	16%	23%	26%	80%	
Sem	18%	15%	25%	77%	

Table 7. Experiment 3 analysis of variance results for regions 6-9.

	Region 6 (V2). *sank*	Region 7 (NP). *the British vessel*	Region 8 (DisambV). *did not*	Region 9 (WrapUp). *send out lifeboats.*
First fixation dur.	$F1<1$ $F2<1$	$F1<1$ $F2<1$	$F1<1$ $F2<1$	$F1<1$ $F2=.1.913$, p=.162
First pass dwell time	$F1<1$	$F1<1$	$F1=4.796$*	$F1<1$

	$F2<1$	$F2<1$	$F2=.4.618$*	$F2<1$
Reg. path dur.	$F1<1$	$F1=10.05$**	$F1=2.408$, p=.099†	$F1<1$
	$F2<1$	$F2=.15.882$**	$F2=.2.723$, p=.079†	$F2<1$
Total dwell time	$F1=7.876$**	$F1=5.845$*	$F1=6.465$*	$F1=3.084$, p=.05*
	$F2=6.045$*	$F2=8.200$**	$F2=5.156$*	$F2=2.267$, p=.118
Percent reg. out	$F1<1$	$F1=8.090$**	$F1<1$	$F1=6.599$*
	$F2<1$	$F2=9.674$**	$F2<1$	$F2=4.926$*

**significance p≤.001; *significance p≤.05; †marginal significance p<.1; additional p values of interest noted in table.
All means were transformed to Log10 prior to analysis
All $F1$ statistics utilize (2,60) DF; All $F2$ statistics utilize (2,36) DF

Figure 6. Experiment 3 mean total dwell times

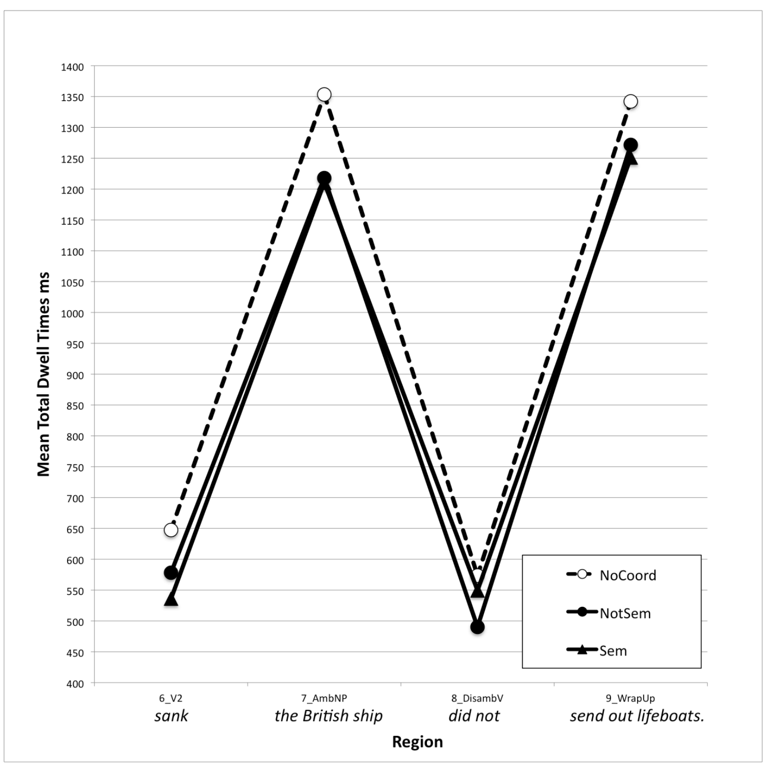


Figure 7. Experiment 3 mean first pass dwell times.

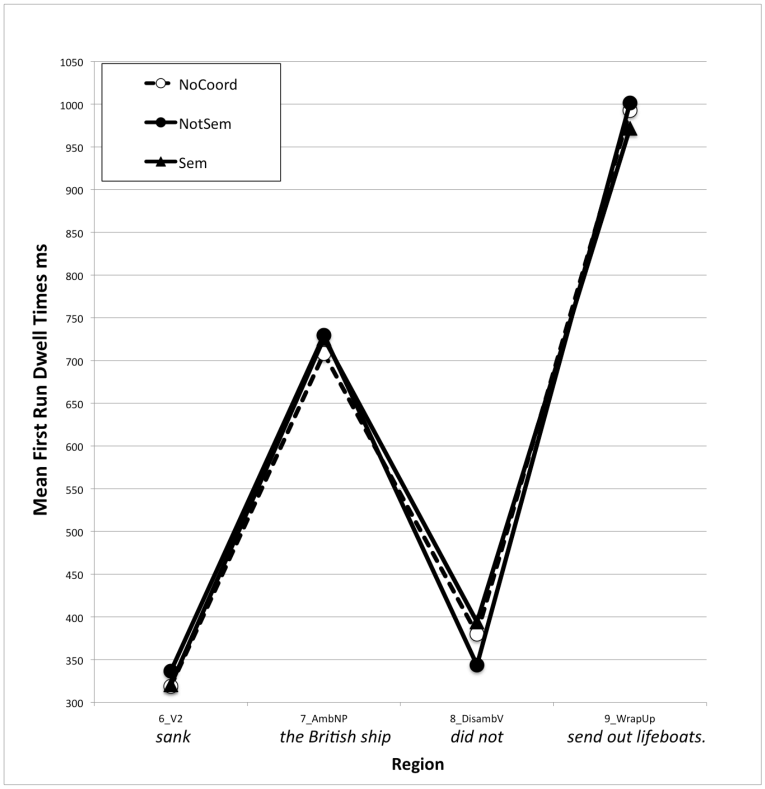


Figure 8. Experiment 3 percent regression out.

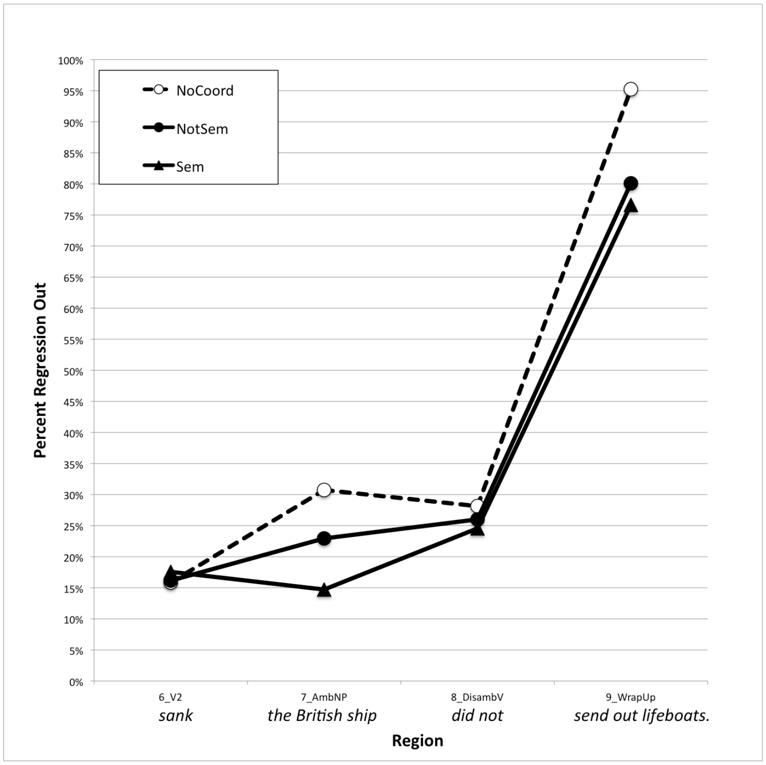
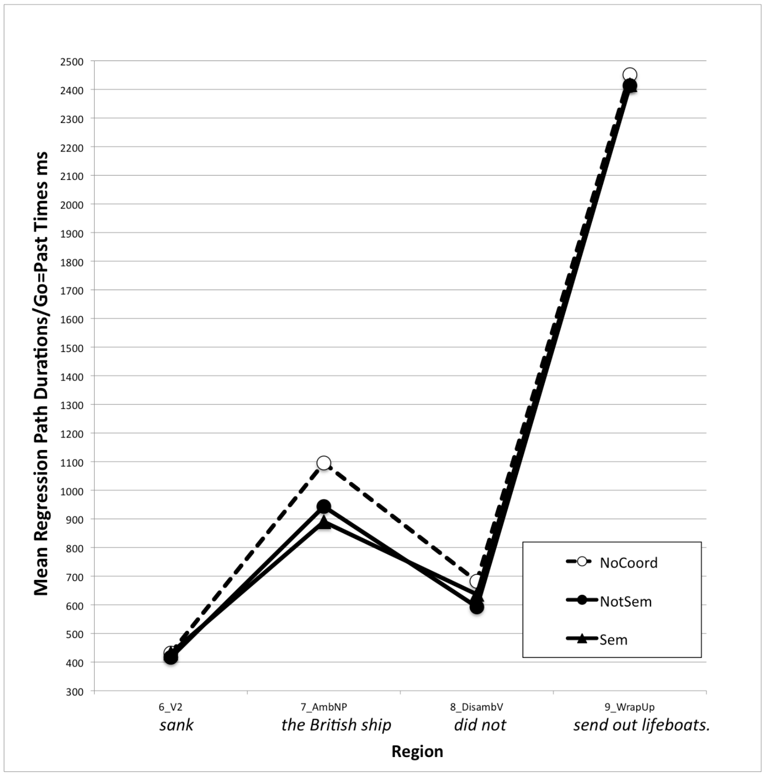


Figure 9. Experiment 3 regression path durations



In the V2 region, Region 6, total dwell times showed a significant effect of coordination [*F1*=7.876, p=.001; *F2*=6.045, p<.05]. For both the subject and item analyses, post hoc tests (Bonferroni, α=.05) indicated that readers spent more time reading the NoCoord condition than both NotSem and Sem. No other measures were significant in this region.

At the ambiguous NP, Region 7, there was again a significant effect of coordination by subjects and items for the total dwell times measure [*F1*(2,60)=5.845, p<.05; *F2*(2,36)=8.200, p=.001]. Post hoc tests (Bonferroni, α=.05) indicated that reading times were longer for NoCoord in comparison to both NotSem and Sem. Regression path durations also displayed a main effect of coordination. This was significant by subjects

[$F1$(2,60)=10.05, p<.001], with post hoc tests (Bonferroni, α=.05) indicating that NoCoord reading times were longer than both NotSem and Sem. This was also significant by items [$F2$(2,36)=.15.882, p<.001] for which post hoc tests (Bonferroni, α=.05) revealed that NoCoord was marginally slower than Sem. Also in Region 7, there were a higher percentage of regressions out of the region. This was significant by subjects and items [$F1$(2,60)=8.090, p=.001; $F2$(2,36)=9.674, p<.001] with post hoc tests (Bonferroni, α=.05) showing NoCoord generating more regressive looks than Sem in for both subject and item analyses, and NotSem generating a marginally greater percent of regressions than Sem by items.

For Region 8, the disambiguating verb region, total dwell times displayed a main effect of coordination by subjects [$F1$(2,60)=6.465, p<.05] for which post hoc tests (Bonferroni, α=.05) showed NoCoord was longer than NotSem and Sem was longer than NotSem. This was also true by items [$F2$(2,36)=5.156, p<.05], with NoCoord displaying longer reading times than NotSem in post hoc tests (α=.05). First pass dwell times also displayed a main effect of coordination by subjects and items [$F1$(2,60)=4.796, p<.05; $F2$(2,36)=.4.618 p<.05]. For post hoc tests (Bonferroni, α=.05) in both measures, NoCoord was longer than NoSem, and Sem was longer than NotSem. Regression path durations showed a marginally significant effect of coordination in the subject analysis [$F1$(2,60)=2.408, p=.099] for which post hoc tests (Bonferroni, α=.05) indicated that NoCoord was marginally longer than NotSem (p=.092). Coordination was also marginally significant by items [$F2$(2,36)=.2.723, p=.079] with post hoc tests (Bonferroni, α=.05) indicating that NoCoord was significantly longer than NotSem.

In the wrap up region, Region 9, total dwell times displayed a main effect of coordination in the items analysis [$F1(2,60)=3.084$, $p=.05$], though in post hoc tests (Bonferroni, $\alpha=.05$) NoCoord was only marginally longer than Sem. A coordination effect was also found for percent of regressions out in the subject analysis [$F1(2,60)=6.599$, $p<.05$]. Post hoc tests (Bonferroni, $\alpha=.05$) revealed that NoCoord was longer than both NotSem and Sem. Coordination was also significant by items [$F2=4.926(2,36)$, $p<.05$], with NoCoord being longer than NotSem in post hoc tests ($\alpha=.05$).

3.4.3 Discussion

I begin discussion first with the latter sentential regions, as this is where facilitation was originally expected. At the disambiguating verb region, both total dwell times (Figure 6) and first pass dwell times (Figure 7) were shorter for the NotSem condition than NoCoord. Unexpectedly, the semantically related conditions were not also faster than NoCoord – in fact, first pass dwell times were longer for Sem than NoCoord in this region. Given this pattern, it is not clear that either semantic/conceptual similarity or the presence of coordination has helped to bolster the intransitive analysis of the V2.

Total dwell times in the final region (Figure 6) showed a significant effect of coordination, though again only the non-semantically related condition showed an advantage over the non-coordinated condition. The semantically related condition does pattern faster, and thus in the expected direction, but is not significantly different from the non-coordinated condition. Thus, the results in this region only suggest that the presence of coordination heightens the intransitive V2 analysis, and that the parallelism of the coordinated phrase is sensitive to and affected by semantic manipulations.

First pass dwell times showed a significant effect of coordination at the disambiguating verb region. Yet, while NoCoord showed longer times than NotSem, Sem patterned along with NoCoord – again hindering the current study's ability to support claims of higher intransitive V2 activation for coordination, and presenting the opposite semantic/conceptual pattern than was expected.

A clearer indicator of both coordination and semantic/conceptual effects may be found in percent regression out measure for the final region (Figure 8). For this measure, a greater proportion of regressions out of the final region was found for the NoCoord as opposed to both Coord conditions, and while Sem and NotSem were not significantly different, they did pattern in the expected way, with Sem incurring fewer regressive looks than NotSem.

Turning to the earlier sentential regions, of interest is that the potential facilitation noted in Experiment 2 was again observed for the parallel coordinated conditions at the VP and ambiguous NP. This was found in total dwell times for the V2 region and in total dwell times (Figure 6) and regression path durations (Figure 9) for the NP region. This replication of the Experiment 2 findings suggests that the early region effects are not spurious, and that at least the conclusions from Experiment 2 regarding the NP region may be on target. However, this pattern was only present in the rather late measure, total dwell times, which is not as informative as if it had also been present in an earlier measure, like first pass dwell times. Again, the lack of an adequate comparison point for V2 is still needed to draw any conclusions regarding whether or not the pattern seen at the V2 region actually represents facilitation. It is worth noting that the pattern of results at the V2 region is the opposite from those found in Staub. Whereas he found facilitation for the NoCoord condition, the current study displayed potential facilitation for both coordinated conditions. This may be because the introductory material in the Staub study is highly variable, whereas in the current study it is considerably more consistent both within and across items.

In terms of how Experiment 3 informs how the current study might proceed, consider the coordinated conditions in the new materials. The grain size of similarity is still not as optimally “deep” as it could be, as alternating unaccusative verbs still encompass a number of different subclasses with varying behavior. Thus it is possible that the verbs are not yet sufficiently matched at a deep representational level. If parallelism is dependent on the degree of representational similarity, including a more highly matched condition may clarify whether the effect observed here for coordinated conditions actually represents facilitation.

In sum, the pattern of results suggests an effect of coordination (potentially parallel lexical-semantically based) that is perhaps modulated by a semantic component in late measures like total dwell time in the final region. Such an effect is less clear at earlier points in the sentence. In regard to the earlier regions, it is possible that facilitation requires varying degrees of lexical-semantic similarity between conjuncts to show a difference. If a more highly matched condition was created, it would be expected to show more processing difficulty in relation to a less matched condition at the V2, and NoCoord would be expected to pattern closer to a less matched condition (though perhaps some differences would remain).

3.5 General Discussion Experiments 1-3

Surprisingly, Experiment 1 did not replicate the parallel coordination advantage found in the late eyetracking measures in Staub (2007). The results from a subsequent normative study indicated that the new materials have a higher basic intransitive bias than the Staub verbs. This bias appears to be reduced by the addition of parallel coordination and the presence of a following NP.

The addition of a semantic condition to the moving window paradigm in Experiment 2 tested the hypothesis that coordinated, semantically related verbs (*capsized* and *sank*), would engender higher activation of the intransitive analysis in the second conjunct than both coordinated, non-semantically related verbs (*halted* and *sank*) and non-coordinated controls. A significant main effect of coordination was found, but as in Staub (2007), only in the final region. In paired comparisons, reading times were marginally faster for the semantically related over the non-semantically related verbs, with the non-coordinated condition patterning with the non-semantically related coordinated condition. This suggests that semantics play some role in establishing parallelism. In addition, processing facilitation was observed for coordinated conditions in the ambiguous NP region, and potential facilitation was seen in the V2 region. This was taken to represent both competition effects and persistence of structural alternatives over multiple words, lending some support for constraint-based/competition models of processing that allow for decay effects.

Experiment 3 used the materials from Experiment 2 in an eye-tracking paradigm. A greater proportion of regressions out of the final region were found for the non-coordinated as opposed to both coordinated conditions. Total dwell times in the final region were marginally slower for the non-coordinated conditions compared to the semantically related, coordinated conditions. A similar pattern of facilitation was observed in V2 and NP regions to that seen in Experiment 2, supporting the conclusions for the NP region in Experiment 2. The question of facilitation for the V2 region still requires further investigation.

At this stage, the Experiment 2 and 3 results from the ambiguous NP region suggest that parallelism effects may be sensitive to deep representational information, at least if viewed from the perspective of a constraint-based/competition processing model that allows for long-lasting effects of argument structure activation. In regard to the sought after effects at the disambiguating verb region, the effects would appear to be somewhat fragile, and are perhaps most easily seen in highly on-line measures, such as eyetracking. Both of these conclusions remain highly speculative however, since Experiments 2 and 3 only tested for the presence of coordination and did not include controls for lexical-semantic similarity. Semantic/Conceptual relatedness between conjuncts, which was directly tested in the studies, appears to also be important.

Experiments 1-3 also raise related questions about the process of ambiguity resolution at the V2 and NP regions. The original goal of the current study was to elicit a facilitatory effect at the disambiguating verb region. Following Staub (2007), it was hypothesized that earlier activation and selection of an intransitive parse at the V2 region would help to mitigate any garden path effects when that analysis was ultimately found to be correct at the main clause verb. For this to work, three things are necessary. For one, effective parallel coordination must support an intransitive parse of the V2 verb. Second, this parse must be abandoned at the following NP region. Third, the initial intransitive parse must remain sufficiently active such that it is still available for the reanalysis at the main clause verb. Experiments 2 and 3 provide tentative support for intransitive activation at the V2 region (via the potentially facilitatory pattern observed there). However, at the NP region in Experiments 2 and 3, a facilitatory pattern was seen for the coordinated conditions. The basic premise of the initial approach was that V2 intransitive activation would facilitate processing for the main clause verb. However, such an effect was not found. It was proposed that the transitive analysis from the V2 region, despite being discarded (or suppressed etc.) was still sufficiently active at the NP region to preclude any cost of reanalysis at that same region. Likewise, intransitive activation from V2 would also preclude processing difficulty at the disambiguating verb. Facilitation effects seen for late measures in the final wrap up region would then be taken to reflect either reduced cost of reanalysis at the disambiguating verb region or an advantage in wrap up processing which arises from the inclusion of coordinated material.

To demonstrate that the above hypothesis is correct and not conjecture, some metric of measurable difference between coordinated items (as opposed to between coordinated and uncoordinated items) is needed for the V2 region. This might be attained by contrasting coordinated conditions that are matched and mismatched in their lexical-semantic representations, thereby accentuating differences and providing more room for facilitation at the V2 region. With this new approach, there would be little reason to expect differences in the late measures between coordinated conditions for the final region.

In Experiments 4 and 5, two new approaches are examined. Experiment 4 contrasts one matched with two mismatched conditions as an better means of demonstrating a potential facilitatory effect of lexical-semantic parallelism between coordinated verb phrases. Experiment 5 takes an additional step - addressing whether the inherent, intransitive bias of the verbs used for the second conjunct in Experiments 1-4 is masking any additional facilitatory effects. That is, because the verbs were already so intransitively biased, there was no “room” in the design for parallelism (coordination with an intransitive, first verbal conjunct) to make them more intransitive.

3.6 Experiment 4

Staub (2007: Experiment 2) found that coordination of an initial, intransitive verb with the original verb in the introductory clause heightens the activation of the intransitive parse at the second verb and thus allows for greater facilitation at the disambiguating verb region. But, as mentioned above, this effect was only present in his late measures.

In an effort to elicit an earlier, facilitatory effect of coordination on a main clause garden path, Experiments 1-3 avoided mismatches among underlying representational verb forms. It was proposed that by eliminating differences among the coordinated verbs, there would be more experimental room to demonstrate higher parallel intransitive activation for the second of the two coordinated verbs. In Experiment 1, there was no replication of the findings from Staub (2007), even for his own materials. In the final regions of Experiments 2 and 3, which primarily tested for a modulating effect of semantics on coordination, only weak and somewhat late effects of coordination were found for the new set of matched stimuli. However, evidence of both facilitation at the ambiguous NP region and potential facilitation at the V2 region was found. This raised three questions: 1) whether the V2 effect indeed actually represented a parallelism effect,

2) whether any facilitation should be expected at the disambiguating verb region and beyond (i.e., if the intransitive analysis was still sufficiently active at that point), and 3) whether lexical-semantic representations contribute to parallelism above and beyond coordination of superficially similar conjuncts.

Experiment 4, an eyetracking while reading experiment, uses the reinforcement and manipulation of differences between underlying lexical-semantic representations as a new approach to the question of how underlying representations affect parallel coordination. The new materials contrast one matched condition: a pair of alternating unaccusative conjuncts (e.g., *stopped* and *sank*), as well as two different unmatched conditions: one using a non-alternating unaccusative/alternating unaccusative pair (e.g., *arrived* and *sank*) and the other using an implicit object verb/alternating unaccusative (e.g., *struck* and *sank*). By clearly defining and accentuating these differences, it is expected that the impact of representational forms towards the establishment of parallelism will become clearer.

As in the earlier set of experiments, the experimental manipulation continues to test for an effect of coordination type on recovery from a garden path at the disambiguating verb region (*did not*). If the degree of lexical-semantic representational similarity is relevant to establishing intransitive parallelism, activation of a parallel (to V1), intransitive V2 will be greater in the coordinated, matched condition than in all other conditions. This will in turn facilitate processing at the disambiguating verb region and beyond. If such an effect is gradient, the non-alternating/alternating pair may yield more facilitation than the implicit object/alternating pair, as it is representationally closer to the matched condition. If however, superficial rather than representational information is important to establishing intransitive parallelism, all coordinated conditions would show an equal advantage over the non-coordinated condition.

As discussed above, it is possible that these differences will be observed in the V2 region and again at the NP region instead of at the disambiguating verb and beyond. The new experimental manipulation will provide a suitable contrast for determining whether or not differences in this region constitute processing facilitation. If deep lexical-semantic representations are referenced in establishing parallelism, the more matched a pair of conjuncts are, the greater the facilitation at the V2 region should be. In addition, it is possible that by matching deep verbal representations in both conjuncts, greater competition between available structural alternatives will ensue. Greater competition would lead to heightened activation of structural alternatives. Assuming long-lasting activation of structural alternatives, there is expected to be facilitation at the following NP region in those cases where the highly activated alternatives include a transitive analysis (i.e., for highly matched pairs of alternating unaccusative verbs). For cases where the alternatives include an intransitive analysis (i.e., for all conditions, as will be explained below), no significant effects are expected at the disambiguating verb and beyond.

3.6.1 Method

3.6.1.1 Participants.

Sixty-one English-speaking undergraduates from the University of Michigan participated in the experiment to receive partial credit for an introductory psychology class. Thirteen participants were removed prior to analysis on account of tracking issues and to balance the presentation lists, leaving 48 participants for analysis.

3.6.1.2 Materials.

Critical items were similar in structure to those used in Experiments 1-3. There were 20 critical sentences, each appearing in four conditions: Eighty filler items of varying types were included to mask the experimental manipulation.

Experiment 4 relies on the unaccusative classification system adopted by Levin and Rapport (1995; but cf., Perlmutter, 1978 among others) to inform the current selection of verbs. Levin and Rapport identify two broad classes of unaccusative verbs. The first are the dyadic type that, like transitive verbs, have one internal and one external argument in their basic representation. This class includes the externally caused change of state verbs (i.e., *break*) as well as manner of motion verbs (i.e., *roll*) identified in Levin (1993). The second class comprises those that have only internal arguments in their basic lexical-semantic representation. Such verbs include verbs of existence and appearance, internal cause change of state verbs (i.e., *bloom*), and verbs of inherently directed motion (i.e., *arrive*), again as cataloged in Levin (1993).

In the current experiment, the matched condition (24a) pairs two alternating unaccusative verbs within a coordinated phrase (Alt/Alt). The verbs selected for this condition are of the first type identified above, and thus are either manner of motion verbs or externally caused change of state verbs. The two classes are assumed to be representationally similar to a sufficient degree.

(24) a. *When the giant iceberg /<u>stopped</u> /suddenly /and /<u>sank</u> /the nearby British vessel /did not /send out help.*

b. *When the giant iceberg /appeared /suddenly /and /sank /the nearby British vessel /did not /send out help.*

c. *When the giant iceberg /struck /suddenly /and /sank /the nearby British vessel /did not /send out help.*

d. *When the giant iceberg /sank /the nearby British vessel /did not /send out help.*

In addition, two mismatched conditions are used, the first of which (24b) pairs a non-alternating unaccusative verb (*appear*) with an alternating unaccusative verb (*sink*) (NonAlt/Alt). Non-alternating unaccusatives fall into the second class of unaccusatives described above. Whereas alternating unaccusatives are able to detransitivize, non-alternating unaccusatives cannot, as, unlike the alternating unaccusatives, they have neither an external argument nor the appropriate primitives in their basic template to do so. The two verbs in the first mismatch condition are thus taken to be representationally distinct, at least under the Levin and Rappaport (1995) account.

The second mismatch condition (24c) pairs implicit object intransitive verbs (unspecified object verbs in Levin & Rappaport, 1995) with alternating unaccusative verbs (Implicit/Alt). For the purposes of this study, implicit object verbs are verbs that despite being "intransitive" at the level of a linearized, surface representation are arguably transitive both at the lexical-semantic representational level and at the conceptual level, at least for English. Take for example the verb *eat.* The overt expression of the theme of *eat* is optional, yet the semantics of the verb would seem to require that something definite or indefinite always be eaten.In actuality, this loose grouping of verbs comprises a number of classes of variable behavior. For example, verbs of consumption like *eat* pattern quite differently from verbs of surface contact like *hit* (Levin & Rappaport, 2005). But, this grouping is unified in that when it does appear in it's reduced form, it is the theme or oblique complement that is omitted and not the external argument, as with alternating unaccusatives that detransitivize.

For the current experiment, only a limited number of implicit object verbs were available for selection. For the most part these verbs were of the surface contact type (e.g., *hit*, *pushed*, *impacted*, etc.). Other transitive verbs were also used however (e.g., *studied* and *visited*). It was also necessary to include three unergative verbs to provide enough items to balance the materials. These were always of the verbs of emission class (*spurted*, *leaked, and discharged*). Under the Levin and Rappaport account, verbs of emission are basically monadic in their lexical-semantic representation, but may have both internal and external causation and thus may causativize. The inclusion of unergative verbs is thus not an ideal match at the deep representational level, but the fact that their causativized instantiations may appear in the implicit object form (e.g., *the old electric steam iron spurted*), makes them the best candidate to fulfill the numerical requirements of the experimental condition. Thus, such verbs, despite superficial similarities to unaccusative intransitives, are arguably representationally different. One additional caveat is that given that both implicit object verbs and alternating unaccusatives may have some form of basically transitive lexical-semantic representation (depending on whether transitivized unergatives are treated as having two distinct representations), there are certain similarities such as order of arguments that may cause the two conditions to pattern more similarly than other pairings. In addition to the above conditions, a non-coordinated control (24d) (NoCoord) was also included to provide a baseline of facilitation or the absence thereof.

Sentence level, contextual information has been shown to have an early, influential affect on processing; comprehenders are sensitive to the thematic fit of a subject to a verb (Altmann, 1998, 1999; Altmann & Kamide, 1999; Altmann & Steedman, 1988; Kamide et al., 2003; MacDonald et al., 1994), and context has been shown to highly influence the argument structure activated by a verb (Hare, McRae, & Elman, 2003; 2004). Thus, the degree to which a coordinate structure engenders a parallelism effect is likely to be determined in part by earlier sentence level factors/constraints. To rule out any effect of bias, subject/verb pairings were designed to be more transitively biased than in the previous experiments. This was confirmed by a sentence completion normative study in which intransitively biased conditions (taken from the upcoming Experiment 5, where the role of subject/verb coherence is given more attention) produced significantly fewer transitive responses than transitively biased conditions. In actuality, the verbs labeled as transitively biased here would be more accurately described as equibiased. The limited number of verbs available prohibited stronger selection requirements. Complete details on the study are presented as Normative Study 2 in Appendix A.

In addition, a second normative sentence completion study assessed the acceptability of the new sentences using a five-point Likert scale. Results indicated that the non-coordinated sentences are somewhat more acceptable than the coordinated ones, which is perhaps to be expected given that the coordinated conditions represent more complex events. Importantly, there were no significant differences between coordinated conditions. Complete details on the normative study are presented as Normative Study 3 in Appendix B. Full materials for Experiment 4 are presented in Appendix F.

3.6.1.3 Apparatus and display.

The study utilized an Eyelink2 head-mounted eyetracker running at 250Hz in corneal reflection mode. Nine-point recalibrations were performed at the beginning of the experiment and as necessary throughout the experiment. One-point drift corrections were performed after every trial. Sentences were displayed in 12 pt Courier New font on a 17" CRT monitor (1024 x 768). A carriage return was included after each disambiguating verb region in the presentation materials on account of screen space limitations. Thus, item presentation was split between two lines of text.

3.6.1.4 Procedure.

The experiment proceeded in the same manner as Experiment 3. Participants first read through an introductory screen that presented a set of instructions and a sample sentence. They then completed a practice block consisting of three items and two comprehension questions. The practice block was identical in design and appearance to the experimental block. Both the experimental and practice blocks began with a small fixation cross to the center left of the screen. When participants looked to this cross, an, invisible eye-contingent trigger automatically brought up a first a blank screen for 500 ms which was then followed by the complete critical sentence. After reading the sentence, participants were required to make a button press to advance to the next item. They were next either presented with a comprehension question or advanced to the next item. Breaks were built into the experimental design, appearing after every 25 trials, during which participants were encouraged to close their eyes for one or two minutes to reduce any possibility of eyestrain or discomfort associated with the lengthy duration of the experiment. In some cases, participants were allowed to remove the headset for a few minutes. A nine-point recalibration (and manual readjustment for cases where the headset was removed) was performed after each break.

3.6.2 Results

For analysis each sentence was divided into nine regions, indicated by "/" in (15) above. The words included in each region corresponded exactly to those used in each presentation region from Experiment 2. Regions were contiguous on the x-axis and extended 45 pixels above and below the words that they contained.

Following Rayner and Pollatsek (1989), an automatic procedure was used to pool short contiguous fixations. The procedure incorporated fixations of less than 80 ms into larger fixations within one character, and then deleted fixations of less than 40 ms that fell within three characters of any other fixation. Following Sturt (2003), fixations greater than 1200 ms were also removed, as these usually indicate tracker loss.

Fixations falling beyond 2.5 SD from the region mean, for each subject, were trimmed to equal the mean plus or minus 2.5 SD (see Chace, Rayner and Well, 2005 for example of SD trim being used on eyetracking). Two percent of the data were affected.

Six separate dependent variables were analyzed: first fixation duration, first pass dwell times (gaze duration), regression path duration (go past times), selective regression path duration (the duration of fixations and re-fixations of the current region before the eyes enter exit rightward to a region with a higher ID), total dwell time, and percent regression out.

Mean reading times for each area are presented for each condition in Table 8. For both subject and item analyses, the dependent variables were converted to Log10 values and analyzed using repeated measures ANOVAs, with four levels of parallel coordination type (Alt/Alt, Implicit/Alt, NonAlt/Alt, and NoCoord) as a within subjects/items variable. Only p-values at or approaching the .05 level are reported below. Additional *F*-scores may be found in Table 9. Presentation of results begins with Regions 6-9, as these were examined in the earlier experiments. This is followed by the results from Region 3 (V1) and 4 (Adv), as the new experimental manipulation is expected to have consequences for measures in these regions.

Table 8. Experiment 4 mean reading times (ms) and percent regression out. SD in parenthesis.

	Region 1 (Intro)	Region 2 (SubjNP)	Region 3 (V1)	Region 4 (Adverb)	Region 5 (Conj)
Total dwell time					
Coord Alt/Alt	300 (216)	1220 (682)	664 (457)	595 (401)	140 (225)
NoCoord	291 (240)	1340 (824)	N/A	N/A	N/A
Coord NonAlt/Alt	281 (219)	1172 (735)	587 (398)	542 (384)	147 (210)
Coord Implicit/Alt	285 (229)	1241 (674)	655 (460)	595 (427)	134 (200)
First fixation duration					
Coord Alt/Alt	191 (108)	208 (66)	268 (114)	266 (115)	93 (118)
NoCoord	181 (103)	211 (64)			
Coord NonAlt/Alt	180 (98)	207 (58)	268 (110)	252 (112)	97 (118)
Coord Implicit/Alt	172 (92)	207 (66)	269 (110)	261 (105)	96 (119)
First pass dwell time					
Coord Alt/Alt	224 (147)	631 (429)	330 (170)	309 (163)	95 (123)
NoCoord	203	633 (405)	N/A	N/A	N/A

	(125)				
Coord NonAlt/Alt	212 (133)	585 (387)	331 (168)	286 (137)	101 (124)
Coord Implicit/Alt	196 (117)	651 (457)	314 (148)	298 (154)	97 (121)
Regression path dur.					
Coord Alt/Alt	225 (153)	882 (506)	413 (390)	454 (376)	141 (245)
NoCoord	203 (125)	875 (585)	N/A	N/A	N/A
Coord NonAlt/Alt	212 (133)	854 (520)	424 (373)	392 (325)	146 (250)
Coord Implicit/Alt	196 (117)	863 (543)	445 (381)	446 (397)	149 (276)
Selective Regression path dur.					
Coord Alt/Alt	225 (153)	812 (447)	358 (212)	359 (203)	98 (129)
NoCoord	203 (125)	820 (535)	N/A	N/A	N/A
Coord NonAlt/Alt	212 (133)	788 (466)	360 (190)	322 (161)	106 (133)
Coord Implicit/Alt	196 (117)	807 (486)	355 (174)	350 (207)	103 (133)
Percent regression out					
Coord Alt/Alt	0%	23%	8%	21%	4%
NoCoord	0%	19%	0%	0%	0%
Coord NonAlt/Alt	0%	23%	9%	16%	5%
Coord Implicit/Alt	0%	19%	15%	21%	4%
	Region 6 (V2)	Region 7 (AmbNP)	Region 8 (DisambV)	Region 9 (WrapUp)	
Total dwell time					
Coord Alt/Alt	615 (480)	1068 (710)	509 (418)	959 (613)	
NoCoord	600 (448)	1160 (795)	520 (429)	976 (540)	
Coord NonAlt/Alt	570 (422)	1091 (755)	463 (396)	970 (569)	
Coord Implicit/Alt	615 (412)	1052 (689)	499 (414)	997 (591)	
First fixation duration					
Coord Alt/Alt	262 (91)	255 (87)	230 (127)	222 (91)	
NoCoord	246 (91)	248 (82)	244 (132)	230 (81)	
Coord NonAlt/Alt	247 (96)	241 (72)	222 (127)	223 (84)	
Coord Implicit/Alt	268	245 (75)	238 (134)	226 (89)	

	(101)			
First pass dwell time				
Coord Alt/Alt	313 (135)	539 (264)	302 (209)	687 (401)
NoCoord	287 (138)	585 (309)	309 (212)	728 (425)
Coord NonAlt/Alt	290 (146)	574 (280)	291 (203)	679 (390)
Coord Implicit/Alt	315 (143)	515 (264)	303 (200)	705 (473)
Regression path dur.				
Coord Alt/Alt	417 (362)	634 (340)	591 (904)	2492 (2303)
NoCoord	360 (273)	752 (464)	571 (821)	2269 (1816)
Coord NonAlt/Alt	350 (273)	732 (449)	521 (690)	2426 (2026)
Coord Implicit/Alt	435 (362)	656 (406)	570 (735)	2595 (2174)
Selective Regression path dur.				
Coord Alt/Alt	344 (161)	597 (294)	365 (271)	959 (613)
NoCoord	311 (160)	666 (310)	380 (308)	976 (540)
Coord NonAlt/Alt	311 (180)	653 (309)	340 (265)	970 (569)
Coord Implicit/Alt	352 (175)	593 (291)	369 (291)	997 (591)
Percent regression out				
Coord Alt/Alt	12%	13%	18%	69%
NoCoord	9%	16%	22%	70%
Coord NonAlt/Alt	11%	16%	19%	71%
Coord Implicit/Alt	15%	15%	17%	73%

Table 9. Experiment 4 Analysis of variance results for regions 6-9.

	Region 6 (V2). *sank*	Region 7 (NP). *the British vessel*	Region 8 (DisambV). *did not*	Region 9 (WrapUp). *send out help.*
First fixation dur.	*F*1=3.088* *F*2=3.840*	*F*1=1.108, p=.348 *F*2=1.220,	*F*1=2.224, p=.088† *F*2=1.873,	*F*1<1 *F*2=.636,

		p=.313	p=.147	p=.595
First pass dwell time	F1=3.691* F2=2.748, p=.053†	F1=5.185* F2=3.089*	F1<1 F2<1	F1<1 F2=1.326, p=.277
Reg. path dur.	F1=6.575** F2=2.385, p=.081†	F1=6.584** F2=7.182**	F1=1.201, p=.312 F2<1	F1=1.045, p=.375 F2=1.447, p=.241
Sel. reg. path dur.	F1=5.990* F2=3.433*	F1=6.799** F2=6.031**	F1=1.613, p=.189 F2=1.613, p=.199	F1<1 F2<1
Total dwell time	F1=1.628, p=.186 F2<1	F1=1.566, p=.201 F2=1.314, p=.281	F1=1.858, p=.140 F2=1.322, p=.278	F1<1 F2<1
Percent reg. out	F1=1.627, p=.186 F2<1	F1<1 F2<1	F1<1 F2<1	F1<1 F2<1

**significance p≤.001; *significance p≤.05; †marginal significance p<.1; other p values of interest noted in table
All means were transformed to Log10 prior to analysis
All *F*1 statistics utilize (3,132) DF; All *F*2 statistics utilize (3,48) DF

In Region 6, the V2 region, a number of measures were significant. For first fixation duration, there was a significant effect of parallel coordination [$F1(3,132) =3.088$, $p<.05$; $F2(3,132) =3.840$, $p<.05$] with the Implicit/Alt condition being slower than the NoCoord condition by items ($\alpha=.05$).

For first pass dwell times, there was a significant effect of parallel coordination by subjects [$F1(3,132) =3.691$, $p<.05$] and a marginal effect by items [$F2(3,132) =2.748$, $p=.053$]. Post hoc tests did not show significance ($\alpha=.05$).

Regression path durations displayed a significant effect of parallel coordination by subjects [$F1(3,132) = 6.575$, $p < .001$] and a marginal effect by items [$F2(3,132) = 2.385$, $p = .081$]. Post hoc tests ($\alpha = .05$), revealed that by subjects, the Alt/Alt condition was slower than both the NoCoord condition and the NonAlt/Alt condition. In addition, the Implicit/Alt condition was slower than the NonAlt/Alt condition by subjects and marginally slower by items and was slower than the NoCoord condition by subjects.

For the related measure, selected regression path duration, an effect of parallel coordination was again found [$F1(3,132) = 5.990$, $p = .001$; $F2(3,132) = 3.433$, $p < .05$]. Post hoc tests (Bonferroni, $\alpha = .05$) indicated that by subjects, the Alt/Alt condition was slower than the NoCoord condition and marginally slower than the NonAlt/Alt condition. The Implicit/Alt condition was slower than the NonAlt/Alt and NoCoord condition by subject and item.

In Region 7, the ambiguous subject/object NP region, first pass dwell time showed a significant effect of parallel coordination [$F1(3,132) = 5.185$, $p < .05$; $F2(3,132) = 3.089$, $p < .05$] for which post hoc tests ($\alpha = .05$). showed that NoCoord condition was slower than the Implicit/Alt condition by subjects and marginally slower than Implicit/Alt by items. In addition, the NonAlt/Alt condition was slower than the Implicit/Alt condition by subjects.

Regression path duration showed a highly significant effect of parallel coordination [$F1(3,132) = 6.584$, $p < .001$; $F2(3,132) = 7.182$, $p < .001$]. Pairwise comparisons (Bonferroni, $\alpha = .05$) revealed that the NonAlt/Alt condition was significantly slower than the Alt/Alt and Implicit/Alt conditions, by subjects and marginally so by items. The NoCoord condition was slower than Alt/Alt and Implicit/Alt condition by subject and item.

Selective regression path duration also demonstrated a significant parallel coordination effect [$F1(3,132) = 6.799$, p<001; $F2(3,132) = 6.031$, $p = .001$] for which post hoc tests (Bonferroni, $\alpha = .05$) indicated that the NonAlt/Alt condition was slower than the Implicit/Alt condition by subject and item and was significantly slower than Alt/Alt by subjects. The NoCoord condition was slower than the Alt/Alt and Implicit/Alt conditions by subject and item.

In Region 8, the disambiguating verb region, first fixation durations displayed a marginal effect of parallel coordination by subjects [$F1(3,132) = 2.224$, $p = .088$]. Post hoc tests were non-significant ($\alpha = .05$).

No dependent measures were found to show significance in the final wrap up region, Region 9.

Because Experiment 4 involves a contrast of verb class, some differences in reading time at the V1 region, as well as spillover in the adverb region were also expected. Thus, for the Experiment 4 analysis, Regions 3 (V1) and 4 (Adv) were also examined. However, because words that are frequently used have been shown to use shorter fixations than less frequently used words (Just & Carpenter, 1980; Rayner, 1977), it was necessary to include frequency scores for each verb as a covariate in the repeated measures analysis. Raw frequency scores were retrieved from the Corpus of Contemporary American English (COCA) (Davies, 2008) and then transformed to log10s values and centered from the mean. To best accommodate this verb frequency covariate, data from Regions 2 and 3 were subjected to a mixed model repeated measures analysis treating parallel coordination as a fixed factor, participant and item as random factors, and the log frequency as a fixed factor covariate. Only p-values at or approaching the .05 level are reported below. Additional *F*-scores may be found in Table 10.

Table 10. Experiment 4 repeated measures with covariate (V1 frequency) mixed model analysis results for regions 3-4.

	Region 3 (V1) *slowed*	Region 4 (Adv) *suddenly*
First fixation dur.		
Coord	*F*<1	*F*(2,415)=1.248, p=.288
V1 Log Freq	*F*(1,191)=5.474*	*F*(1,333)=5.011*
Coord *V1 Log Freq	*F*(2,115)=1.823, p=.166	*F*<1
First pass dwell time		
Coord	*F*<1	*F*(2,431)=2.120, p=.121
V1 Log Freq	*F*(1,611)= 14.636**	*F*(1,559)=3.963*
Coord *V1 Log Freq	*F*(2,439)=1.431, p=.131	*F*<1
Reg. path dur.		
Coord	*F*<1	*F*(2,430)=2.579, p=.077†
V1 Log Freq	*F*(1,611)= 14.636**	*F*(1,561)=.612, p=.434
Coord*V1 Log Freq	*F*(2,439)=1.431, p=.240	*F*(2,453)=3.620*
Sel. reg. path dur.		
Coord	*F*<1	*F*(2,436)=3.432*
V1 Log Freq	*F*(1, 209)= 34.552**	*F*(1,572)=4.235*
Coord*V1 Log Freq	*F*(2,132)= 1.112, p=.332	*F*(2,504)=1.251, p=.287
Total dwell time		
Coord	*F*(2,450)=3.422*	*F*(2,420)=1.831, p=.161
V1 Log Freq	*F*(1,534)=8.183*	*F*(1,587)=3.404, p=.066†
Coord*V1 Log Freq	*F*(2,406)=2.301, p=.101†	*F*(2,470)=3.226*
Percent reg. out		
Coord	*F*(2,454)= 2.916, p=.055†	*F*(2,425)=1.181, p=.308
V1 Log Freq	*F*<1	*F*<1
Coord*V1 Log Freq	*F*(2,180)=1.043, p=.354	*F*(2,204)=4.424*

**Significance p≤.001; *significance p≤.05; †marginal significance p<.1; other p values

of interest noted in table
Degrees of freedom listed in parentheses

At the V1 region (Region 3), first fixation durations showed a main effect of verb frequency [F(1,190.826)=5.474, p<.05], as did first pass dwell times [F(1,610.647)= 14.636, p<.001], regression path durations [F(1,610.647)= 14.636, p<.001], and selective regression path durations, [F(1 208.586)= 34.552, p<.001].

For total dwell times there was a significant main effect of parallel coordination [F(2,449.609)=3.422, p<.05] for which AltAlt was marginally longer than NonAltAlt (p=.057). There was also a main effect of verb frequency [F(1,534.013)=8.183, p<.05], as well as a nearly marginal interaction between the two factors [F(2,406.385)=2.301, p=.101].

Percent regression out showed a marginally significant effect of parallel coordination [F(2,454.038)= 2.916, p=.055] in which ImplicitAlt had a marginally greater percent of regressions out than AltAlt (p=.062).

At the adverb region (Region 4), first fixation durations again displayed a main effect of verb frequency [F(1,333.028)=5.011 p<.05] as did first pass dwell times [F(1,559.317)=3.963, p<.05].

Regression path durations showed a marginally significant main effect of parallel coordination [F(2,429.720)=2.579 p=.077] for which AltAlt patterned longer than NonAltAlt. There was also a significant interaction between parallel coordination and verb frequency [F(2,452.970)=3.620, p<.05].

Selected regression path durations showed significant main effects of parallel coordination [$F(2,435.737)=3.432$, $p<.05$] for which AltAlt was longer than NonAltAlt ($p<.05$). There was also a main effect of verb frequency [$F(1,572.433)=4.235$, $p<.05$].

Finally, there was a significant interaction between parallel coordination and verb frequency for both total dwell times [$F(2,470.481)=3.226$, $p<.05$] and percent regression out [$F(2,204.186)=4.424$, $p<.05$].

In addition, a backwards stepwise regression analysis was conducted to assess how well the mean percent transitive, acceptability ratings, experimental design factors, and the presence or absence of parallel coordination, serve as predictors for residual Total Dwell Times in Experiments 4 and 5. It appears that, across all regions, the acceptability of the introductory clauses in the materials accurately predicts total reading times for each item: the less acceptable the initial clause is, the more difficulty will ensue in the final region. Details are provided in Appendix B.

3.6.3 Discussion

Based on the results of both Staub (2007) and Exp 2-3, there was some expectation of a parallel coordination advantage for at least the matched Alt/Alt condition in the final region, though the absence of such an effect was also considered to be a possibility, especially if intransitive activation at the V2 region could have a long-lasting effect on later regions. No clear evidence of a parallel coordination advantage was found at either the disambiguating verb or final wrap up region for any of the coordinated conditions. However, there were effects of interest in the earlier regions, prior to subject/object disambiguation, which fits well with the results from Experiments 2 and 3 discussed above. In addition, on account of new effects seen in the V1 and Adverb regions, these effects may be taken to support a constraint-based/competition account that accommodates long-lasting effects as a mechanism for ambiguity resolution.

In the early regions (V1 and Adv), the most important finding was that for the total dwell times there was a main effect of parallel coordination, by which the Alt/Alt condition was more difficult to process than the unmatched NonAltAlt. A similar pattern of effects was seen in the adverb region for regression path duration and selective regression path duration, potentially representing spillover processing from the first verb. This effect was present even when verb frequency is entered into the model as a covariate, which effectively rules out verb frequency differences as solely driving the effect.

The differences observed in the V1 and adverb regions can be taken to indicate that verbs that have a larger number of structural alternatives (e.g., alternating unaccusatives, like the V1 in the matched, AltAlt condition) are more difficult to process than those with only one available choice (e.g., non-alternating unaccusatives like the V1 in the NonAltAlt condition). Such a conclusion is in line with studies that demonstrate that a verb's representational complexity affects online sentence processing (Fodor, Garrett and Bever, 1968; Shapiro, Zurif, & Grimshaw, 1987). In addition, as discussed in Chapter 2, processing differences that arise at points of ambiguity have often been cast as competition effects by proponents of constraint-based/competition models (e.g., Elman et al., 2005; McRae et al., 1998). When multiple structural analyses are available, the analyses must for compete for activation. If an equal number of constraints support both analyses, it will take more cycles for the model to settle on analysis, and thus there would be more processing cost. In this instance, available constraints would include, but not be limited to the goodness-of-fit of a subject to a V1 as well as the transitivity bias a V1. While normative data has not been conducted for the early regions, the presence of processing differences observed at the V1 and adverb regions indicates that both transitive and intransitive analyses are equally supported at this juncture. Such a finding is in line with the predictions of constraint-based competition models that posit a higher degree of competition when constraints equally support multiple structural alternatives (e.g., McRae et al., 1998; Elman et al. 2005; Tabor et al., 1997). Neither qualified constraint-based approaches nor two-stage models would predict this difference, as for both types of models, the presence of multiple alternatives never results in processing cost.

Turning to the V2 region, first recall that for the four versions of each item, the verb being accessed is always the same alternating unaccusative (notated as the second "Alt" in AltAlt, ImplicitAlt, and NonAltAlt, and present as the lone verb in NoCoord). Next note that the matched Alt/Alt condition and the superficially, but not representationally matched Implicit/Alt conditions again showed longer fixation times than both the NoCoord control and the superficially and representationally unmatched NonAlt condition. This was seen in first fixation durations, first pass dwell times, regression path durations, and selective regression path durations. Thus the same pattern seen at the V1 and adverb regions was again observed, but for a greater number of measures - and this occurred when all the V2 verbs being accessed were the same for each item across conditions. This finding appears to be in opposition to other findings in the literature (e.g., Frazier et al. 2000) that claim there is a straightforward processing advantage at the second verb for conjoined phrases that are structurally "similar" (though

Staub (2007) did also see a slow-down at the V2 for coordinated conditions, which he attributed to readers not fixating on the conjunction).

These findings at the V2 region are not necessarily in conflict with the findings from Experiments 2 and 3, and do not necessarily mean that parallelism does not have a facilitatory benefit. For the conditions with LSRs bearing two structural alternatives (AltAlt and ImplicitAlt), difficulty in the V2 region may again be seen as competition effects arising from the availability of multiple structural analyses. The fact that competition is seen in a greater number of measures at V2 than at V1 suggests that there may be more constraints supporting both alternatives at V2, thus enhancing competition.

For example, one constraint would be the transitivity bias of V2 (transitive vs. intransitive). Normative Study 2 showed that for this region, the new materials were more transitively biased (for the uncoordinated, short version) than the materials used in Experiments 1-3, though completions still fell towards the intransitive end of the spectrum. A second constraint would be the transitivity bias of the subject NP in relation to the event denoted by the V2 (transitive vs. intransitive). A third constraint would be the transitivity of the already parsed V1. Finally, there would be additional constraints reflecting any probabilistic information related to sentence-level, contextual, or structural biases activated by the material in the coordinated phrase (adverbial attachment biases and coordination biases). A first assessment of the pattern of differences might then be that there is a parallelism effect, albeit, one that does not yield facilitation, in which the deep lexical-semantic representation of one conjunct, together with other constraints, influences the activation of a similar/matched lexical-semantic representation and its associated argument structures in a second conjunct. An explanation that relies solely on superficial metrics like "transitive" or "intransitive" and that does not consider competition during processing could not account for these effects.

However, the absence of competition effects for the NonAlt condition raises some questions for this conclusion. The alternating unaccusative verbs in the V2 region have two possible analyses whereas the non-alternating verbs at V1 do not (a comparison to NoCoord is not considered at this point, as the material prior to V2 is unequal). It appears that because only one analysis was available at V1, only one analysis was also available at V2, despite the fact that the V2 LSRs allow for both transitive and intransitive analyses. Thus, it is possible to claim a facilitatory parallelism effect here, though it would have to be reliant, not on a match between the full set of structures linked to the underlying representations, but rather on the argument structure analysis that was selected in the first conjunct.

Considering both aspects of the results from the early regions, a more complete conclusion would thus be that the LSR of the first conjunct influences activation levels of a matched LSR when available, but influences only the superficially similar analyses (transitive vs. intransitive) available at the second conjunct when a matching LSR is not available. Whether the shorter durations for the NonAlt condition represent facilitation or some baseline of activation cannot be determined here, but the former option at least remains a possibility. It is thus possible that the types of facilitatory effects noted in Frazier et al. (2000) are only manifest because the materials are not precisely matched – though this remains speculation.

At the ambiguous NP region (Region 7), the pattern seen in Region 6 reverses. In both selective regression path durations and regression path durations, processing is facilitated for both the matched Alt/Alt condition and the Implicit/Alt condition in comparison to both the NoCoord control and the mismatched NonAlt/Alt condition. This pattern is highly similar to what was seen in Experiments 2 and 3 for the same region.

To consider the import of the NP region effects in more depth, I return momentarily to the V2 region. For each of the processing accounts discussed in Chapter 2, there would be one analysis that was selected at any given word in the sentence. If the V1 has an influence, at least in terms of eliciting the selection of another representation (if not in causing facilitation), then we would expect that at V2, it is the intransitive analysis that ultimately is selected. At the following NP region, the overwhelming tendency for the parser to attach ambiguous subject/object NPs as objects (Pickering & Traxler, 1998), even when implausible (Pickering, Traxler, & Crocker, 2000), would likely cause a reanalysis from intransitive to transitive to accommodate an object NP parse. As all NPs were constructed to be plausible objects of the V2 verb, the goodness-of-fit between V2 and ambiguous NP would also support reanalysis. This analysis might be relatively easy if structural alternatives are maintained for some time, as in the ranked parallel account detailed in Gibson (1991) or in dynamic processing models like Tabor and Hutchins' (2004) SOPARSE model or Tabor et al.'s (1997) visitation set gravitation model.

Because both analyses were active at the V2 region for the matched conditions, the transitive analysis, though not selected, would still be more active at the NP region than it would be for the unmatched condition for which the intransitive analysis potentially received more support (and possibly for the NoCoord condition for which only the intransitive analysis was highly activated). Without a transitive analysis highly activated in parallel, there would be a reanalysis cost when constraints provided more support to the transitive analysis at the NP region. Thus, the AltAlt and ImplicitAlt conditions would see a processing advantage over the NonAltAlt condition (and possibly NoCoord) at the NP.

As expected, no differences were observed between coordinated conditions at the disambiguating verb and beyond, adding more support to the claim that reanalysis under a ranked parallel model does not incur measurable processing cost.

In conclusion, deep lexical-semantic representations do appear to play a role in establishing parallelism (and thus in eliciting facilitation), but representational identity between conjuncts is not necessary for this to occur. If deep similarity does exist between conjuncts, the second conjunct will be influenced by the full representation of the first. If it does not exist, only some limited feature of the first conjunct will influence the second, for example, it's selected argument structure analysis. Constraint-based/competition models that allow for long-lasting effects provide most of the mechanisms needed to explain the data.

3.7 Experiment 5

Experiment 5, again using eyetracking while reading, examines to what extent manipulation of sentence-level, contextual/pragmatic constraints like the conceptual relation between a subject and a verb might further enhance the parallelism and competition effects seen in Experiments 2-4. Sentence-level and contextual factors have been claimed to play an important role in processing both in the coherence literature (e.g., Kehler, 2002) as well as in other studies online comprehension (e.g., Kamide et al., 2003). Recall that the inherently intransitive bias of the verbs used for the second conjunct in Experiments 1-3 may have limited the ability to see any facilitatory effect in the latter regions. Some attempts were made to hold constant the effects of contextual bias in Experiment 4, most notably in regard to the subject/verb relation, but a comparison point was not included by which to measure this effect.

A new strategy involves contrasting a set of intransitively biased subject/V2 pairings with a set of equibiased subject/V2 pairings by controlling for the pragmatic or conceptual (which here will be treated as equivalent) “goodness-of-fit” of an initial clause’s subject in relation to a transitive or intransitive parse of its V2. Subjects that serve as good agents for the event denoted by a V2 could potentially “fit” better with a transitive parse of V2 than those that serve as good experiencers for the same event. By manipulating these differences, the transitivity of V2 is treated as being more closely dependent on contextually or pragmatically relevant features between the verb and the subject it is paired with. Take the sentence in (25) below as an example. In (25a), a giant iceberg is intuitively an excellent sinker of a British vessel, and is thus a good fit for an agent of a sinking event that acts on another entity. In contrast, being quite buoyant, the iceberg is unlikely to sink on its own, and is thus also unlikely to be the experiencer of an intransitive sinking event that bears no external cause. Thus, the initial subject and the V2 are well matched conceptually to support a transitive parse for the V2; in regard to a transitive parse, there exists a goodness-of-fit. This contrasts markedly with the sentence in (25b). Here, the leaky lifeboat intuitively serves as a very poor sinker or agent for a transitive sinking event. But, the same leaky lifeboat would certainly be very good at sinking, and thus the pairing supports an intransitive parse for the V2.

(25) a. *When /the giant iceberg /slowed /suddenly /and /sank /the nearby British vessel /did not /send out help*.

b. *When /the leaky lifeboat /slowed /suddenly /and /sank /the nearby British vessel /did not /send out help*.

The intransitively biased subject/V2 pairing (subject-experiencer) condition (25b) is expected to provide more support for an intransitive V2 parse than the transitively biased subject/V2 pairing (subject-agent) condition (25a). A consequence of this would be lower activation of the transitive analysis at the V2 region and at the following subject/object ambiguous NP. This would in turn potentially make reanalysis to a transitive analysis at that NP more difficult. Thus the subject-experiencer condition is expected to show more processing cost at the ambiguous NP than the subject-agent condition. At the disambiguating verb region, facilitation (if any) should only be seen for the subject-experiencer condition, as only this condition has the potential to heighten activation of the intransitive analysis at the V2 such that it would still be active enough to ease reanalysis at the disambiguating verb region.

Experiment 5 also continues to test for an overall processing advantage for coordinated conditions over non-coordinated conditions, though only matched alternating unaccusative pairings are used, and consequently the relevance of lexical-semantic similarity to parallelism is not able to be addressed. It may be that coordination is facilitatory only when the subject/verb relation supports an intransitive parse. That is, there may be an interaction in which the subject-experiencer condition (25b) shows less processing difficulty at the V2 and NP regions (and beyond) than the subject-agent condition (25a) only in the presence of coordination, though the subject/verb relation may also provide a benefit regardless of the presence of coordination. In such a case, the parallelism effect would appear to have less to do with structural parallelism and may be more the result of coherence factors.

Unlike in Experiment 4, earlier regions will not be investigated here. Since there are no representational differences between the verbs being used (all alternating unaccusatives for both conjuncts), there is no reason to postulate differences based on representational form.

3.7.1 Method

3.7.1.1 Participants

Seventy-seven English-speaking undergraduates from the University of Michigan took the study for credit in an undergraduate psychology class. Thirty-four participants were removed on account of tracking issues and three additional participants were removed for having incorrect responses on five or more comprehension questions. Forty participants were left for analysis.

3.7.1.2 Materials

Critical items were similar in structure to those used in Experiments 1-4. There were 20 critical sentences in total. Eighty filler items of varying types were also included to mask the experimental manipulation.

Critical items, exemplified in (26) below, each had four variants. All verbs were of the matched Alt/Alt variety, with the critical manipulation involving the presence or absence of coordination and transitivity bias (subject-experiencer vs. subject-agent). The first type, the subject-agentive condition (26a), used subjects that serve as good agents for the event denoted by the V2 in order to create a case where the subject would provide a potentially good "fit" with a transitive parse of the V2. The second type, the subject-experiencer condition (26b), used subjects that serve as good experiencers of the event denoted by the V2. Finally, two control conditions were enlisted: a subject-agent-biased, non-coordinated control (26c) and an subject-experiencer-biased non-coordinated control (26d).

(26) a. When /the giant iceberg /slowed /suddenly /and /sank /the nearby British vessel /did not /send out help.

b. When /the leaky lifeboat /slowed /suddenly /and /sank /the nearby British vessel /did not /send out help.

c. When /the giant iceberg /sank /the nearby British vessel /did not /send out help.

d. When /the leaky lifeboat sank /the nearby British vessel /did not /send out help.

To assess the effectiveness of the new experimental manipulations, a sentence completion normative study was conducted. Overall, the results showed that the subject-experiencer conditions produced significantly fewer transitive responses than the subject-agent conditions (though this effect was not significant in the items analysis). The results indicate that the new biasing manipulation is relatively successful at creating more experimental room by which a facilitating effect of intransitive coordination might be observed. However, the subject-agent conditions were not as transitive as had been hoped, performing more like equibiased verbs than strongly transitive verbs. Still, given the numerous constraints on constructing the experimental materials, this was viewed as sufficient. The complete details on the study are presented in Normative Study 2 in Appendix A.

A second normative sentence completion study assessed the acceptability of the new sentences using a five-point Likert scale. Results indicated that the non-coordinated sentences are somewhat more acceptable than the coordinated ones, which is perhaps to be expected given that the coordinated conditions represent more complex events. Importantly, there were no significant differences between coordinated conditions. Complete details on Normative Study 3 in Appendix B. Full materials for Experiment 5 are presented in Appendix F.

3.7.1.3 Apparatus and display.

The study utilized an Eyelink2 head-mounted eyetracker running at 250Hz in corneal reflection mode. Nine-point recalibrations were performed at the beginning of the experiment and as necessary throughout the experiment. One-point drift corrections were performed after every trial. Sentences were displayed in 12 pt Courier New font on a 17" CRT monitor (1024 x 768). A carriage return was included after each disambiguating verb region in the presentation materials on account of screen space limitations. Thus, item presentation was split between two lines of text.

3.7.1.4 Procedure.

The experiment proceeded in the same manner as Experiments 3 and 4. Participants first read through an introductory screen that presented a set of instructions and a sample sentence. They then completed a practice block consisting of three items and two comprehension questions. The practice block was identical in design and appearance to the experimental block. Both the experimental and practice blocks began with a small fixation cross to the center left of the screen. When participants looked to this cross, an, invisible eye-contingent trigger automatically brought up a first a blank screen for 500 ms which was then followed by the complete critical sentence. After reading the sentence, participants were required to make a button press to advance to the next item. They were next either presented with a comprehension question or advanced to the next item. Breaks were built into the experimental design, appearing after every 25 trials, during which time participants were encouraged to close their eyes for one or two minutes to reduce any possibility of eyestrain or discomfort associated with the lengthy duration of the experiment. In some cases, participants were allowed to remove the headset for a few minutes. A nine-point recalibration (and manual readjustment for cases where the headset was removed) was performed after each break.

3.7.2 Results

For analysis, each sentence was divided into nine interest areas, indicated by "/" in (26) above. Regions were identical in form to those used in Experiments 4 above. As in the previous studies, some measures were taken to smooth the data before analysis. Short contiguous fixations were pooled to incorporate fixations of less than 80 ms into larger fixations within one character. Fixations of less than 40 ms and greater than 1200 ms were also removed. Finally, fixations falling beyond 2.5 SD from the region mean, for each subject, were trimmed to equal the mean plus or minus 2.5 SD. Mean reading times are presented in Table 11.

Six separate dependent variables were analyzed in a 2 (Coord) X 2 (Subject/V2 Bias) repeated measures ANOVA: first fixation duration, first pass dwell times (gaze duration), regression path duration (go past times), selective regression path duration (the duration of fixations and re-fixations of the current region before the eyes enter exit rightward to a region with a higher ID), total dwell time, and percent regression out. Only p-values at or approaching the .05 level are reported below. Additional *F*-scores may be found in Table 12.

In Region 6, first pass dwell time displayed a marginal main effect of coordination by items [$F2(1,16)=3.860$, $p=.067$] for which the NoCoord conditions were faster than the Coord conditions.

In Region 7, first pass dwell time showed a main effect of coordination that was significant by items [$F2(1,16)=5.521$, $p<.05$] and marginal by subject [$F1(1,36)=3.034$, $p=.090$] in which the NoCoord conditions were slower than the Coord conditions.

Regression path durations also showed a coordination effect by subject [$F1(1,36)=5.086$, $p<.05$] by which the NoCoord conditions were slower than the Coord conditions. There was also an effect of Subject/V2 bias [$F1(1,36)=4.970$, $p<.05$; $F2(1,16)=4.579$, $p<.05$] with the subject-experiencer conditions being slower than the subject-agent conditions.

The related measure, selective regression path durations, showed a main effect of coordination by which the NoCoord conditions were slower than the Coord conditions [$F1(1,36)=4.354$, $p<.05$; $F2(1,16)=4.486$, $p=.050$], as well as a main effect of Subject/V2 Bias in the subject analysis [$F1(1,36)=4.917$, $p<.05$] in which the subject-experiencer conditions were slower than the subject-agent conditions.

In Region 8, first pass dwell times showed a marginal main effect of Subject/V2 Bias in the subject analysis, with the subject-experiencer conditions being faster than the subject-agent conditions [$F1(1,36)=3.430$, $p=.072$].

Total dwell times showed a main effect of Subject/V2 Bias as well [$F1(1,36)=5.101$, $p<.05$; $F2(1,16)=9.569$, $p<.05$], for which the subject-experiencer conditions were faster than the subject-agent conditions.

Percent regression out also demonstrated a main effect of Subject/V2 Bias by which the subject-experiencer conditions had more regressions out than the subject-agent conditions. This was significant by items [$F2(1,16)=5.847$, $p<.05$] and was marginally significant by subjects [$F1(1,36)=3.544$, $p=.068$]

In Region 9, a number of measures were significant or marginally significant. First fixation durations showed a main effect of Subject/V2 Bias in which the subject-experiencer conditions were slower than the subject-agent conditions. This was significant by items [$F2(1,16)=4.789$, $P<.05$] and marginally significant by subjects [$F1(1,36)=3.537$, $p=.068$].

For first pass dwell times, there was a main effect of coordination in which the NoCoord conditions were significantly slower than the Coord conditions [$F1(1,36)=6.939$, $p<.05$; $F2(1,16)=10.270$, $p<.05$].

For regression path durations, there was a marginally significant main effect of coordination in which the NoCoord conditions were faster than the Coord conditions in the items analysis [$F2(1,16)=3.134$, $p=.096$].

Selective regression path durations displayed a marginal main effect of coordination, by which the NoCoord conditions were slower than the Coord conditions [*F1*(1,36)=3.111, p=.086; *F2*(1,16)=3.634, p=.075].

Finally, total dwell times showed a marginal main effect of coordination in which the NoCoord conditions were slower than the Coord conditions [*F1*(1,36)=3.111, p=.086; *F2*(1,16)=3.634, p=.075.

Table 11. Experiment 5 mean reading times (ms) and percent regression out. SD in parentheses.

	Region 1 (Intro)	Region 2 (SubjNP)	Region 3 (V1)	Region 4 (Adverb)	Region 5 (Conj)
Total dwell time					
NoCoord SubjExp	376 (262)	1392 (711)	N/A	N/A	N/A
NoCoord SubjAgent	412 (294)	1462 (876)	N/A	N/A	N/A
Coord SubjExp	353 (262)	1381 (735)	729 (478)	661 (464)	157 (233)
Coord SubjAgent	355 (259)	1387 (766)	700 (499)	673 (430)	168 (262)
First fixation duration					
NoCoord SubjExp	205 (102)	189 (85)	N/A	N/A	N/A
NoCoord SubjAgent	224 (113)	183 (77)	N/A	N/A	N/A
Coord SubjExp	182 (106)	181 (62)	268 (111)	283 (117)	108 (130)
Coord SubjAgent	194 (112)	183 (84)	264 (138)	277 (117)	100 (123)
First pass dwell time					
NoCoord SubjExp	257 (127)	521 (397)	N/A	N/A	N/A
NoCoord SubjAgent	273 (137)	494 (441)	N/A	N/A	N/A
Coord SubjExp	238 (145)	564 (539)	347 (199)	342 (172)	109 (131)
Coord SubjAgent	247 (131)	533 (456)	341 (200)	335 (156)	105 (133)
Regression path dur.					
NoCoord SubjExp	258 (127)	1028 (537)	N/A	N/A	N/A
NoCoord SubjAgent	273 (137)	1065 (568)	N/A	N/A	N/A
Coord SubjExp	238 (145)	1054 (528)	504 (424)	556 (511)	172 (346)
Coord SubjAgent	247 (131)	1059 (531)	505 (474)	562 (584)	188 (395)
Selective regression path dur.					
NoCoord SubjExp	258 (127)	886 (440)	N/A	N/A	N/A
NoCoord SubjAgent	273 (137)	900 (480)	N/A	N/A	N/A
Coord SubjExp	238 (145)	913 (492)	409 (240)	426 (269)	113 (137)
Coord SubjAgent	247 (131)	920 (433)	395 (210)	410 (226)	114 (148)
Percent regression out					

NoCoord SubjExp	0%	42%	N/A	N/A	N/A
NoCoord SubjAgent	0%	49%	N/A	N/A	N/A
Coord SubjExp	0%	49%	18%	25%	4%
Coord SubjAgent	0%	41%	17%	22%	6%

	Region 6 (V2)	Region 7 (AmbNP)	Region 8 (DisambV)	Region 9 (WrapUp)
Total dwell time				
NoCoord SubjExp	601 (403)	1151 (686)	543 (387)	1119 (570)
NoCoord SubjAgent	596 (374)	1187 (779)	590 (422)	1119 (521)
Coord SubjExp	596 (453)	1105 (721)	519 (353)	1071 (548)
Coord SubjAgent	586 (399)	1132 (683)	584 (393)	1073 (515)
First fixation duration				
NoCoord SubjExp	250 (102)	246 (100)	248 (128)	209 (103)
NoCoord SubjAgent	253 (108)	258 (117)	246 (116)	197 (87)
Coord SubjExp	261 (115)	251 (84)	243 (128)	208 (100)
Coord SubjAgent	252 (100)	245 (83)	248 (118)	196 (89)
First pass dwell time				
NoCoord SubjExp	294 (143)	654 (379)	344 (194)	866 (425)
NoCoord SubjAgent	303 (156)	652 (322)	371 (234)	861 (418)
Coord SubjExp	320 (184)	625 (339)	344 (204)	822 (429)
Coord SubjAgent	311 (146)	588 (297)	375 (246)	787 (395)
Regression path dur.				
NoCoord SubjExp	448 (380)	836 (508)	663 (795)	2282 (1780)
NoCoord SubjAgent	431 (297)	793 (443)	574 (624)	2452 (1944)
Coord SubjExp	454 (378)	811 (498)	605 (627)	2540 (2274)
Coord SubjAgent	442 (397)	727 (434)	579 (694)	2700 (2310)
Selective regression path dur.				
NoCoord SubjExp	347 (186)	752 (382)	437 (310)	1119 (570)
NoCoord SubjAgent	349 (170)	724 (342)	432 (284)	1119 (521)
Coord SubjExp	368 (218)	724 (358)	426 (284)	1071 (548)
Coord SubjAgent	355 (193)	673 (313)	435 (292)	1073 (515)
Percent regression out				
NoCoord SubjExp	16%	15%	22%	76%
NoCoord SubjAgent	17%	14%	17%	77%

Coord SubjExp	16%	14%	22%	74%
Coord SubjAgent	18%	14%	17%	77%

Table 12. Experiment 5 Analysis of variance results for regions 6-9.

	Region 6 (V2). *sank*	Region 7 (NP). *the British vessel*	Region 8 (DisambV). *did not*	Region 9 (WrapUp). *send out help.*
First fixation dur.				
Coord	*F*1<1	*F*1<1	*F*1<1	*F*1<1
	*F*2=1.173, p=.295	*F*2<1	*F*2<1	*F*2<1
Bias	*F*1<1	*F*1<1	*F*1<1	*F*1=3.537, p=.068†
	*F*2<1	*F*2<1	*F*2<1	*F*2=4.789*
Coord*Bias	*F*1<1	*F*1=2.345, p=.134	*F*1<1	*F*1<1
	*F*2<1	*F*2=2.138, p=.163	*F*2<1	*F*2<1
First pass dwell time				
Coord	*F*1=1.890, p=.178	*F* 1=3.034, p=.090†	*F*1<1	*F* 1=6.939*
	*F*2=3.860, p=.067†	*F*2=5.521*	*F*2<1	*F*2=10.270*
Bias	*F*1<1	*F*1<1	*F*1=3.430, p=.072†	*F*1<1
	*F*2<1	*F*2<1	*F*2=2.722, p=.118	*F*2<1
Coord*Bias	*F*1<1	*F*1=1.186, p=.283	*F*1<1	*F*1<1
	*F*2<1	*F*2=1.871, p=.190	*F*2<1	*F*2<1
Reg. path dur.				
Coord	*F*1<1	*F*1=5.086*	*F*1<1	*F*1=1.332, p=.256
	*F*2<1	*F*2=2.995, p=.103	*F*2<1	*F*2=3.134, p=.096†
Bias	*F*1<1	*F*1=4.970*	*F*1=2.191,	*F*1=1.535,

			p=.148	p=.223
	*F*2<1	*F*2=4.579* 1>2	*F*2=1.126, p=.304	*F*2=1.348, p=.263
Coord*Bias	*F*1<1	*F*1<1	*F*1<1	*F*1<1
	*F*2<1	*F*2=1.423, p=.250	*F*2<1	*F*2<1
Sel. reg. path dur.				
Coord	*F*1<1	*F*1=4.354*	*F*1<1	*F*1=3.111, p=.086†
	*F*2<1	*F*2=4.486, p=.050**	*F*2<1	*F*2=3.634, p=.075†
Bias	*F*1<1	*F*1=4.917*	*F*1<1	*F*1<1
	*F*2<1	*F*2=2.527, p=.131	*F*2<1	*F*2<1
Coord*Bias	*F*1<1	*F*1<1	*F*1<1	*F*1<1
	*F*2<1	*F*2<1	*F*2<1	*F*2<1
Total dwell time				
Coord	*F*1<1	*F*1=2.624, p=.114	*F*1<1	*F*1=3.111, p=.086†
	*F*2<1	*F*2=1.040, p=.323	*F*2<1	*F*2=3.634, p=.075†
Bias	*F*1<1	*F*1=1.037, p=.315	*F*1=5.101*	*F*1<1
	*F*2<1	*F*2<1	*F*2=9.569*	*F*2<1
Coord*Bias	*F*1<1	*F*1<1	*F*1=1.003, p=.323	*F*1<1
	*F*2<1	*F*2<1	*F*2<1	*F*2<1
Percent reg. out				
Coord	*F*1<1	*F*1<1	*F*1<1	*F*1<1
	*F*2<1	*F*2<1	*F*2<1	*F*2<1
Bias	*F*1<1	*F*1<1	*F*1=3.544, p=.068†	*F*1=1.150, p=.291
	*F*2<1	*F*2<1	*F*2=5.847*	*F*2=1.522, p=.235
Coord*Bias	*F*1<1	*F*1<1	*F*1<1	*F*1<1
	*F*2<1	*F*2<1	*F*2<1	*F*2<1

**significance p≤.001; *significance p≤.05; †marginal significance p<.1; other p values of interest noted in table

All means were transformed to Log10 prior to analysis
All $F1$ statistics utilize (3,132) DF; All $F2$ statistics utilize (3,48) DF

As in Experiment 4, a backwards stepwise regression analysis was conducted to assess how well the mean percent transitive, acceptability ratings, experimental design factors, as well as the presence or absence of coordination serve as predictors for residual total dwell times in Experiments 4 and 5. It appears that, across all regions, the acceptability of the introductory clauses in the materials accurately predicts total reading times for each item: the less acceptable the initial clause is, the more difficulty will ensue in the final region. Details are provided in Appendix B.

3.7.3 Discussion

Ideally, the results from Experiment 5 would reveal an interaction whereby the coordinated, intransitive-biased V2 shows less processing difficulty than the coordinated, transitive-biased condition and both non-coordinated conditions at the V2 and NP regions, but no interactions were found. Beginning with the coordination effect, facilitation for the non-coordinated conditions was found in the V2 region for first pass dwell times. However, as in Experiments 2 and 3, this was again somewhat uninterpretable on account of sentential differences arising from the absence of coordinated material in the uncoordinated conditions. Similar to Experiment 4, facilitation was again seen for both coordinated conditions in the following ambiguous NP region, this time in first pass dwell times and in both regressive measures. This supports the conclusion from Experiment 4 that coordinated parallelism between the matched AltAlt conditions may bolster some form of ranked parallel activation of both structural analyses such that they are still available at the following NP region when reanalysis occurs, precluding any difficulty that may arise from a transitive reanalysis. Interestingly, the experimental manipulation did not find a coordination benefit at the disambiguating verb region (Region 8), which lends support to the presence of a lingering intransitive analysis at this point. In the final region, a number of early and late measures showed a processing advantage for the coordinated conditions over NoCoord. Throughout the experiments, it has been somewhat unclear how to explain such facilitation, especially if reanalysis cost has been headed off at the disambiguating verb region by earlier intransitive activation. It may be that because intransitive activation has even more time to decay than transitive activation (one additional region than the transitive parse at the NP), that there is some minor reanalysis cost.

Subject/V2 Bias effects were also found. For both regression path durations and selective regression path durations at the NP, the subject-experiencer condition was slower than the subject-agent condition. Thus it appears that while the presence of parallel coordination heightens competition at a V2, when the intransitive analysis is given more contextual support, less competition ensues, and thus the competing transitive parse is less available at a following NP region to head off any processing difficulty. The intransitive bias was also seen to help at the disambiguating verb. Here the strong intransitive activation facilitated recovery from the transitive to intransitive reanalysis. However, the reverse pattern, whereby the intransitive biased conditions are slower than the transitive biased ones, as seen in the percent regression out measure at the disambiguating verb region, does not fit well with this conclusion.

The final wrap up region also presents somewhat contradictory results. A slow down for the intransitive biased conditions appeared in first fixation durations. Yet, in the same region the intransitive biased conditions displayed facilitation for first pass dwell times, another early measure. Analysis of the final region is further complicated by the simultaneous faster fixation times mentioned earlier for regression path measures, but slower total dwell times and selective regression path durations (which are essentially definitionally the same for the final region) for the non-coordinated conditions in the final region. As the three measures all reflect somewhat later stages of processing, one would expect that they would all pattern somewhat the same.

The Experiment 5 results demonstrate that bolstering intransitive activation in the initial clause can lead to processing facilitation at the ambiguous NP region and at the disambiguating verb region when the intransitive parse is necessarily reactivated. By implicating subject/verb goodness-to-fit in amplifying this facilitation, more support is given to the notion that processing makes early online use of constraint-based information. In addition, these data also support the claim that activation of structural alternatives may persist over multiple word regions. Together with the findings from Experiments 2-4, a greater picture of the processing of coordinated structures emerges, in which detailed lexical-semantic representations act as lexical constraints alongside other structural and contextual constraints in online (parallel) processing.

Chapter 4

GENERAL DISCUSSION

In the five studies presented above, I have attempted to provide a more detailed account of the representations that are accessed in the processing of coordinated verb phrases, as well as some discussion of the mechanisms needed to conduct this processing. One of the primary goals was to determine whether deeper notions of representational similarity contribute to the facilitatory effects often noted at the second conjunct of such phrases. As has been discussed above, similarity, particularly in regard to syntactic similarity, has sometimes been construed using somewhat superficial descriptors, such as categorical placeholders like NP, PP, or VP or argument structure generalizations such as transitive and intransitive (e.g., Frazier et al., 1984; Frazier et al., 2000; Henstra, 1996; Staub, 2007). Particularly for verbal coordination, such an approach runs the risk of being too superficial and omitting the role of critical representational information from the analysis. Even descriptive categories like intransitive and transitive may be still too general, masking differences that even under a highly structural approach to the lexicon (e.g., Levin and Rappaport, 1995) are considered to provide necessary information regarding how events are represented and are linked to linear syntactic structure.

With this in mind, the current study took as its inspiration the approach enlisted by another body of studies that seek to determine the role of deeper representational and featural information in establishing parallelism in coordination. These studies have implicated a wide range of relevant features, such as discourse level information (e.g., Kehler, 2002), information structure (e.g., Hoeks, 1999), detailed syntactic and semantic information (e.g., Sturt et al., 2010), and prosodic information (e.g., Schepman and Rodway, 2000; Shapiro and Hestvik, 1995) in establishing parallelism.

For the current study the focus has been directed to verbal representations, looking beyond superficial categories to include details regarding both lexical-semantic representations and conceptual similarity into the experimental design. Conceptual similarity is admittedly still a rough hewn measure, but when treated as a constraint in a constraint-based/competition model, it does take on a somewhat more descriptive nature. With these enhancements, I sought to strengthen representational parallelism within the coordinated phrases and thereby elicit earlier and stronger facilitatory effects at points of difficulty later in the parse. The approach utilized necessarily relies on notions of structural persistence, which are demonstrated to be best accounted for by constraint-based/competition models of the processing architecture that allow for different analyses to be maintained over multiple word regions. (e.g., Tabor et al., 1997).

In Experiment 1, a word-by-word reading study, I failed to replicate the coordination advantage noted in Staub, both in the new materials and in his own materials, though the new materials appeared to be easier to process overall, perhaps signaling that the verbs were more successfully parallel, or that the events were significantly less complex for the new materials than they were for Staub's. A subsequent normative study demonstrated that the new materials bear a higher intransitive bias than the materials from Staub, which were shown to vary significantly in their degree of transitivity.

In an attempt to find a better, more detailed metric of similarity, a semantic condition was added in Experiment 2, a word-by-word readings study, testing the hypothesis that semantically related verbs would engender higher activation of a parallel intransitive analysis. In contrast to Experiment 1, some effects were found for the final region, signaling that conceptual/semantic features may play some role in parallelism. More importantly, potential facilitation in the V2 region and a facilitatory pattern in the ambiguous NP regions provided novel evidence in support of competition at the V2 region. A subsequent eyetracking study replicated the findings in Experiment 2. It was determined that the constraint-based/competition class of processing models provided the best account for the data pattern.

In light of the findings from Experiments 1-3, it was determined that a new approach was needed to create more experimental room by which any facilitatory effects could be seen. In addition, a more precise level of detail was enlisted to differentiate the verbal representations so as to clarify whether the apparently facilitatory pattern seen at the V2 region was actually facilitation. In Experiment 4, an eyetracking study, I sought to engender facilitation by accentuating the representational differences between verbal conjuncts, rather than minimizing them. Under this new approach, it was hypothesized that there would be either intransitive/transitive competition at the V2 region, and that because both representations were highly active (at least for the matched conditions) reanalysis costs would not be found at the disambiguating verb region

Facilitation was still not found at the expected disambiguating region, but competition effects were seen at the V1 region, and earlier effects of coordination and representational similarity did emerge at the second verbal conjunct and at the immediately following noun phrase. However, whereas the similarity effects were facilitatory at the NP, the opposite was seen at the V2 region. To accommodate this finding, it was proposed that deep representational information is relevant to establishing parallelism, but that it affects coordination differentially depending on whether or not the conjuncts have matching LSRs. When matched, all of the potential analyses are highly activated for the second conjunct, resulting in competition. When unmatched, only the argument structure that was selected for the first conjunct is bolstered in the second conjunct (though both are likely still activated). Thus, Experiment 4 demonstrates that the early influence of constraints can actually reverse any expected facilitation from parallelism. This is shown to provide support for constraint-based/competition models of the processing architecture. The facilitation noted at the NP and lack of effects at the main clause verb support that the competition model must be able to accommodate long-term effects.

Finally, Experiment 5, also an eyetracking study, corroborated the findings from Experiment 4 using slightly different materials. In addition, support was found for the hypothesis that one sentence-level, contextual/pragmatic constraint, the goodness-of-fit of the subject to the event denoted by the verb, may influence the establishment of parallelism.

In sum, the above experiments add to body of literature that supports the role of detailed featural information in the processing of coordinate structures and provide novel evidence of competition during the V1 and ambiguous NP regions. As I have claimed above, the constraint-based/competition class of processing models best accommodates these findings. However, some questions do still remain. The conclusion from the current study requires that one linguistic object, the first conjuncts LSR, can somehow be assessed in regard to the second conjuncts LSR (and vice versa). That is, parallelism effects (facilitatory or not) arise at a second conjunct on account of the ability of the processor to see into each representation and assess the degree of representational match and then act in accordance to that match. Such a process would seem to require a distinctly linguistic mechanism to achieve – perhaps a linguistic comparator function that is sensitive to linguistic representations. Yet, most constraint-based models aim to provide a generalized account of language processing, one that acts on linguistic representations/objects, but that is also representative of a general cognitive process, and is not a specific linguistic mechanism. One exception is the visitation set gravitation model of Tabor et al. (1997) which implements a recurrent system in a dynamical systems model approach to explain how linguistic objects, like syntactic categories might emerge from the processes involved in a constraint-based approach. More work needs to be done to determine whether the effects seen in this study are in fact emergent effects of a dynamical system. Other questions that remain include the relation of the parallelism effect to priming, which is addressed to some extent in Sturt et al., (2010), and the question of why we should even see parallelism effects at all – what is its function in language? For example, independent motivation for parallelism effects may be found in other linguistic phenomena like gapping, which often involves or requires the activation of parallel representations (as in Carlson, 2002). It is possible that what is seen in coordinate structures involves the same processes seen in this other syntactic environment. Such questions are left for future research.

Appendices

Appendix A: Normative Study 2

A sentence completion normative study was conducted to assess the effectiveness of the new items in Experiments 4 and 5 (including the match/mismatch conditions as well as the subject-agent/subject experiencer bias conditions) towards increasing the transitivity bias of each item and thus providing additional “space” for a particular item to benefit from intransitive coordination and thus become more intransitive. Normative Study 2 was similar in methodology to the first normative study above.

1.1 Method

1.1.1 Participants.

Twenty-seven native English-speaking participants from the University of Michigan took the study in exchange in fulfillment for a requirement of an undergraduate psychology class. One participant was removed for finishing the study in an exceedingly short period of time, leaving 26 for analysis.

1.1.2 Materials.

Six conditions were constructed for each of the 20 sentences used in Experiment 4 and 5 were used for the study, reflecting each of the conditions in those studies. Each sentence appeared in only partial form, stopping after the V2 region (unlike Normative Study 1, no direct object conditions were included). The first and second conditions consisted of a matched alternating unaccusative coordinated V2 paring, the first of which was intransitively biased (27a) (Coord Alt/Alt SubjExper) and the second of which was transitively biased (27b) (Coord Alt/Alt SubjAgent). The third and fourth conditions were both transitively biased, mismatch conditions, with one using an implicit argument verb (27c) (Coord Implicit/Alt SubjAgent) and the second using a non-alternating unaccusative (27d) (Coord NonAlt/Alt SubjAgent) to coordinate with an alternating unaccusative and create the mismatch. Finally, two non-coordinated conditions were included as controls – one transitively biased (27e) (NoCoord SubjExper) and one intransitively biased (27f) (NoCoord SubjAgent). Full materials are presented in Appendix E.

(27) a. *When the leaky lifeboat slowed suddenly and sank*_____

b. *When the giant iceberg slowed suddenly and sank*_____

c. *When the giant iceberg struck suddenly and sank*_____

d. *When the giant iceberg appeared suddenly and sank*_____

e. *When the leaky lifeboat sank*_____

f. *When the giant iceberg sank*_____

This yielded a total of 120 critical sentence items. Items were then rotated in three blocks across two presentations lists and randomized, with three of the six conditions appearing in each list. In this way, each version of each item was distanced as much as possible without having a predictable placement. No fillers were used.

1.1.3 Procedure.

Sentences were presented using E-Prime 2.0 and were displayed in 12 pt Courier New font on a 19" widescreen LCD monitor (1680 x 1050). Subjects were instructed to type completions for each partial sentence presented on the screen. The study was conducted at each participant's own pace. Participants were allowed to revise completions prior to advancing to the next item.

1.2 Results

Normative Study 2 was analyzed in a repeated measures ANOVA. Means are presented in Table 13. All post hoc tests used the Bonferroni correction.

For the item analysis, there was a significant effect of coordination [$F2(5,120)=23.520$ $P<.001$; $F2(5,90) = 13.892$ $P<.001$]. Post hoc tests (Bonferroni, $\alpha=.05$) revealed that Coord Alt/Alt SubjExper was less transitively biased than Coord Implicit/Alt SubjAgent and Coord NonAlt/Alt SubjAgent. In addition, Coord Alt/Alt SubjAgent was more transitive than NoCoord SubjExper, and the Coord Implicit/Alt SubjAgent condition was more transitive than both the Coord Alt/Alt SubjExper and NoCoord SubjExper conditions. Finally, Coord NonAlt/Alt SubjAgent was more transitive than Coord Alt/Alt SubjExper and NoCoord SubjExper.

For the item analysis of the non-coordinated conditions, post hoc tests (Bonferroni, $\alpha=.05$) showed that NoCoord SubjExper was less transitive than Coord Alt/Alt SubjAgent, Coord Implicit/Alt SubjAgent, Coord NonAlt/Alt SubjAgent, and NoCoord SubjAgent. In addition, NoCoord SubjAgent was more transitive than NoCoord SubjExper.

In the subject analysis, post hoc tests (Bonferroni, $\alpha=.05$) revealed that Coord Alt/Alt SubjExper was less transitive than Coord Alt/Alt SubjAgent, Coord Implicit/Alt

SubjAgent, Coord NonAlt/Alt SubjAgent, and NoCoord SubjAgent. In addition, Coord Alt/Alt SubjAgent was more transitive than Coord Alt/Alt SubjExper and NoCoord SubjExper, but less transitive than Coord Implicit/Alt SubjAgent and Coord NonAlt/Alt SubjAgent. Coord Implicit/Alt SubjAgent was more transitive than Coord Alt/Alt SubjExper, Coord Alt/Alt SubjAgent, and NoCoord SubjExper. Coord NonAlt/Alt SubjAgent was more transitive than Coord Alt/Alt SubjExper, Coord Alt/Alt SubjAgent, and NoCoord SubjExper.

For the item analysis of the non-coordinated conditions, post hoc tests (Bonferroni, α=.05) showed that NoCoord SubjExper was less transitive than Coord Alt/Alt SubjAgent, Coord Implicit/Alt SubjAgent, Coord NonAlt/Alt SubjAgent, and NoCoord SubjAgent. Finally, NoCoord SubjAgent was more transitive than both Coord Alt/Alt SubjExper and NoCoord SubjExper.

Table 13. Normative Study 2 mean transitive completions.

Coordination and Transitive Bias Condition	Mean Transitive Completion
Coord Alt/Alt SubjExper	0.15
Coord Alt/Alt SubjAgent	0.24
Coord Implicit/Alt SubjAgent	0.39
Coord NonAlt/Alt SubjAgent	0.37
NoCoord SubjExper	0.08
NoCoord SubjAgent	0.30

1.3 Discussion

In sum, at least in the subject analysis, the subject-experiencer biased conditions produced significantly fewer transitive responses than all of the subject-agent biased conditions. The same was also true for the items analysis, with the exception of Coord

Alt/Alt SubjAgent and NoCoord SubjAgent, which were not significantly more transitive than the two intransitively biased conditions, but which patterned in the correct direction.

The general pattern of results thus indicates that the new biasing manipulation is successful at creating more experimental room by which a facilitating effect of intransitive coordination might be observed. The conditions are relatively stable within each biasing group, with one noteworthy exception being the matched subject-agent condition, Coord Alt/Alt SubjAgent, which, in the subject analysis was significantly less transitive than the Coord Implicit/Alt and Coord NonAlt/Alt mismatch conditions. This could be taken to suggest that, in the presence of featurally matched coordination, information about the inherent bias of the verb is not utilized by the processor to the same extent as it is in uncoordinated or poorly coordinated clauses. Thus, Normative Study 2 at least suggests that featural information may be accessed under some circumstances and play a role in establishing parallelism.

Appendix B: Normative Study 3

A normative rating study was conducted to assess whether subjects considered the Experiment 4 and 5 items to be acceptable sentences of English.

2.1 Method

2.1.1 Participants.

Twenty-three native English-speaking participants from the University of Michigan took the study in exchange in fulfillment for a requirement of an undergraduate psychology class. One participant was removed prior to analysis to balance the two presentation lists leaving 22 for analysis.

2.1.2 Materials.

The same six conditions used in Normative Study 2 were also used in Normative Study 3, but this time in their full sentential form, continuing beyond the V2 region to include the NP, disambiguating verb, and final wrap up regions, as in Experiments 4 and 5. As in Normative Study 2, the first and second conditions consisted of a matched alternating unaccusative coordinated V2 paring, the first of which was subject-experiencer biased (28a) and the second of which was subject-agent biased (28b). The third and fourth conditions were both subject-experiencer biased mismatch conditions, with one using an implicit argument verb (28c) and the second using a non-alternating unaccusative (28d) to coordinate with an alternating unaccusative and create the mismatch. Finally, two non-coordinated conditions were included as controls – one subject-agent biased (28e) and one subject-experiencer biased (28f).

(28) a. *When the leaky lifeboat slowed suddenly and sank the nearby British vessel did not send out help.*

b. *When the giant iceberg slowed suddenly and sank the nearby British vessel did not send out help.*

c. *When the giant iceberg struck suddenly and sank the nearby British vessel did not send out help.*

d. *When the giant iceberg appeared suddenly and sank the nearby British vessel did not send out help.*

e. *When the leaky lifeboat sank the nearby British vessel did not send out help.*

f. *When the giant iceberg sank the nearby British vessel did not send out help.*

There were thus 120 critical sentence items, rotated in three blocks across two presentations lists and randomized. Again, no fillers were used. Full materials are presented in Appendix E.

2.1.3 Procedure.

Sentences were presented using E-Prime 2.0 and were displayed in 12 pt Courier New font on a 19" widescreen LCD monitor (1680 x 1050). Subjects were informed that they would be reading a series of sentences that depicted certain events. They were then instructed to rate each sentence from 1-5 according to how realistic/plausible the described event seemed, with 1 being a highly implausible sentence and 5 being a highly plausible sentence. The study was conducted at each participant's own pace. Participants were allowed to revise scores prior to advancing to the next item.

2.2 Results

Normative Study 3 was analyzed using repeated measures ANOVA with Coordination condition as the within-subject variable. Means are presented in Table 14.

There was a significant effect of coordination by item [$F2(5,90)=2.952$ $p<.05$], but not by subject [$F1(5,100)=3.184$ $p>.05$]. A post hoc analysis (Bonferroni) (Bonferroni, $\alpha=.05$) reveled that in the items analysis, Coord Alt/Alt SubjAgent was less acceptable than its non-coordinated control, NoCoord SubjAgent and that Coord Implicit/Alt SubjAgent was less acceptable than its non-coordinated control, NoCoord SubjAgent. No other significant differences were found.

Table 14. Normative Study 3 mean acceptability ratings.

Coordination and Transitive Bias Condition	Mean Acceptability Rating (1-5)
Coord Alt/Alt SubjExper	3.25
Coord Alt/Alt SubjAgent	3.19
Coord Implicit/Alt SubjAgent	3.08
Coord NonAlt/Alt SubjAgent	3.31
NoCoord SubjExper	3.37
NoCoord SubjAgent	3.50

A backwards stepwise regression analysis was conducted to assess how well the mean percent transitive and acceptability ratings, as well as experimental design factors, experiment (4 or 5) and presence or absence of coordination, serve as predictors for residual total dwell times in Experiments 4 and 5. The analysis was conducted simultaneously on the data from regions 6-9 from both experiments using (the presence or absence of) coordination, mean percent transitive ratings, mean acceptability scores, and experiment (4 or 5) as predictors. Coordination and experiment, being categorical, were recoded as continuous using dummy variables for the analysis. All B reported below represent the standardized coefficients (Beta).

In Region 6, the V2, mean acceptability ratings significantly predicted total dwell times when percent transitive, coordination, and experiment were all removed from the model [B = -.198, t(157) = -2.569, p <.05]. Mean acceptability ratings also explained a significant proportion of the variance in total dwell times [R2 = .060, F(2,159) = 6.107 P<.05]. Thus lower acceptability scores predict higher total dwell times.

For the ambiguous NP (Region 7), mean acceptability ratings [B = -.234, t(157) = -2.928, p<.05] together with coordination [B = -.166, t(157) = -2.017, p<.05] and (marginally) experiment [B = -.152, t(157) = -1.910, p=.058] predicted total dwell times. The model explained a significant proportion of the variance in total dwell times [R2 = .058 F(3,159) = 4.281 p<.05]. Thus lower acceptability ratings, together with the absence of coordination predict longer reading times for the Experiment 4 data.

For Region 8, the disambiguating verb region, percent transitive [B = .159, t(157) = 2.194 p<.05] and acceptability [B =-.398, t(157) = -5.492 p<.001] predicted total dwell times and explained a significant proportion of the total dwell time variance when all other predictors were removed [R2 = .197 F(2,159) = 20.556, p<.001]. Thus higher degrees of transitivity coupled with a lower degree of acceptability predict longer reading times for this region.

Finally, in the WrapUp region, region 9, when all other predictors were removed from the model, acceptability marginally predicted total dwell times [B = -.144, t(157) = -1.829 p=.069] and explained a marginally significant proportion of the total dwell time variance [$R2 = .015$ $F(1,157) = 3.345$, $p=.069$]. Thus lower acceptability ratings predict longer total dwell times.

2.3 Discussion

The results from Normative Study 3 indicate that the non-coordinated sentences are somewhat more acceptable than the coordinated ones. What is interesting is that the unmatched NonAlt/Alt condition patterns somewhat with the NoCoord condition, suggesting that the more closely matched conditions Alt/Alt and Implicit/Alt are being treated in a different way than the unmatched, NonAlt/Alt and NoCoord conditions.

For the backwards stepwise regression, it appears that, across all regions, the acceptability of the introductory clauses in the materials accurately predicts total reading times for each item: the less acceptable the initial clause is, the more difficulty will ensue in the final region. There also appears to be an advantage for coordination in the ambiguous NP region as well as an advantage for intransitivity in the disambiguating verb region. While it is not clear at this stage what is occurring in the NP region, the results from the disambiguating verb region comport with any claim of facilitation from a later garden path when intransitivity is bolstered. Since coordination type is confounded here however, it is difficult to pinpoint to what degree this is actually informative. Stepwise regressions are admittedly highly exploratory in nature, and the results should be taken as only suggestive of what patterns might be expected in Experiments 4 and 5.

Appendix C: Normative Study 1 sentence completion materials.

Items 22-41 are taken from Staub (2007).

Item	Condition	Length	Sentence
1	NoCoord	Long	Although the pirate ship sank the nearby British vessel
	NoCoord	Short	Although the pirate ship sank
	NotSem	Long	Although the pirate ship halted suddenly and sank the nearby British vessel
	NotSem	Short	Although the pirate ship halted suddenly and sank
	Sem	Long	Although the pirate ship capsized suddenly and sank the nearby British vessel
	Sem	Short	Although the pirate ship capsized suddenly and sank
2	NoCoord	Long	Because the injured athlete rested her sprained ankle
	NoCoord	Short	Because the injured athlete rested
	NotSem	Long	Because the injured athlete stretched yesterday and rested her sprained ankle
	NotSem	Short	Because the injured athlete stretched yesterday and rested
	Sem	Long	Because the injured athlete relaxed yesterday and rested her sprained ankle
	Sem	Short	Because the injured athlete relaxed yesterday and rested
3	NoCoord	Long	When the electric heater burned the old power supply
	NoCoord	Short	When the electric heater burned
	NotSem	Long	When the electric heater started suddenly and burned the old power supply
	NotSem	Short	When the electric heater started suddenly and burned
	Sem	Long	When the electric heater ignited suddenly and burned the old power supply
	Sem	Short	When the electric heater ignited suddenly and burned
4	NoCoord	Long	Although the volatile substance exploded the fragile dynamite
	NoCoord	Short	Although the volatile substance exploded
	NotSem	Long	Although the volatile substance deteriorated gradually and exploded the fragile dynamite
	NotSem	Short	Although the volatile substance deteriorated gradually and exploded
	Sem	Long	Although the volatile substance expanded gradually and exploded the fragile dynamite
	Sem	Short	Although the volatile substance expanded gradually and exploded
5	NoCoord	Long	Because the wounded soldier healed his bullet wound
	NoCoord	Short	Because the wounded soldier healed
	NotSem	Long	Because the wounded soldier returned miraculously and healed his bullet wound

	NotSem	Short	Because the wounded soldier returned miraculously and healed
	Sem	Long	Because the wounded soldier improved miraculously and healed his bullet wound
	Sem	Short	Because the wounded soldier improved miraculously and healed
6	NoCoord	Long	Because the boat's battery corroded the electrical wires
	NoCoord	Short	Because the boat's battery corroded
	NotSem	Long	Because the boat's battery drained quickly and corroded the electrical wires
	NotSem	Short	Because the boat's battery drained quickly and corroded
	Sem	Long	Because the boat's battery rusted quickly and corroded the electrical wires
	Sem	Short	Because the boat's battery rusted quickly and corroded
7	NoCoord	Long	Although the engine's gears rotated the plastic wheels
	NoCoord	Short	Although the engine's gears rotated
	NotSem	Long	Although the engine's gears shifted easily and rotated the plastic wheels
	NotSem	Short	Although the engine's gears shifted easily and rotated
	Sem	Long	Although the engine's gears spun easily and rotated the plastic wheels
	Sem	Short	Although the engine's gears spun easily and rotated
8	NoCoord	Long	When the experimental airplane shattered its fiberglass wings
	NoCoord	Short	When the experimental airplane shattered
	NotSem	Long	When the experimental airplane dropped suddenly and shattered its fiberglass wings
	NotSem	Short	When the experimental airplane dropped suddenly and shattered
	Sem	Long	When the experimental airplane broke suddenly and shattered its fiberglass wings
	Sem	Short	When the experimental airplane broke suddenly and shattered
9	NoCoord	Long	Although the washing machine shook the white clothes
	NoCoord	Short	Although the washing machine shook
	NotSem	Long	Although the washing machine turned intensely and shook the white clothes
	NotSem	Short	Although the washing machine turned intensely and shook
	Sem	Long	Although the washing machine jiggled intensely and shook the white clothes
	Sem	Short	Although the washing machine jiggled intensely and shook
10	NoCoord	Long	Although the old carnival ride toppled the nervous fair-goers
	NoCoord	Short	Although the old carnival ride toppled

	NotSem	Long	Although the old carnival ride moved dangerously and toppled the nervous fair-goers
	NotSem	Short	Although the old carnival ride moved dangerously and toppled
	Sem	Long	Although the old carnival ride tilted dangerously and toppled the nervous fair-goers
	Sem	Short	Although the old carnival ride tilted dangerously and toppled
11	NoCoord	Long	As the immense glacier froze the surrounding land
	NoCoord	Short	As the immense glacier froze
	NotSem	Long	As the immense glacier formed slowly and froze the surrounding land
	NotSem	Short	As the immense glacier formed slowly and froze
	Sem	Long	As the immense glacier cooled slowly and froze the surrounding land
	Sem	Short	As the immense glacier cooled slowly and froze
12	NoCoord	Long	Because the solar panels bent the plastic sheeting
	NoCoord	Short	Because the solar panels bent
	NotSem	Long	Because the solar panels warmed somewhat and bent the plastic sheeting
	NotSem	Short	Because the solar panels warmed somewhat and bent
	Sem	Long	Because the solar panels warped somewhat and bent the plastic sheeting
	Sem	Short	Because the solar panels warped somewhat and bent
13	NoCoord	Long	As the TV drama's plot developed many new inconsistencies
	NoCoord	Short	As the TV drama's plot developed
	NotSem	Long	As the TV drama's plot changed mysteriously and developed many new inconsistencies
	NotSem	Short	As the TV drama's plot changed mysteriously and developed
	Sem	Long	As the TV drama's plot unfolded mysteriously and developed many new inconsistencies
	Sem	Short	As the TV drama's plot unfolded mysteriously and developed
14	NoCoord	Long	Because the foaming glue solidified the wood structure
	NoCoord	Short	Because the foaming glue solidified
	NotSem	Long	Because the foaming glue activated quickly and solidified the wood structure
	NotSem	Short	Because the foaming glue activated quickly and solidified
	Sem	Long	Because the foaming glue hardened quickly and solidified the wood structure
	Sem	Short	Because the foaming glue hardened quickly and solidified
15	NoCoord	Long	Although the wild begonias grew many delicate flowers

	NoCoord	Short	Although the wild begonias grew
	NotSem	Long	Although the wild begonias improved marvelously and grew many delicate flowers
	NotSem	Short	Although the wild begonias improved marvelously and grew
	Sem	Long	Although the wild begonias sprouted marvelously and grew many delicate flowers
	Sem	Short	Although the wild begonias sprouted marvelously and grew
16	NoCoord	Long	When the sick boy's expression brightened our worried hearts
	NoCoord	Short	When the sick boy's expression brightened
	NotSem	Long	When the sick boy's expression calmed finally and brightened our worried hearts
	NotSem	Short	When the sick boy's expression calmed finally and brightened
	Sem	Long	When the sick boy's expression lightened finally and brightened our worried hearts
	Sem	Short	When the sick boy's expression lightened finally and brightened
17	NoCoord	Long	Because the gushing flood water stopped the rescuers' efforts
	NoCoord	Short	Because the gushing flood water stopped
	NotSem	Long	Because the gushing flood water circulated slowly and stopped the rescuers' efforts
	NotSem	Short	Because the gushing flood water circulated slowly and stopped
	Sem	Long	Because the gushing flood water decreased slowly and stopped the rescuers' efforts
	Sem	Short	Because the gushing flood water decreased slowly and stopped
18	NoCoord	Long	Although the acidic mixture dissolved the metal piping
	NoCoord	Short	Although the acidic mixture dissolved
	NotSem	Long	Although the acidic mixture neutralized suddenly and dissolved the metal piping
	NotSem	Short	Although the acidic mixture neutralized suddenly and dissolved
	Sem	Long	Although the acidic mixture decomposed suddenly and dissolved the metal piping
	Sem	Short	Although the acidic mixture decomposed suddenly and dissolved
19	NoCoord	Long	Although the iron rod polarized the drilling machine
	NoCoord	Short	Although the iron rod polarized
	NotSem	Long	Although the iron rod oxidized rapidly and polarized the drilling machine
	NotSem	Short	Although the iron rod oxidized rapidly and polarized

	Sem	Long	Although the iron rod magnetized rapidly and polarized the drilling machine
	Sem	Short	Although the iron rod magnetized rapidly and polarized
20	NoCoord	Long	Because the young Senator toughened the new bill
	NoCoord	Short	Because the young Senator toughened
	NotSem	Long	Because the young Senator advanced somewhat and toughened the new bill
	NotSem	Short	Because the young Senator advanced somewhat and toughened
	Sem	Long	Because the young Senator strengthened somewhat and toughened the new bill
	Sem	Short	Because the young Senator strengthened somewhat and toughened
21	NoCoord	Long	When the little monkey dangled the yummy banana
	NoCoord	Short	When the little monkey dangled
	NotSem	Long	When the little monkey swung lazily and dangled the yummy banana
	NotSem	Short	When the little monkey swung lazily and dangled
	Sem	Long	When the little monkey hung lazily and dangled the yummy banana
	Sem	Short	When the little monkey hung lazily and dangled
22	NoCoord	Long	The vet said that because the dog ate the medicine
	NoCoord	Short	The vet said that because the dog ate
	NotSem	Long	The vet said that because the dog slept and ate the medicine
	NotSem	Short	The vet said that because the dog slept and ate
23	NoCoord	Long	John said that if the soldiers fight the enemy
	NoCoord	Short	John said that if the soldiers fight
	NotSem	Long	John said that if the soldiers stay and fight the enemy
	NotSem	Short	John said that if the soldiers stay and fight
24	NoCoord	Long	If Tom has time to write the book
	NoCoord	Short	If Tom has time to write
	NotSem	Long	If Tom has time to sit and write the book
	NotSem	Short	If Tom has time to sit and write
25	NoCoord	Long	Julie said that if the students perform the show
	NoCoord	Short	Julie said that if the students perform
	NotSem	Long	Julie said that if the students stand and perform the show
	NotSem	Short	Julie said that if the students stand and perform
26	NoCoord	Long	If the kids study the next book
	NoCoord	Short	If the kids study
	NotSem	Long	If the kids work and study the next book
	NotSem	Short	If the kids work and study
27	NoCoord	Long	Because the Hollywood star wants to direct the play
	NoCoord	Short	Because the Hollywood star wants to direct

	NotSem	Long	Because the Hollywood star wants to act and direct the play
	NotSem	Short	Because the Hollywood star wants to act and direct
28	NoCoord	Long	As the Beatles played their songs
	NoCoord	Short	As the Beatles played
	NotSem	Long	As the Beatles traveled and played their songs
	NotSem	Short	As the Beatles traveled and played
29	NoCoord	Long	The chief said that if the reactor restarts the process
	NoCoord	Short	The chief said that if the reactor restarts
	NotSem	Long	The chief said that if the reactor cools and restarts the process
	NotSem	Short	The chief said that if the reactor cools and restarts
30	NoCoord	Long	After the store advertised the merchandise
	NoCoord	Short	After the store advertised
	NotSem	Long	After the store opened and advertised the merchandise
	NotSem	Short	After the store opened and advertised
31	NoCoord	Long	Because the sea birds tend to attack ships
	NoCoord	Short	Because the sea birds tend to attack
	NotSem	Long	Because the sea birds tend to congregate and attack ships
	NotSem	Short	Because the sea birds tend to congregate and attack
32	NoCoord	Long	Though the adult animals just feed their young
	NoCoord	Short	Though the adult animals just feed
	NotSem	Long	Though the adult animals just hibernate and feed their young
	NotSem	Short	Though the adult animals just hibernate and feed
33	NoCoord	Long	When the chef finishes cooking the dinner
	NoCoord	Short	When the chef finishes cooking
	NotSem	Long	When the chef finishes shopping and cooking the dinner
	NotSem	Short	When the chef finishes shopping and cooking
34	NoCoord	Long	When the demonstrators leave the building
	NoCoord	Short	When the demonstrators leave
	NotSem	Long	When the demonstrators get up and leave the building
	NotSem	Short	When the demonstrators get up and leave
35	NoCoord	Long	Because the Senator stole the money
	NoCoord	Short	Because the Senator stole
	NotSem	Long	Because the Senator lied and stole the money
	NotSem	Short	Because the Senator lied and stole
36	NoCoord	Long	Though the maid mopped the floor
	NoCoord	Short	Though the maid mopped
	NotSem	Long	Though the maid arrived and mopped the floor
	NotSem	Short	Though the maid arrived and mopped
37	NoCoord	Long	Because Alan likes to contemplate the forest
	NoCoord	Short	Because Alan likes to contemplate

	NotSem	Long	Because Alan likes to walk and contemplate the forest
	NotSem	Short	Because Alan likes to walk and contemplate
38	NoCoord	Long	If the politician plans the campaign
	NoCoord	Short	If the politician plans
	NotSem	Long	If the politician strategizes and plans the campaign
	NotSem	Short	If the politician strategizes and plans
39	NoCoord	Long	Though the recruits tried to jump the barrier
	NoCoord	Short	Though the recruits tried to jump
	NotSem	Long	Though the recruits tried to sprint and jump the barrier
	NotSem	Short	Though the recruits tried to sprint and jump
40	NoCoord	Long	Mary thought that if she saved her money
	NoCoord	Short	Mary thought that if she saved
	NotSem	Long	Mary thought that if she waited and saved her money
	NotSem	Short	Mary thought that if she waited and saved
41	NoCoord	Long	When it was time to summarize the files
	NoCoord	Short	When it was time to summarize
	NotSem	Long	When it was time to speak and summarize the files
	NotSem	Short	When it was time to speak and summarize

Appendix D: Experiment 1 materials

Items 1-20 represent new materials; items 21-40 were taken from Staub (2007)
Regions are indicated by "/"
Presentation carriage returns are indicated by "RTRN"

Item	Condition	Sentence
1	Coord	Although the pirate ship halted suddenly and/sank/the nearby British vessel/did notRTRN/send out lifeboats.
	NoCoord	Although the pirate ship/sank/the nearby British vessel/did notRTRN/send out lifeboats.
2	Coord	Because the injured athlete stretched yesterday and/rested/her sprained ankle/did notRTRN/hurt at all in the morning.
	NoCoord	Because the injured athlete/rested/her sprained ankle/did notRTRN/hurt at all in the morning.
3	Coord	When the electric heater started suddenly and/burned/the old power supply/was completelyRTRN/damaged beyond repair.
	NoCoord	When the electric heater/burned/the old power supply/was completelyRTRN/damaged beyond repair.
4	Coord	Although the volatile substance deteriorated gradually and/exploded/the fragile dynamite/was notRTRN/at all disturbed.
	NoCoord	Although the volatile substance/exploded/the fragile dynamite/was notRTRN/at all disturbed.
5	Coord	Because the wounded soldier returned miraculously and/healed/his bullet wound/did notRTRN/bother him after a while.
	NoCoord	Because the wounded soldier/healed/his bullet wound/did notRTRN/bother him after a while.
6	Coord	Because the boat's battery drained quickly and/corroded/the electrical wires/were allRTRN/in need of serious repair.
	NoCoord	Because the boat's battery/corroded/the electrical wires/were allRTRN/in need of serious repair.
7	Coord	Although the engine's gears shifted easily and/rotated/the plastic wheels/did notRTRN/work correctly on the new invention.
	NoCoord	Although the engine's gears/rotated/the plastic wheels/did notRTRN/work correctly on the new invention.
8	Coord	When the experimental airplane dropped suddenly and/shattered/its fiberglass wings/were notRTRN/spared from destruction.
	NoCoord	When the experimental airplane/shattered/its fiberglass wings/were notRTRN/spared from destruction.
9	Coord	Although the washing machine turned intensely and/shook/the white clothes/did notRTRN/fall onto the floor.
	NoCoord	Although the washing machine/shook/the white clothes/did notRTRN/fall onto the floor.
10	Coord	Although the old carnival ride moved dangerously and/toppled/the nervous fair-goers/were mostlyRTRN/able to escape injury.

	NoCoord	Although the old carnival ride/toppled/the nervous fair-goers/were mostlyRTRN/able to escape injury.
11	Coord	As the immense glacier formed slowly and/froze/the surrounding land/was completelyRTRN/unable to support vegetation.
	NoCoord	As the immense glacier/froze/the surrounding land/was completelyRTRN/unable to support vegetation.
12	Coord	Because the solar panels warmed somewhat and/bent/the plastic sheeting/could notRTRN/be used to cover them.
	NoCoord	Because the solar panels/bent/the plastic sheeting/could notRTRN/be used to cover them.
13	Coord	As the TV drama's plot changed mysteriously and/developed/many new inconsistencies/became somewhatRTRN/too apparent.
	NoCoord	As the TV drama's plot/developed/many new inconsistencies/became somewhatRTRN/too apparent.
14	Coord	Because the foaming glue activated quickly and/solidified/the wood structure/was wellRTRN/preserved for the season.
	NoCoord	Because the foaming glue/solidified/the wood structure/was wellRTRN/preserved for the season.
15	Coord	Although the wild begonias improved marvelously and/grew/many delicate flowers/were partiallyRTRN/damaged during the cold snap.
	NoCoord	Although the wild begonias/grew/many delicate flowers/were partiallyRTRN/damaged during the cold snap.
16	Coord	When the sick boy's expression calmed finally and/brightened/our worried hearts/were allRTRN/set free from sadness.
	NoCoord	When the sick boy's expression/brightened/our worried hearts/were allRTRN/set free from sadness.
17	Coord	Because the gushing flood water circulated slowly and/stopped/the rescuers' efforts/were allRTRN/at last in vain.
	NoCoord	Because the gushing flood water/stopped/the rescuers' efforts/were allRTRN/at last in vain.
18	Coord	Although the iron rod oxidized rapidly and/polarized/the drilling machine/was stillRTRN/in working order.
	NoCoord	Although the iron rod/polarized/the drilling machine/was stillRTRN/in working order.
19	Coord	Because the young Senator advanced somewhat and/toughened/the new bill/was veryRTRN/strong when it hit the floor.
	NoCoord	Because the young Senator/toughened/the new bill/was veryRTRN/strong when it hit the floor.
20	Coord	When the little monkey swung lazily and/dangled/the yummy banana/was somewhatRTRN/difficult to hold on to.
	NoCoord	When the little monkey/dangled/the yummy banana/was somewhatRTRN/difficult to hold on to.
21	Coord	The vet said that because the dog slept and/ate/the medicine/had itsRTRN/effect.
	NoCoord	The vet said that because the dog/ate/the medicine/had itsRTRN/effect.

22	Coord	John said that if the soldiers stay and/fight/the enemy/will soonRTRN/leave.
	NoCoord	John said that if the soldiers/fight/the enemy/will soonRTRN/leave.
23	Coord	If Tom has time to sit and/write/the book/will certainlyRTRN/turn out great.
	NoCoord	If Tom has time to/write/the book/will certainlyRTRN/turn out great.
24	Coord	Julie said that if the students stand and/perform/the show/will beRTRN/a hit.
	NoCoord	Julie said that if the students/perform/the show/will beRTRN/a hit.
25	Coord	If the kids work and/study/the next book/will beRTRN/their choice.
	NoCoord	If the kids/study/the next book/will beRTRN/their choice.
26	Coord	Because the Hollywood star wants to act and/direct/the play/will beRTRN/a failure.
	NoCoord	Because the Hollywood star wants to/direct/the play/will beRTRN/a failure.
27	Coord	As the Beatles traveled and/played/their songs/became knownRTRN/everywhere.
	NoCoord	As the Beatles/played/their songs/became knownRTRN/everywhere.
28	Coord	The chief said that if the reactor cools and/restarts/the process/will beRTRN/safe.
	NoCoord	The chief said that if the reactor/restarts/the process/will beRTRN/safe.
29	Coord	After the store opened and/advertised/the merchandise/soldRTRN/out.
	NoCoord	After the store/advertised/the merchandise/soldRTRN/out.
30	Coord	Because the sea birds tend to congregate and/attack/ships/should beRTRN/careful.
	NoCoord	Because the sea birds tend to/attack/ships/should beRTRN/careful.
31	Coord	Though the adult animals just hibernate and/feed/their young/remainRTRN/active.
	NoCoord	Though the adult animals just/feed/their young/remainRTRN/active.
32	Coord	When the chef finishes shopping and/cooking/the dinner/will beRTRN/fantastic.
	NoCoord	When the chef finishes/cooking/the dinner/will beRTRN/fantastic.
33	Coord	When the demonstrators get up and/leave/the building/will beRTRN/locked.
	NoCoord	When the demonstrators/leave/the building/will beRTRN/locked.
34	Coord	Because the Senator lied and/stole/the money/is noRTRN/longer available.
	NoCoord	Because the Senator/stole/the money/is noRTRN/longer available.
35	Coord	Though the maid arrived and/mopped/the floor/would notRTRN/get clean.
	NoCoord	Though the maid/mopped/the floor/would notRTRN/get clean.
36	Coord	Because Alan likes to walk and/contemplate/the forest/is hisRTRN/favorite place.

	NoCoord	Because Alan likes to/contemplate/the forest/is hisRTRN/favorite place.
37	Coord	If the politician strategizes and/plans/the campaign/will goRTRN/well.
	NoCoord	If the politician/plans/the campaign/will goRTRN/well.
38	Coord	Though the recruits tried to sprint and/jump/the barrier/was justRTRN/too high.
	NoCoord	Though the recruits tried to/jump/the barrier/was justRTRN/too high.
39	Coord	Mary thought that if she waited and/saved/her money/would beRTRN/sufficient.
	NoCoord	Mary thought that if she/saved/her money/would beRTRN/sufficient.
40	Coord	When it was time to speak and/summarize/the files/wereRTRN/missing.
	NoCoord	When it was time to/summarize/the files/wereRTRN/missing.
41	Filler	When the boy hit forcefully and/slammed/a home run/his proud parents/cheered wildlyRTRN/from the bleachers.
42	Filler	When the soccer team scored suddenly and/won/the game/the crowd/went completelyRTRN/wild.
43	Filler	Although the band practiced daily and/recorded/a CD/they/still didn'tRTRN/make it big.
44	Filler	As the confused student studied more and/read/her textbook/the material/became muchRTRN/more clear.
45	Filler	Although the comedy troupe met daily and/rehearsed/their parts/the sketch/did notRTRN/become any better.
46	Filler	Because the investor stole indiscriminately and/swindled/his partners/he/was eventuallyRTRN/fired.
47	Filler	Because the shipwreck survivors rowed fiercely and/battled/the current/they/managed somehowRTRN/to get to shore.
48	Filler	Although the student arose quickly and/rode/her bike/she/was stillRTRN/late for class.
49	Filler	Because the soldiers endured bravely and/conquered/the enemy/the world/is nowRTRN/at peace.
50	Filler	Because the Red Sox prevailed unexpectedly and/defeated/the Yankees/the city/was finallyRTRN/freed of its curse.
51	Filler	Although the maid stayed overtime and/mopped/the floor/the fraternity/was stillRTRN/not clean.
52	Filler	When the great white shark appeared suddenly and/bit/the scuba diver/nobody/knewRTRN/what to do.
53	Filler	Because Ernest waited patiently and/invested/his money/he/had just enoughRTRN/to retire on.
54	Filler	When the company accountant vanished suddenly and/withdrew/lots of money/we all/becameRTRN/a little suspicious.
55	Filler	The little girl/grabbed/a handful of candy/from/her Halloween stash/and/ate/itRTRN/as fast as she could.
56	Filler	Morgan/replaced/his broken glasses/with/a new pair/when/he/finallyRTRN/cashed his paycheck.

57	Filler	The famous actress/accepted/the prestigious award/at/the ceremony/but/did not/thankRTRN/any of her friends or family.
58	Filler	The famous detective/inspected/the evidence/at/the crime scene/but/did not/findRTRN/any useful clues.
59	Filler	The backpacker/removed/his bag/from/his shoulders/and/rested/his legsRTRN/for a little while.
60	Filler	The thirsty athlete/guzzled/two Gatorades/while/he/rested/on/the sidelinesRTRN/during half time.
61	Filler	The magician/switched/the selected card/with/one/that/was/hiddenRTRN/in his shirtsleeve.
62	Filler	The train enthusiast/connected/two new tracks/for/the electric train set/that/was/set upRTRN/in his basement.
63	Filler	One passenger/delayed/the flight/on/Thursday morning/because/she/arrivedRTRN/late to the gate.
64	Filler	The movers/lowered/the player piano/from/the third floor window/to/the ground/inRTRN/less than half an hour.
65	Filler	The audio engineer/tweaked/the song's mix/in/the recording studio/until/it/soundedRTRN/perfect to his ears
66	Filler	The tattoo artist/pierced/the customer's skin/with/a special needle/that/injects/colored inksRTRN/safely and in a controlled manner.
67	Filler	The maid/soaked/the dirty linens/in/bleach/for/more/thanRTRN/three hours.
68	Filler	The beachgoers/disturbed/the endangered birds/that/were/nesting/in/the beach grassRTRN/up on the high dunes.
69	Filler	The school board/proposed/a plan/for/the new gym/during/the conference/thatRTRN/was held last night.
70	Filler	The talented artist/illustrated/children's books/for/a living/before/his paintings/becameRTRN/wildly successful.
71	Filler	The hurricane waves/pummeled/the large rocks/at/the beach/for/three daysRTRN/and three nights.
72	Filler	The clumsy cook/spilled/two gallons of oil/on/the kitchen floor/on/his first dayRTRN/at the new restaurant.
73	Filler	The old farmer/leaned/his pitchfork/against/the wooden fence/and/sat downRTRN/for a spell.
74	Filler	The oil baron/dug/a new well/in/the middle/of/the Western DesertRTRN/in Egypt.
75	Filler	The teenage driver/insured/her new car/with/a company/that/sheRTRN/knew nothing about.
76	Filler	The film crew/videotaped/the street performers/for/the TV special/that/airedRTRN/last Thursday night.
77	Filler	The rescue party/searched/the mineshaft/for/survivors/after/the horrible accidentRTRN/last Tuesday morning.
78	Filler	The policeman/arrested/the escaped convict/behind/a Dunkin Donuts/in/BrooklynRTRN/late last night.
79	Filler	The tightrope walker/amazed/the audience/with/his feats of

		daring/on/the opening nightRTRN/of the new circus.
80	Filler	The mechanic/greased/the ball bearings/before/he/rebuilt/the bike wheel's hubRTRN/on Monday afternoon.
81	Filler	The wealthy couple/tipped/the waiter/for/his excellent service/during/the fundraiserRTRN/on Saturday night.
82	Filler	Mr. Jennings/keeps/his important papers/in/a locked drawer/inRTRN/his downtown office.
83	Filler	The new father/held/his little baby/with/care/then/gentlyRTRN/put her in the crib.
84	Filler	Lisa-Marie/shared/her peppermint candies/with/the rest of the class/duringRTRN/the Valentine's Day party.
85	Filler	The deer hunter/killed/three large bucks/in/the national park/about/three weeksRTRN/into the hunting season.
86	Filler	The inquisitive girl/poked/the guinea pig/in/the pet store/untilRTRN/it squealed out in protest.
87	Filler	Only reckless drivers/disregarded/the speed limit/on/the highway/duringRTRN/the rush hour commute.
88	Filler	That girl/wore/the same dress/to/last year's ball/atRTRN/the Marriot Hotel.
89	Filler	The hungry hatchling/swallowed/the worms/its mother/brought/back with herRTRN/to the nest.
90	Filler	The news story/jolted/us/from/our state of complacency/toRTRN/a state of action.
91	Filler	The deadly spider/paralyzed/its victim/with/its powerful venom/thenRTRN/wrapped it in webbing.
92	Filler	Mark shouted loudly and/punched/Jimmy/during/their argument/about/the girlRTRN/that they both liked.
93	Filler	The missionary journeyed far and/educated/the/ villagers/from/the poor nation/in/a schoolRTRN/with only one room.
94	Filler	The evil witch cackled loudly and/stirred/the magic goop/in/the boiling cauldron/withRTRN/a large wooden stick
95	Filler	The basketball player dribbled deftly and/passed/the ball/to/his teammate/atRTRN/the last minute.
96	Filler	The big black bear growled suddenly and/surprised/the campers/on/the mountain pass/justRTRN/before sundown.
97	Filler	The captain/ returned safely and/secured/his craft/to/the rickety pier/withRTRN/10 meters of rope.
98	Filler	Seana drove fast and/parked/her car/in/the parking garage/right before workRTRN/on Monday morning.
99	Filler	The irritated mother rubbed hard and/scrubbed/the grass stains/on/her child's clothes/untilRTRN/they came out.
100	Filler	The restless boy yawned loudly and/counted/5sheep/before/he/fell/asleepRTRN/in the unfamiliar hotel bed.
101	Filler	The red wine dripped down and/stained/the white carpet/in/the dining room/ofRTRN/the fabulous mansion

102	Filler	Duane rowed silently and/watched/his big brother/catch/a turtle/from/the pondRTRN/with his bare hands.
103	Filler	The termites spawned quickly and/consumed/all of the wood/that/they/encountered/includingRTRN/our new deck.
104	Filler	The puppy drooled sloppily and/licked/his master's face/when/he/fed/him/dog foodRTRN/in the kitchen.
105	Filler	The bully acted terribly and/intimidated/the other children/in/the/ playground/until/the teacherRTRN/decided to intervene.

Appendix E Experiment 2 and 3 materials

Regions are indicated by "/"
Presentation carriage returns are indicated by "RTRN"

Item	Condition	Sentence
1	NoCoord	Although/the pirate ship/sank/the nearby British vessel/did notRTRN/send out lifeboats.
	NotSem	Although/the pirate ship/halted/suddenly/and/sank/the nearby British vessel/did notRTRN/send out lifeboats.
	Sem	Although/the pirate ship/capsized/suddenly/and/sank/the nearby British vessel/did notRTRN/send out lifeboats.
2	NoCoord	Because/the injured athlete/rested/her sprained ankle/did notRTRN/hurt at all in the morning.
	NotSem	Because/the injured athlete/stretched/yesterday/and/rested/her sprained ankle/did notRTRN/hurt at all in the morning.
	Sem	Because/the injured athlete/relaxed/yesterday/and/rested/her sprained ankle/did notRTRN/hurt at all in the morning.
3	NoCoord	When/the electric heater/burned/the old power supply/was completelyRTRN/damaged beyond repair.
	NotSem	When/the electric heater/started/suddenly/and/burned/the old power supply/was completelyRTRN/damaged beyond repair.
	Sem	When/the electric heater/ignited/suddenly/and/burned/the old power supply/was completelyRTRN/damaged beyond repair.
4	NoCoord	Although/the volatile substance/exploded/the fragile dynamite/was notRTRN/at all disturbed.
	NotSem	Although/the volatile substance/deteriorated/gradually/and/exploded/the fragile dynamite/was notRTRN/at all disturbed.
	Sem	Although/the volatile substance/expanded/gradually/and/exploded/the fragile dynamite/was notRTRN/at all disturbed.
5	NoCoord	Because/the wounded soldier/healed/his bullet wound/did notRTRN/bother him after a while.
	NotSem	Because/the wounded soldier/returned/miraculously/and/healed/his bullet wound/did notRTRN/bother him after a while.
	Sem	Because/the wounded soldier/improved/miraculously/and/healed/his bullet wound/did notRTRN/bother him after a while.
6	NoCoord	Because/the boat's battery/corroded/the electrical wires/were allRTRN/in need of serious repair.
	NotSem	Because/the boat's battery/drained/quickly/and/corroded/the electrical wires/were allRTRN/in need of serious repair.
	Sem	Because/the boat's battery/rusted/quickly/and/corroded/the electrical wires/were allRTRN/in need of serious repair.
7	NoCoord	Although/the engine's gears/rotated/the plastic wheels/did notRTRN/work correctly on the new invention.

	NotSem	Although/the engine's gears/shifted/easily/and/rotated/the plastic wheels/did notRTRN/work correctly on the new invention.
	Sem	Although/the engine's gears/spun/easily/and/rotated/the plastic wheels/did notRTRN/work correctly on the new invention.
8	NoCoord	When/the experimental airplane/shattered/its fiberglass wings/were notRTRN/spared from destruction.
	NotSem	When/the experimental airplane/dropped/suddenly/and/shattered/its fiberglass wings/were notRTRN/spared from destruction.
	Sem	When/the experimental airplane/broke/suddenly/and/shattered/its fiberglass wings/were notRTRN/spared from destruction.
9	NoCoord	Although/the washing machine/shook/the white clothes/did notRTRN/fall onto the floor.
	NotSem	Although/the washing machine/turned/intensely/and/shook/the white clothes/did notRTRN/fall onto the floor.
	Sem	Although/the washing machine/jiggled/intensely/and/shook/the white clothes/did notRTRN/fall onto the floor.
10	NoCoord	Although/the old carnival ride/toppled/the nervous fair-goers/were mostlyRTRN/able to escape injury.
	NotSem	Although/the old carnival ride/moved/dangerously/and/toppled/the nervous fair-goers/were mostlyRTRN/able to escape injury.
	Sem	Although/the old carnival ride/tilted/dangerously/and/toppled/the nervous fair-goers/were mostlyRTRN/able to escape injury.
11	NoCoord	As/the immense glacier/froze/the surrounding land/was completelyRTRN/unable to support vegetation.
	NotSem	As/the immense glacier/formed/slowly/and/froze/the surrounding land/was completelyRTRN/unable to support vegetation.
	Sem	As/the immense glacier/cooled/slowly/and/froze/the surrounding land/was completelyRTRN/unable to support vegetation.
12	NoCoord	Because/the solar panels/bent/the plastic sheeting/could notRTRN/be used to cover them.
	NotSem	Because/the solar panels/warmed/somewhat/and/bent/the plastic sheeting/could notRTRN/be used to cover them.
	Sem	Because/the solar panels/warped/somewhat/and/bent/the plastic sheeting/could notRTRN/be used to cover them.
13	NoCoord	As/the TV drama's plot/developed/many new inconsistencies/became somewhatRTRN/too apparent.
	NotSem	As/the TV drama's plot/changed/mysteriously/and/developed/many new inconsistencies/became somewhatRTRN/too apparent.
	Sem	As/the TV drama's plot/unfolded/mysteriously/and/developed/many new inconsistencies/became somewhatRTRN/too apparent.
14	NoCoord	Because/the foaming glue/solidified/the wood structure/was wellRTRN/preserved for the season.
	NotSem	Because/the foaming glue/activated/quickly/and/solidified/the wood structure/was wellRTRN/preserved for the season.
	Sem	Because/the foaming glue/hardened/quickly/and/solidified/the wood structure/was wellRTRN/preserved for the season.

15	NoCoord	Although/the wild begonias/grew/many delicate flowers/were partiallyRTRN/damaged during the cold snap.
	NotSem	Although/the wild begonias/improved/marvelously/and/grew/many delicate flowers/were partiallyRTRN/damaged during the cold snap.
	Sem	Although/the wild begonias/sprouted/marvelously/and/grew/many delicate flowers/were partiallyRTRN/damaged during the cold snap.
16	NoCoord	When/the sick boy's expression/brightened/our worried hearts/were allRTRN/set free from sadness.
	NotSem	When/the sick boy's expression/calmed/finally/and/brightened/our worried hearts/were allRTRN/set free from sadness.
	Sem	When/the sick boy's expression/lightened/finally/and/brightened/our worried hearts/were allRTRN/set free from sadness.
17	NoCoord	Because/the gushing flood water/stopped/the rescuers' efforts/were allRTRN/at last in vain.
	NotSem	Because/the gushing flood water/circulated/slowly/and/stopped/the rescuers' efforts/were allRTRN/at last in vain.
	Sem	Because/the gushing flood water/decreased/slowly/and/stopped/the rescuers' efforts/were allRTRN/at last in vain.
18	NoCoord	Although/the acidic mixture/dissolved/the metal piping/was stillRTRN/a bit damaged.
	NotSem	Although/the acidic mixture/neutralized/suddenly/and/dissolved/the metal piping/was stillRTRN/a bit damaged.
	Sem	Although/the acidic mixture/decomposed/suddenly/and/dissolved/the metal piping/was stillRTRN/a bit damaged.
19	NoCoord	Although/the iron rod/polarized/the drilling machine/was stillRTRN/in working order.
	NotSem	Although/the iron rod/oxidized/rapidly/and/polarized/the drilling machine/was stillRTRN/in working order.
	Sem	Although/the iron rod/magnetized/rapidly/and/polarized/the drilling machine/was stillRTRN/in working order.
20	NoCoord	Because/the young Senator/toughened/the new bill/was veryRTRN/strong when it hit the floor.
	NotSem	Because/the young Senator/advanced/somewhat/and/toughened/the new bill/was veryRTRN/strong when it hit the floor.
	Sem	Because/the young Senator/strengthened/somewhat/and/toughened/the new bill/was veryRTRN/strong when it hit the floor.
21	NoCoord	When/the little monkey/dangled/the yummy banana/was somewhatRTRN/difficult to hold on to.
	NotSem	When/the little monkey/swung/lazily/and/dangled/the yummy banana/was somewhatRTRN/difficult to hold on to.
	Sem	When/the little monkey/hung/lazily/and/dangled/the yummy banana/was somewhatRTRN/difficult to hold on to.
22	Filler	When/the boy/hit/forcefully/and/slammed/a home run/his proud parents/cheered wildlyRTRN/from the bleachers.
23	Filler	When/the soccer team/scored/suddenly/and/won/the game/the crowd/went completelyRTRN/wild.

24	Filler	Although/the band/practiced/daily/and/recorded/a CD/they/still didn'tRTRN/make it big.
25	Filler	As/the confused student/studied/more/and/read/her textbook/the material/became muchRTRN/more clear.
26	Filler	Although/the comedy troupe/met/daily/and/rehearsed/their parts/the sketch/did notRTRN/become any better.
27	Filler	Because/the investor/stole/indiscriminately/and/swindled/his partners/he/was eventuallyRTRN/fired.
28	Filler	Because/the shipwreck survivors/rowed/fiercely/and/battled/the current/they/managed somehowRTRN/to get to shore.
29	Filler	Although/the student/arose/quickly/and/rode/her bike/she/was stillRTRN/late for class.
30	Filler	Because/the soldiers/endured/bravely/and/conquered/the enemy/the world/is nowRTRN/at peace.
31	Filler	Because/the Red Sox/prevailed/unexpectedly/and/defeated/the Yankees/the city/was finallyRTRN/freed of its curse.
32	Filler	Although/the maid/stayed/overtime/and/mopped/the floor/the fraternity/was stillRTRN/not clean.
33	Filler	When/the great white shark/appeared/suddenly/and/bit/the scuba diver/nobody/knewRTRN/what to do.
34	Filler	Because/Ernest/waited/patiently/and/invested/his money/he/had just enoughRTRN/to retire on.
35	Filler	When/the company accountant/vanished/suddenly/and/withdrew/lots of money/we all/becameRTRN/a little suspicious.
36	Filler	Because/the professor/summarized/his previous lecture/we/did wellRTRN/on the pop quiz.
37	Filler	While/the mechanic/adjusted/our transmission/we/waited patientlyRTRN/in the lobby.
38	Filler	Although/the spelunkers/explored/the major caverns/they/did notRTRN/discover any new ones.
39	Filler	When/the priest/blessed/the dying man/his family/sighed outRTRN/in relief.
40	Filler	Although/Grandma/brought/her famous blueberry pie/nobody/had anyRTRN/of it.
41	Filler	When/the computer technician/enabled/the security program/our computers/slowedRTRN/to a halt.
42	Filler	When/the teacher/collected/our homework/one student's/was conspicuouslyRTRN/missing.
43	Filler	When/the Blockbuster clerk/suggested/that terrible movie/we/laughedRTRN/in disbelief.
44	Filler	Because/the jeweler/repaired/my mother's necklace/we/recommendedRTRN/him to our friends.
45	Filler	Although/the loud music/bothered/Josefin/she/did notRTRN/leave the bar.
46	Filler	When/Bobby/kicked/the broken refrigerator/it/suddenly startedRTRN/to work.

47	Filler	Because/the ruthless spy/poisoned/the food/the politician/becameRTRN/very sick.
48	Filler	Because/the students/respected/the teacher/they/did notRTRN/act up during class.
49	Filler	Although/Grandpa/chopped/a lot of firewood/we/did notRTRN/have enough in the winter.
50	Filler	The famous actress/accepted/the prestigious award/at/the ceremony/but/did not/thankRTRN/any of her friends or family.
51	Filler	The famous detective/inspected/the evidence/at/the crime scene/but/did not/findRTRN/any useful clues.
52	Filler	The little girl/grabbed/a handful of candy/from/her Halloween stash/and/ate/itRTRN/as fast as she could.
53	Filler	Morgan/replaced/his broken glasses/with/a new pair/when/he/finallyRTRN/cashed his paycheck.
54	Filler	The mean bully/intimidated/the other children/in/the school playground/until/the teacher/finallyRTRN/decided to intervene.
55	Filler	The thirsty athlete/guzzled/two Gatorades/while/he/rested/on/the sidelinesRTRN/during half time.
56	Filler	The backpacker/removed/his bag/from/his shoulders/and/rested/his legsRTRN/for a little while.
57	Filler	The train enthusiast/connected/two new tracks/for/the electric train set/that/was/set upRTRN/in his basement.
58	Filler	The magician/switched/the selected card/with/one/that/was/hiddenRTRN/in his shirtsleeve.
59	Filler	The puppy/licked/his master's face/when/he/fed/him/dog foodRTRN/in the kitchen.
60	Filler	One passenger/delayed/the flight/on/Thursday morning/because/she/arrivedRTRN/late to the gate.
61	Filler	The movers/lowered/the player piano/from/the third floor window/to/the ground/inRTRN/less than half an hour.
62	Filler	The audio engineer/tweaked/the song's mix/in/the recording studio/until/it/soundedRTRN/perfect to his ears.
63	Filler	The tattoo artist/pierced/the customer's skin/with/a special needle/that/injects/colored inksRTRN/safely and in a controlled manner.
64	Filler	The maid/soaked/the dirty linens/in/bleach/for/more/thanRTRN/three hours.
65	Filler	The beachgoers/disturbed/the endangered birds/that/were/nesting/in/the beach grassRTRN/up on the high dunes.
66	Filler	The school board/proposed/a plan/for/the new gym/during/the conference/thatRTRN/was held last night.
67	Filler	The talented artist/illustrated/children's books/for/a living/before/his paintings/becameRTRN/wildly successful.
68	Filler	The hurricane waves/pummeled/the large rocks/at/the beach/for/three daysRTRN/and three nights.
69	Filler	The clumsy cook/spilled/two gallons of oil/on/the kitchen floor/on/his

		first dayRTRN/at the new restaurant.
70	Filler	The old farmer/leaned/his pitchfork/against/the wooden fence/and/sat downRTRN/for a spell.
71	Filler	The oil baron/dug/a new well/in/the middle/of/the Western DesertRTRN/in Egypt.
72	Filler	The teenage driver/insured/her new car/with/a company/that/sheRTRN/knew nothing about.
73	Filler	The film crew/videotaped/the street performers/for/the TV special/that/airedRTRN/last Thursday night.
74	Filler	The rescue party/searched/the mineshaft/for/survivors/after/the horrible accidentRTRN/last Tuesday morning.
75	Filler	The policeman/arrested/the escaped convict/behind/a Dunkin Donuts/in/BrooklynRTRN/late last night.
76	Filler	The tightrope walker/amazed/the audience/with/his feats of daring/on/the opening nightRTRN/of the new circus.
77	Filler	The mechanic/greased/the ball bearings/before/he/rebuilt/the bike wheel's hubRTRN/on Monday afternoon.
78	Filler	The wealthy couple/tipped/the waiter/for/his excellent service/during/the fundraiserRTRN/on Saturday night.
79	Filler	The termites/consumed/all of the wood/that/they/encountered/includingRTRN/our new deck.
80	Filler	The new father/held/his little baby/with/care/then/gentlyRTRN/put her in the crib.
81	Filler	Mark/punched/Jimmy/during/their argument/about/the girlRTRN/that they both liked.
82	Filler	The deer hunter/killed/three large bucks/in/the national park/three weeks/intoRTRN/the hunting season.
83	Filler	Duane/watched/his big brother/catch/a turtle/from/the pondRTRN/with his bare hands.
84	Filler	The missionary/educated/the poor villagers/from/the impoverished nation/in/a small schoolRTRN/with only one room.
85	Filler	The restless boy/counted/51 sheep/before/he/fell/asleepRTRN/in the unfamiliar hotel bed.
86	Filler	The red wine/stained/the white carpet/in/the dining room/ofRTRN/the fabulous mansion.
87	Filler	The evil witch/stirred/the magic goop/in/the boiling cauldron/withRTRN/a large wooden stick.
88	Filler	Only reckless drivers/disregarded/the speed limit/on/the highway/duringRTRN/the rush hour commute.
89	Filler	Mr. Jennings/keeps/his important papers/in/a locked drawer/inRTRN/his downtown office.
90	Filler	The inquisitive girl/poked/the guinea pig/in/the pet store/untilRTRN/it squealed out in protest.
91	Filler	Lisa-Marie/shared/her peppermint candies/with/the rest of the class/duringRTRN/the Valentine's Day party.

92	Filler	That girl/wore/the same dress/to/last year's ball/atRTRN/the Marriot Hotel.
93	Filler	The basketball player/passed/the ball/to/his teammate/atRTRN/the last minute.
94	Filler	The hungry hatchling/swallowed/the worms/its mother/brought/back with herRTRN/to the nest.
95	Filler	The big black bear/surprised/the campers/on/the mountain pass/justRTRN/before sundown.
96	Filler	The captain/secured/his craft/to/the rickety pier/withRTRN/10 meters of rope.
97	Filler	The news story/jolted/us/from/our state of complacency/toRTRN/a state of action.
98	Filler	The deadly spider/paralyzed/its victim/with/its powerful venom/thenRTRN/wrapped it in webbing.
99	Filler	Seana/parked/her car/in/the parking garage/right before workRTRN/on Monday morning.
100	Filler	The irritated mother/scrubbed/the grass stains/on/her child's clothes/untilRTRN/they came out.

Appendix F: Experiments 4 and 5 and Normative Study 2 and 3 materials.

Material in parentheses only appeared in Experiments 4 and 5 and Normative Study 3. Presentation carriage returns are indicated by "RTRN"

Item	Condition	Sentence
1	Coord Alt/Alt SubExpBias	When the leaky lifeboat slowed suddenly and sank (the nearby British vessel did not RTRNsend out help.)
	Coord Alt/Alt SubAgntBias	When the giant iceberg slowed suddenly and sank (the nearby British vessel did not RTRNsend out help.)
	Coord Implicit/Alt SubAgntBias	When the giant iceberg struck suddenly and sank (the nearby British vessel did not RTRNsend out help.)
	Coord NonAlt/Alt SubAgntBias	When the giant iceberg appeared suddenly and sank (the nearby British vessel did not RTRNsend out help.)
	NoCoord SubExpBias	When the leaky lifeboat sank (the nearby British vessel did not RTRNsend out help.)
	NoCoord SubAgntBias	When the giant iceberg sank (the nearby British vessel did not RTRNsend out help.)
2	Coord Alt/Alt SubExpBias	When the old gas lamp started suddenly and burned (the kitchen floor was quickly RTRNdamaged beyond repair.)
	Coord Alt/Alt SubAgntBias	When the old electric steam iron started suddenly and burned (the kitchen floor was quickly RTRNdamaged beyond repair.)
	Coord Implicit/Alt SubAgntBias	When the old electric steam iron spurted suddenly and burned (the kitchen floor was quickly RTRNdamaged beyond repair.)
	Coord NonAlt/Alt SubAgntBias	When the old electric steam iron malfunctioned suddenly and burned (the kitchen floor was quickly RTRNdamaged beyond repair.)
	NoCoord SubExpBias	When the old gas lamp burned (the kitchen floor was quickly RTRNdamaged beyond repair.)
	NoCoord SubAgntBias	When the old electric steam iron burned (the kitchen floor was quickly RTRNdamaged beyond repair.)

3	Coord Alt/Alt SubExpBias	Although the volatile substance activated unexpectedly and exploded (the fragile dynamite was not RTRNat all disturbed.)
	Coord Alt/Alt SubAgntBias	Although the trigger mechanism activated unexpectedly and exploded (the fragile dynamite was not RTRNat all disturbed.)
	Coord Implicit/Alt SubAgntBias	Although the trigger mechanism contacted unexpectedly and exploded (the fragile dynamite was not RTRNat all disturbed.)
	Coord NonAlt/Alt SubAgntBias	Although the trigger mechanism faltered unexpectedly and exploded (the fragile dynamite was not RTRNat all disturbed.)
	NoCoord SubExpBias	Although the volatile substance exploded (the fragile dynamite was not RTRNat all disturbed.)
	NoCoord SubAgntBias	Although the trigger mechanism exploded (the fragile dynamite was not RTRNat all disturbed.)
4	Coord Alt/Alt SubExpBias	Because the injured soldier steadied suddenly and healed (the old woman did not RTRNbecome highly infected.)
	Coord Alt/Alt SubAgntBias	Because the medicine man steadied suddenly and healed (the old woman did not RTRNbecome highly infected.)
	Coord Implicit/Alt SubAgntBias	Because the medicine man visited suddenly and healed (the old woman did not RTRNbecome highly infected.)
	Coord NonAlt/Alt SubAgntBias	Because the medicine man arrived suddenly and healed (the old woman did not RTRNbecome highly infected.)
	NoCoord SubExpBias	Because the injured soldier healed (the old woman did not RTRNbecome highly infected.)
	NoCoord SubAgntBias	Because the medicine man healed (the old woman did not RTRNbecome highly infected.)
5	Coord Alt/Alt SubExpBias	Because the rusty old battery drained rapidly and deteriorated (the PVC piping was all RTRNin need of serious repair.)
	Coord Alt/Alt SubAgntBias	Because the pressurized sulfuric acid drained rapidly and deteriorated (the PVC piping was all RTRNin need of serious repair.)
	Coord Implicit/Alt SubAgntBias	Because the pressurized sulfuric acid leaked rapidly and deteriorated (the PVC piping was all RTRNin need of serious

		repair.)
	Coord NonAlt/Alt SubAgntBias	Because the pressurized sulfuric acid escaped rapidly and deteriorated (the PVC piping was all RTRNin need of serious repair.)
	NoCoord SubExpBias	Because the rusty old battery deteriorated (the PVC piping was all RTRNin need of serious repair.)
	NoCoord SubAgntBias	Because the pressurized sulfuric acid deteriorated (the PVC piping was all RTRNin need of serious repair.)
6	Coord Alt/Alt SubExpBias	When the delicate model airplane dropped unexpectedly and shattered (the glass window was also RTRNbadly damaged.)
	Coord Alt/Alt SubAgntBias	When the swinging sand bag dropped unexpectedly and shattered (the glass window was also RTRNbadly damaged.)
	Coord Implicit/Alt SubAgntBias	When the swinging sand bag collided unexpectedly and shattered (the glass window was also RTRNbadly damaged.)
	Coord NonAlt/Alt SubAgntBias	When the swinging sand bag fell unexpectedly and shattered (the glass window was also RTRNbadly damaged.)
	NoCoord SubExpBias	When the delicate model airplane shattered (the glass window was also RTRNbadly damaged.)
	NoCoord SubAgntBias	When the swinging sand bag shattered (the glass window was also RTRNbadly damaged.)
7	Coord Alt/Alt SubExpBias	Although the wet golden retriever awakened suddenly and shook (the explorer's tent did not RTRNget damaged in any way.)
	Coord Alt/Alt SubAgntBias	Although the big mean gorilla awakened suddenly and shook (the explorer's tent did not RTRNget damaged in any way.)
	Coord Implicit/Alt SubAgntBias	Although the big mean gorilla hit suddenly and shook (the explorer's tent did not RTRNget damaged in any way.)
	Coord NonAlt/Alt SubAgntBias	Although the big mean gorilla arose suddenly and shook (the explorer's tent did not RTRNget damaged in any way.)
	NoCoord SubExpBias	Although the wet golden retriever shook (the explorer's tent did not RTRNget damaged in any way.)
	NoCoord SubAgntBias	Although the big mean gorilla shook (the

		explorer's tent did not RTRNget damaged in any way.)
8	Coord Alt/Alt SubExpBias	Although the wobbly construction crane shifted repeatedly and toppled (the old building did not RTRNimmediately fall down.)
	Coord Alt/Alt SubAgntBias	Although the powerful demolition crane shifted repeatedly and toppled (the old building did not RTRNimmediately fall down.)
	Coord Implicit/Alt SubAgntBias	Although the powerful demolition crane smashed repeatedly and toppled (the old building did not RTRNimmediately fall down.)
	Coord NonAlt/Alt SubAgntBias	Although the powerful demolition crane surged repeatedly and toppled (the old building did not RTRNimmediately fall down.)
	NoCoord SubExpBias	Although the wobbly construction crane toppled (the old building did not RTRNimmediately fall down.)
	NoCoord SubAgntBias	Although the powerful demolition crane toppled (the old building did not RTRNimmediately fall down.)
9	Coord Alt/Alt SubExpBias	Because the mountain lake widened slowly and froze (the surrounding land was completely RTRNunable to support vegetation.)
	Coord Alt/Alt SubAgntBias	Because the immense glacier widened slowly and froze (the surrounding land was completely RTRNunable to support vegetation.)
	Coord Implicit/Alt SubAgntBias	Because the immense glacier pushed slowly and froze (the surrounding land was completely RTRNunable to support vegetation.)
	Coord NonAlt/Alt SubAgntBias	Because the immense glacier materialized slowly and froze (the surrounding land was completely RTRNunable to support vegetation.)
	NoCoord SubExpBias	Because the mountain lake froze (the surrounding land was completely RTRNunable to support vegetation.)
	NoCoord SubAgntBias	Because the immense glacier froze (the surrounding land was completely RTRNunable to support vegetation.)

10	Coord Alt/Alt SubExpBias	Because the flexible robot arm oxidized extensively and bent (the aluminum sheeting could not RTRNbe finished in time.)
	Coord Alt/Alt SubAgntBias	Because the heavy machinery oxidized extensively and bent (the aluminum sheeting could not RTRNbe finished in time.)
	Coord Implicit/Alt SubAgntBias	Because the heavy machinery hammered extensively and bent (the aluminum sheeting could not RTRNbe finished in time.)
	Coord NonAlt/Alt SubAgntBias	Because the heavy machinery extended extensively and bent (the aluminum sheeting could not RTRNbe finished in time.)
	NoCoord SubExpBias	Because the flexible robot arm bent (the aluminum sheeting could not RTRNbe finished in time.)
	NoCoord SubAgntBias	Because the heavy machinery bent (the aluminum sheeting could not RTRNbe finished in time.)
11	Coord Alt/Alt SubExpBias	Because the cranberry bog filled rapidly and flooded (the farmer's land was completely RTRNsaturated with water.)
	Coord Alt/Alt SubAgntBias	Because the swollen river filled rapidly and flooded (the farmer's land was completely RTRNsaturated with water.)
	Coord Implicit/Alt SubAgntBias	Because the swollen river discharged rapidly and flooded (the farmer's land was completely RTRNsaturated with water.)
	Coord NonAlt/Alt SubAgntBias	Because the swollen river flowed rapidly and flooded (the farmer's land was completely RTRNsaturated with water.)
	NoCoord SubExpBias	Because the cranberry bog flooded (the farmer's land was completely RTRNsaturated with water.)
	NoCoord SubAgntBias	Because the swollen river flooded (the farmer's land was completely RTRNsaturated with water.)
12	Coord Alt/Alt SubExpBias	As the young saplings strenghened gradually and grew (many golden apples were always RTRNavailable on the trees.)
	Coord Alt/Alt SubAgntBias	As the young farmer strenghened gradually and grew (many golden apples were always RTRNavailable on the trees.)

	Coord Implicit/Alt SubAgntBias	As the young farmer planted gradually and grew (many golden apples were always RTRNavailable on the trees.)
	Coord NonAlt/Alt SubAgntBias	As the young farmer matured gradually and grew (many golden apples were always RTRNavailable on the trees.)
	NoCoord SubExpBias	As the young saplings grew (many golden apples were always RTRNavailable on the trees.)
	NoCoord SubAgntBias	As the young farm boy grew (many golden apples were always RTRNavailable on the trees.)
13	Coord Alt/Alt SubExpBias	When the night sky intensified suddenly and brightened (the space station was completely RTRNfilled with radiant light.)
	Coord Alt/Alt SubAgntBias	When the fiery comet intensified suddenly and brightened (the space station was completely RTRNfilled with radiant light.)
	Coord Implicit/Alt SubAgntBias	When the fiery comet impacted suddenly and brightened (the space station was completely RTRNfilled with radiant light.)
	Coord NonAlt/Alt SubAgntBias	When the fiery comet came suddenly and brightened (the space station was completely RTRNfilled with radiant light.)
	NoCoord SubExpBias	When the night sky brightened (the space station was completely RTRNfilled with radiant light.)
	NoCoord SubAgntBias	When the fiery comet brightened (the space station was completely RTRNfilled with radiant light.)
14	Coord Alt/Alt SubExpBias	Although the security cameras turned quietly and stopped (the bank robbers were still RTRNcaptured in the end.)
	Coord Alt/Alt SubAgntBias	Although the police officer turned quietly and stopped (the bank robbers were still RTRNcaptured in the end.)
	Coord Implicit/Alt SubAgntBias	Although the police officer signaled quietly and stopped (the bank robbers were still RTRNcaptured in the end.)
	Coord NonAlt/Alt SubAgntBias	Although the police officer waited quietly and stopped (the bank robbers were still RTRNcaptured in the end.)
	NoCoord SubExpBias	Although the security cameras stopped (the bank robbers were still RTRNcaptured in the end.)
	NoCoord SubAgntBias	Although the police officer stopped (the

		bank robbers were still RTRNcaptured in the end.)
15	Coord Alt/Alt SubExpBias	Although the powdered detergent destabilized suddenly and dissolved (the metal piping was still RTRNa bit damaged.)
	Coord Alt/Alt SubAgntBias	Although the acidic compound destabilized suddenly and dissolved (the metal piping was still RTRNa bit damaged.)
	Coord Implicit/Alt SubAgntBias	Although the acidic compound penetrated suddenly and dissolved (the metal piping was still RTRNa bit damaged.)
	Coord NonAlt/Alt SubAgntBias	Although the acidic compound erupted suddenly and dissolved (the metal piping was still RTRNa bit damaged.)
	NoCoord SubExpBias	Although the powdered detergent dissolved (the metal piping was still RTRNa bit damaged.)
	NoCoord SubAgntBias	Although the acidic compound dissolved (the metal piping was still RTRNa bit damaged.)
16	Coord Alt/Alt SubExpBias	Although the hungry vampire levitated suddenly and transformed (the young woman was still RTRNhuman the next day.)
	Coord Alt/Alt SubAgntBias	Although the famous magician levitated suddenly and transformed (the young woman was still RTRNhuman the next day.)
	Coord Implicit/Alt SubAgntBias	Although the famous magician pointed suddenly and transformed (the young woman was still RTRNhuman the next day.)
	Coord NonAlt/Alt SubAgntBias	Although the famous magician emerged suddenly and transformed (the young woman was still RTRNhuman the next day.)
	NoCoord SubExpBias	Although the hungry vampire transformed (the young woman was still RTRNhuman the next day.)
	NoCoord SubAgntBias	Although the famous magician transformed (the young woman was still RTRNhuman the next day.)
17	Coord Alt/Alt SubExpBias	Although the long distance runner stabilized resolutely and accelerated (the

		slow vehicle did not RTRNget out of the way.)
	Coord Alt/Alt SubAgntBias	Although the race car driver stabilized resolutely and accelerated (the slow vehicle did not RTRNget out of the way.)
	Coord Implicit/Alt SubAgntBias	Although the race car driver steered resolutely and accelerated (the slow vehicle did not RTRNget out of the way.)
	Coord NonAlt/Alt SubAgntBias	Although the race car driver persisted resolutely and accelerated (the slow vehicle did not RTRNget out of the way.)
	NoCoord SubExpBias	Although the long distance runner accelerated (the slow vehicle did not RTRNget out of the way.)
	NoCoord SubAgntBias	Although the race car driver accelerated (the slow vehicle did not RTRNget out of the way.)
18	Coord Alt/Alt SubExpBias	Although the conveyor belt wheels moved quickly and rotated (the cereal boxes were not RTRNon the shelves in time.)
	Coord Alt/Alt SubAgntBias	Although the grocery stock boys moved quickly and rotated (the cereal boxes were not RTRNon the shelves in time.)
	Coord Implicit/Alt SubAgntBias	Although the grocery stock boys swept quickly and rotated (the cereal boxes were not RTRNon the shelves in time.)
	Coord NonAlt/Alt SubAgntBias	Although the grocery stock boys entered quickly and rotated (the cereal boxes were not RTRNon the shelves in time.)
	NoCoord SubExpBias	Although the conveyor belt wheels rotated (the cereal boxes were not RTRNon the shelves in time.)
	NoCoord SubAgntBias	Although the grocery stock boys rotated (the cereal boxes were not RTRNon the shelves in time.)
19	Coord Alt/Alt SubExpBias	Although the little bunny rabbits changed eventually and multiplied (the large numbers did not RTRNmake all that much logical sense.)
	Coord Alt/Alt SubAgntBias	Although the math club members changed eventually and multiplied (the large numbers did not RTRNmake all that much logical sense.)
	Coord Implicit/Alt SubAgntBias	Although the math club members studied eventually and multiplied (the large numbers did not RTRNmake all that much

		logical sense.)
	Coord NonAlt/Alt SubAgntBias	Although the math club members prevailed eventually and multiplied (the large numbers did not RTRNmake all that much logical sense.)
	NoCoord SubExpBias	Although the little bunny rabbits multiplied (the large numbers did not RTRNmake all that much logical sense.)
	NoCoord SubAgntBias	Although the math club members multiplied (the large numbers did not RTRNmake all that much logical sense.)
20	Coord Alt/Alt SubExpBias	Although the bungee cable retracted suddenly and stretched (the new harness was not RTRNin any way damaged.)
	Coord Alt/Alt SubAgntBias	Although the leatherworking machine retracted suddenly and stretched (the new harness was not RTRNin any way damaged.)
	Coord Implicit/Alt SubAgntBias	Although the leatherworking machine pulled suddenly and stretched (the new harness was not RTRNin any way damaged.)
	Coord NonAlt/Alt SubAgntBias	Although the leatherworking machine lapsed suddenly and stretched (the new harness was not RTRNin any way damaged.)
	NoCoord SubExpBias	Although the bungee cable stretched (the new harness was not RTRNin any way damaged.)
	NoCoord SubAgntBias	Although the leatherworking machine stretched (the new harness was not RTRNin any way damaged.)

References

Allopenna, P., Magnuson, J. S. and Tanenhaus, M. K. (1998) Tracking the time course of spoken word recognition using eye-movements: evidence for continuous mapping models. *Journal of Memory and Language*, 38, 419-439.

Altmann, G. T. M. & Steedman, M. (1988). Interaction with context during human sentence processing. *Cognition*, 30, 191-238.

Altmann, G. T. M. (1998). Ambiguity in Sentence Processing. *Trends in Cognitive Sciences*, 1998, 2, 146-152.

Altmann, G. T. M. (1999). Thematic role assignment in context. *Journal of Memory and Language*, 41, 124-145.

Altmann, G. T. M., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition*, 73, 247-264.

Apel, J., Knoeferle, P., Crocker, M. W. (2007). *Processing Parallel Structure: Evidence from Eye-Tracking and a Computational Model*. EuroCogSci 2007.

Arai, M., Van Gompel, R. P. G. & Scheepers, C. (2007). Priming ditransitive structures in comprehension. *Cognitive Psychology*, 54, 218-250.

Baker, M. (1997). Thematic Roles and Syntactic Structure. In L. Haegeman (ed.) *Elements of Grammar* (pp. 73-137). Dordrecht: Kluwer.

Boland, J. E. (1997a). The relationship between syntactic and semantic processes in sentence comprehension. *Language and. Cognitive Processes*, 12, 423-484.

Boland, J. E. (2005). Visual Arguments. *Cognition*, 95, 237-274.

Branigan, H. P., Pickering, M. J., & McLean, J. F. (2005). Priming prepositional-phrase attachment during comprehension. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 31, 468-481.

Carlson, K. (2002). *Parallelism and Prosody in the Processing of Ellipsis Sentences. Outstanding Dissertations in Linguistics series*. New York: Routledge.

Chace, K. H., Rayner, K., & Well, A. D. (2005). Eye-movements and phonological parafoveal preview effects in reading skill. *Canadian Journal of Experimental Psychology*, 59, 209–217.

Chambers, C. G. & Smyth, R. (1998). Structural parallelism and discourse coherence: A test of centering theory. *Journal of Memory and Language*, 39, 593-608.

Chierchia, G. (1989). Structured meanings, thematic roles, and control. In G. Chierchia, B. Partee, and R. Turner. (Eds.), *Properties, Types, and Meaning, Volume 2* (pp. 131-166). Dordrect: Kluwer.

Christianson, K., Hollingworth, A., Halliwell, J. F., & Ferreira, F. (2001). Thematic roles assigned along the garden path linger. *Cognitive Psychology*, 42, 368-407.

Cleland, A. A., & Pickering, M. J. (2003). The use of lexical and syntactic information in language production: Evidence from the priming of noun-phrase structure. *Journal of Memory and Language*, 49, 214-230.

Clifton, C. E., Jr. (1993). Thematic roles in sentence parsing. *Canadian Journal of Experimental Psychology*, 47, 222-246.

Clifton, C. E., & Ferreira, F. (1987). Discourse structure and anaphora: Some experimental results. In M. Coltheart (Ed.), *Attention & Performance XII* (pp. 635-654). Hillsdale, N.J.: Erlbaum.

Cuetos, F., & Mitchell, D. C. (1988). Cross-linguistic difference in parsing: restrictions on the late-closure strategy in Spanish. *Cognition*, 30, 73-105.

Dahan, D., Magnuson, J. S., Tanenhaus, M. K., & Hogan, E. (2001). Subcategorical mismatches and the time course of lexical access: Evidence for lexical competition. *Language and Cognitive Processes*, 16, 507–534.

Davies, M. (2008-). The Corpus of Contemporary American English (COCA): 400+ million words, 1990-present. Available online at http://www.americancorpus.org.

Dubey, A., Keller, F., and Sturt, P. 2008. A Probabilistic Corpus-based Model of Syntactic Parallelism. *Cognition*, 109, 326-344.

Dowty D.R. (1991). Thematic Proto-Roles and Argument Selection. *Language*, 67, 547-619.

Elman, J., Hare, M., & McRae, K. (2005). Cues, constraints, and competition in sentence processing. In M. Tomasello and D. Slobin (Eds.) *Beyond Nature-Nurture: Essays in Honor of Elizabeth Bates* (pp. 111-138). Mahwah, NJ: Lawrence Erlbaum Associates.

Ferreira, F., & Clifton, C. E. (1986). The independence of syntactic processing. *Journal of Memory and Language* , 25, 348–368.

Ferreira, F., & Henderson, J. M. (1991). Recovery from misanalyses of garden-path sentences. *Journal of Memory and Language*, 30, 725-74.

Ferreira, F., & Patson, N. (2007). The good enough approach to language comprehension. *Language and Linguistics Compass*, 1, 71-83.

Ferreira, F., Ferraro, V., & Bailey, K. G. D. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science*, 11, 11-15.

Fillmore, C. 1968. The case for case. In E. Bach and R.T. Harms (eds.), *Universals in linguistic theory* (pp. 1-88). New York: Holt, Rinehart and Winston.

Fodor, J. A. (1983). *The modularity of mind: an essay on faculty psychology*. Cambridge, MA: MIT Press.

Fodor, J. A., Garrett, M., & Bever, T. C. (1968). Some syntactic determinants of sentential complexity: II. Verb structure. *Perception and Psychophysics*, 3, 458-461.

Frazier, L., & Clifton, C. E. (1996). *Construal*. Cambridge, MA: MIT Press.

Frazier, L. (1987). Sentence Processing: A Tutorial Review. In M. Coltheart (Ed.), *The Psychology of Reading* (pp. 559-586). Hove: Erlbaum.

Frazier, L. (1978). *On comprehending sentences: Syntactic parsing strategies* (Doctoral dissertation). University of Connecticut, Storrs, CT.

Frazier, L. & Rayner, K. (1982). Making and correcting errors during sentence comprehension: eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, 14, 178–210.

Frazier, L., Munn, A., & Clifton, C. E. Jr., (2000). Processing coordinate structures. *Journal of Psycholinguistic Research*, 29, 343–370.

Frazier, L., Taft, L., Roeper, T., Clifton, C. E., & Ehrlich, K. (1984). Parallel structure: a source of facilitation in sentence comprehension. *Memory & Cognition*, 12, 421–430.

Gibson, E. (1991). *A computational theory of human linguistic processing: Memory limitations and processing breakdown* (Doctoral dissertation), Carnegie Mellon University, Pittsburgh, PA.

Gahl, S., Jurafsky, D., & Roland, D. (2004a). Verb subcategorization frequencies: American English corpus data, methodological studies, and cross-corpus comparisons. *Behavior Research Methods, Instruments, and Computers*, 36, 432-443.

Gruber, J. S. (1965/1976). *Studies in lexical relations* (Doctoral dissertation), MIT. Reprinted as part of *Lexical structures in syntax and semantics*. Amsterdam: North-Holland, 1976.

Hale, K., & Keyser, J. (1993) On argument structure and the lexical expression of syntactic relations. In K. Hale and J. Keyser (Eds.) *The View from Building 20: A Festschrift for Sylvain Bromberger* (pp. 53-108). Cambridge, MA: MIT Press.

Hale, K., & Keyser, J. (2003). *Prolegomenon to a theory of argument structure*. Cambridge, MA: MIT Press.

Hare, M., McRae, K., & Elman, J. L. (2003). Sense and structure: Meaning as a determinant of verb subcategorization preferences. *Journal of Memory and Language*, 48, 281-303.

Hare, M., McRae, K., & Elman, J.L. (2004). Admitting that admitting verb sense into corpus analyses makes sense. *Language and Cognitive Processes*, 19, 181-224.

Henstra, J. A. (1996). *On the parsing of syntactically ambiguous sentences: Coordination and relative clause attachment* (Doctoral Dissertation), University of Sussex, Sussex, England.

Hobbs, J. R. (1979). Coherence and coreference. *Cognitive Science*, 3, 67-90.

Hoeks, J. C. J. (1999). *The processing of coordination: semantic and pragmatic constraints on ambiguity resolution* (Doctoral Dissertation). University of Nijmegen, Nijmegen, The Netherlands.

Jackendoff, R. (1987). The status of thematic relations in linguistic theory. *Linguistic Inquiry*, 18, 369-412.

Jackendoff, R. (1990). *Semantic Structures*. Cambridge, MA: MIT Press.

Just, M. A. & Carpenter, P. A. (1980). A theory of reading: From eye fixations to comprehension. *Psychological Review*, 87, 329-354.

Kamide, Y., Altmann, G, & Haywood, S. (2003). The time-course of prediction in incremental sentence processing: Evidence from anticipatory eye-movements. *Journal of Memory and Language*, 49, 133-156.

Kehler, A., Kertz, L., Rohde, H., and Elman, J. (2008). Coherence and Coreference Revisited. *Journal of Semantics (Special Issue on Processing Meaning)*, 25, 1-44.

Kehler, A. (2002). *Coherence, reference, and the theory of grammar*. Stanford: CSLI Publications.

Kjelgaard, M. M. & Speer, S. R. (1999). Prosodic facilitation and interference in the resolution of temporary syntactic closure ambiguity. *Journal of Memory and Language*, 40, 153-194.

Levin, B. and M. Rappaport Hovav (2005) *Argument Realization, Research Surveys in Linguistics Series*. Cambridge, UK: Cambridge University Press.

Levin, B. (1993). *English Verb Classes and Alternations: A preliminary Investigation*. Chicago: University of Chicago Press.

Levin, B. and Rappaport Hovav, M. (1995). *Unaccusativity: At the Syntax-Lexical Semantics Interface, Linguistic Inquiry Monograph, 26*. Cambridge, MA: MIT Press.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). Lexical nature of syntactic ambiguity resolution. *Psychological Review*, 101, 676-703.

McRae, K., Spivey-Knowlton, M. J. & Tanenhaus, M. K. (1998). Modeling thematic fit (and other constraints) within an integration competition framework. *Journal of Memory and Language*, 38, 283-312.

Munn, A., 1993. *Topics in the Syntax and Semantics of Coordinate Structures*. (Doctoral dissertation), University of Maryland, MD.

Patson, N. D., Darowski, E. S., Moon, N, & Ferreira, F. (2009). Lingering misinterpretations in Garden-path sentences: Evidence from a paraphrasing task. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 35, 280-285.

Perlmutter, D. M. (1978). *Impersonal Passives and the Unaccusative Hypothesis*. Proceedings of the Fourth Annual Meeting of the Berkeley Linguistics Society, 4, 157-189.

Pickering, M. J., & Traxler, M. J. (1998). Plausibility and recovery from garden paths: An eye tracking study. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 24, 940–961.

Pickering, M. J., Traxler, M. J., & Crocker, M. W. (2000). Ambiguity resolution in sentence processing: Evidence against likelihood. *Journal of Memory and Language*, 43, 447-475.

Pinker, S. (1989). *Learnability and Cognition: The acquisition of Argument Structure*. Cambridge, Mass.: MIT Press.

Rayner, K., (1977). Visual attention in reading: Eye movements reflect cognitive processes. *Memory & Cognition*, 5, 443–448.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 85, 618-660.

Rayner, K., & Pollatsek, A. (1989). *The psychology of reading*. Hillsdale, NJ: Erlbaum.

Reinhart, T. (2000). The Theta System: an Overview. *Theoretical Linguistics*, 28, 229-290.

Ross, J. R. (1967/1986). Constraints on Variables in Syntax. (Doctoral Dissertation), MIT. Published as *Infinite Syntax!* Norton, NJ: Ablex, 1986.

Sag, I., Gazdar, G., Wasow, T., & Weisler, S. (1985). Coordination and how to distinguish categories. *Natural Language and Linguistic Theory*, 3, 117-171.

Shapiro, L. P., & Hestvik, A. (1995). On-line comprehension of VP-ellipsis: Syntactic reconstruction and semantic influence. *Journal of Psycholinguistic Research*, 24, 517–532.

Shapiro, L. P., Zurif, E., and Grimshaw, J. (1987). Sentence Processing and the Mental Representation of Verbs. *Cognition*, 27, 219-246.

Smyth, R. H. (1994). Grammatical determinants of ambiguous pronoun resolution. *Journal of Psycholinguistic Research*, 23, 197-229.

Spivey, M. J. & Tanenhaus, M. K. (1998). Syntactic ambiguity resolution in discourse: Modeling the effects of referential context and lexical frequency. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 24, 1521-1543.

Spivey-Knowlton, M. J. (1996). *Integration of visual and linguistic information: Human data and model simulations* (Doctoral dissertation), University of Rochester, Rochester, N.Y.

Staub, A. (2007). The return of the repressed: Abandoned parses facilitate syntactic reanalysis. *Journal of Memory and Language*, 57, 299-323.

Staub, A. (2007b). The parser doesn't ignore intransitivity, after all. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 33, 550-569.

Stevenson, R., Nelson, A. W. R., & Stenning, K. (1995). The role of parallelism in strategies of pronoun comprehension. *Language and Speech*, 38, 393–418.

Sturt, P., Keller, F. & Dubey, A. (2010). Syntactic priming in comprehension: Parallelism effects with and without co-ordination. *Journal of Memory and Language*, 62, 333-351.

Sturt, P. (2003). The time-course of the application of binding constraints in reference resolution. *Journal of Memory and Language*, 48, 542–562.

Sturt, P., Pickering, M., & Crocker, M. W. (1999). Structural Change and Reanalysis Difficulty in Language Comprehension. *Journal of Memory and Language*, 40, 136-150.

Tabor, W. & Hutchins, S. (2004). Evidence for Self-Organized Sentence Processing: Digging In Effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30, 431-450.

Tabor, W. & Tanenhaus, M. K. (1999). Dynamical Models of Sentence Processing. Cognitive Science, 23(4), 491-515.

Tabor, W., Juliano, C. & Tanenhaus, M. K. (1997). Parsing in a dynamical system: An attractor-based account of the interaction of lexical and structural constraints in sentence processing. *Language and Cognitive Processes*, 12, 211—271.

Thothathiri, M. and Snedeker, J. (2008). Give and take: syntactic priming during spoken language comprehension. *Cognition*, 108, 51-68.

Traxler, M., Pickering, M., & Clifton, C. E., Jr. (1998). Adjunct attachment is not a form of lexical ambiguity resolution. *Journal of Memory and Language*, 39, 558-592.

Traxler, M. J. (2008). Structural priming among prepositional phrases: Evidence from eye movements. *Memory & Cognition*, Vol 36. 659-674.

Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influences on parsing: Use of thematic role information in syntactic disambiguation. *Journal of Memory and Language*, 33, 285–318.

Trueswell, J., Tanenhaus, M. K., & Kello, C. (1993). Verb-specific constraints in sentence processing: Separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning Memory and Cognition*, 19, 528 – 553.

Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influence on syntactic processing: Use of thematic information in syntactic disambiguation. *Journal of Memory and Language*, 33, 265-312.

Van Gompel, R. P. G., Pickering, M. J., & Traxler, M. J. (2001). Reanalysis in sentence processing: Evidence against current constraint-based and two-stage models. *Journal of Memory & Language*, 45, 225-258.

Van Gompel, R.P.G., Pickering, M.J., Pearson, J., & Liversedge, S. P. (2005). Evidence against competition during syntactic ambiguity resolution. *Journal of Memory and Language*, 52, 284-307.

Williams, E. (1981). Argument structure and morphology. *Linguistic Review*, 1, 81-114.