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All Roads Lead to Polenta: Cultural Attractors at the Junction of Public and Personal Culture

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In the process of retelling information, individuals often inadvertently transform it to be more consistent with their cultural schemas. We explore the long-term cultural change inherent in this process, focusing on utterances about cultural tastes as our case study (e.g., music, food, and outdoor hobbies). We use a word embedding model to simulate a "telephone game" where each actor partially hears an utterance, uses their cultural schemas to guess the missing word, and tells the result to the next actor. While laboratory "telephone games" explore short transmission chains of approximately four steps, our approach lets us simulate these chains out to 1000 steps. We find that these chains are often pulled toward powerful "cultural attractors"—essentially points of least resistance where communications end up through transmission error alone. Moreover, some attractors operate across taste domains: transmission chains gravitate toward these attractors regardless of which cultural domain they begin in. The most powerful such attractor we located concerns high-status, broadly liked food. Taste in food may thus have an underappreciated centrality within personal taste: verbal accounts describing taste in food may be particularly stable across multiple retellings, while accounts about other taste domains may become transformed into accounts of taste in food.

KEYWORDS: cultural attractors; cultural schemas; cultural tastes; culture and cognition; telephone game; word embeddings.

INTRODUCTION

Recent theoretical scholarship in cognitive sociology brings attention to interrelationships between cultural modalities: public representations, personal declarative culture, and personal nondeclarative culture (Boutyline and Soter 2021; Cerulo 2018; Lizardo 2017). Here, we use word embeddings to computationally explore one key linkage within this triangle: the relationship between public representations and personal nondeclarative culture, or, more precisely, between public utterances and cultural schemas. Both perception and recall are deeply error-prone processes. When individuals retell a piece of information they hear or remember, they often inadvertently transform it to be more consistent with their cultural schemas (Bartlett 1932; Mesoudi and Whiten 2008). The relationship between public representations and cultural schemas is thus rife with transformative tendencies.

To explore these tendencies, we construct an original computational version of a "telephone game"—a paradigm where one subject hears an utterance and retells it to the next subject from memory, who must then retell it to the third, etc. (e.g., Hun-

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zaker 2016). For logistical reasons, this approach has traditionally explored short transmission chains with four or fewer transmission steps (Mesoudi and Whiten 2008), and has thus been useful for understanding the short-term cultural change tendencies inherent within cultural transmission. Here, we develop an original approach based around word embeddings that lets us simulate transmission chains that extend out to *a thousand* transmission steps. We use a word embedding trained on a massive collection of English-language news articles to capture the space of cultural schemas (Arseniev-Koehler and Foster 2020; Boutyline and Soter 2021), and six simple seed utterances about cultural tastes—(1) food, (2) music, (3) outdoor hobbies, (4) alcohol (5) self-expression, and (6) sports—as the starting points for our transmission chains.

Our investigation reveals that these transformative tendencies reliably give rise to *cultural attractors* (Claidière and Sperber 2007; Sperber 1996)—essentially points of least resistance in the space of cultural schemas, where accumulated errors in the transmission process lead chains of public representations to congregate. In our analyses of the simulated transmission chains, we see that a small number of cultural attractors ends up explaining the majority of the re-told utterances in any given transmission chain. Moreover, we find that transmission chains that begin with *different* utterances are often affected by the *same* attractors. We term these "global attractors." Across all the starting seeds, one global attractor stands out as particularly powerful. This attractor, which we term "good food," is located near utterances about Italian cuisine and vegetable-heavy dishes. It explains an average of 37% of the position of utterances from all six seeds we examined. This suggests that taste in food may have an underappreciated centrality within personal taste: verbal accounts describing a person's taste in food may be particularly stable across multiple retellings, and accounts about other forms of cultural taste may have a long-term tendency to be transformed into accounts of taste in food.

CULTURAL TRANSMISSION

A key component of culture is the interpersonal transmission of information. As Sperber (1996:78–79) notes, each person does "not discover the world unaided, and then make public her privately developed representations of it; rather, a great many of her representations of the world are acquired vicariously." This sharing of representations is a major part of what makes it possible for people to build up shared cumulative understandings of the world.

One major avenue for sharing representations is interpersonal verbal communication. Substantial bodies of research document the role of word-of-mouth in, for example, the adoption of new innovations, purchase of new products, maintenance of organizational narratives, defining group identities, and drawing group boundaries (Dailey and Browning 2014; Mazzarol 2011; Trester 2013; Wortham et al. 2011). There are also many reasons that individuals who hear a fact, rumor, narrative, or other type of utterance may choose to retell it to others: for example, they may do so to signal their identity, vent their frustrations, make themselves look better, punish others for violation of social norms, reduce loneliness or social exclusion,

or simply fill the space of watercooler conversations with idle small talk (Berger 2014).

At the same time, an abundance of scholarship highlights that information is often *in*accurately communicated between individuals (e.g., Bartlett 1920, 1932; Breithaupt et al. 2018; Mesoudi and Whiten 2008; Schegloff 1987). Indeed, any transmission is a complex process: information must cross cultural modalities—personal to public to personal—thus requiring transformations of these representations (Boutyline and Soter 2021). As Buskell (2017:2) notes, "Individuals cannot actually copy things like beliefs or skills, because learners do not have access to beliefs or skills; all that learners have access to are the ways that beliefs or skills are manifest in behavior." To convey an idea to another individual we must transform our personal representation (e.g., beliefs, schemas) into a public representation (e.g., speech, gestures, artifacts). To complete the transmission chain, our listener must then decode this public representation, constructing their own personal representation of the idea.

Numerous aspects of this process can give rise to transmission inaccuracies. For example, language is ambiguous and speakers often overestimate the clarity of their communication (Keysar and Henly 2002). Thus, messages may be incorrectly interpreted. Further, human memory is reconstructive (Schacter 1989) and thus error prone (Dodson and Schacter 2001; Martin 2010). Moreover, because many of the reasons people retell stories have little to do with sharing factual knowledge, the speakers are often insufficiently motivated to put in the mental and communicative effort required for sustained accuracy (Dailey and Browning 2014).

Indeed, empirical studies of social transmission chains illustrate that information often degrades as it is successively retold. For example, one recent study examines the information accuracy of a story across multiple retellings (Breithaupt et al. 2018). The study finds that by the third re-telling, the story became 77% shorter, and retained only 23.5% of the details from the original story. Additionally, 30.7% of retellings lost *all* aspects of the basic event the original storied covered. Such evidence suggests that each time information is transmitted it may be dramatically lost or distorted.

Given that interpersonal transmission is so error-prone, we might expect to see few public representations shared on the macro-social scale. However, social science offers a wealth of examples of representations that are at least partially shared across large social groups. For example, stereotypes about gender, race, and class, are widely held and notoriously durable across time (Ridgeway 2009), as are the grammars and vocabularies of different languages. Thus, rather than accumulation of errors across transmissions, some representations come to be relatively stable and ubiquitous. Cultural attraction theory (CAT) seeks to resolve this paradox: to explain how we can observe stability of representations at the macro level, despite imperfect transmission at the micro level.

Cultural Attractors

Cultural attraction theory suggests that widely shared representations can emerge despite error-prone transmission because there are *regularities* in these errors

(Claidière and Sperber 2007; Scott-Phillips et al. 2018; Sperber 1997). Cultural attraction theory holds that cultural representations are not merely *replicated* from the person communicating the representations (the "speaker") to the person receiving the representation (the "listener"); rather, cultural representations must be *reconstructed* anew by the listener (Claidière and Sperber 2007). This reconstruction process relies greatly on the listener's preexisting base of cognitive resources, thus resulting in substantial biases in the representations received by the listener. These transmission biases nudge the transmission chains closer to representations that conform particularly well to the existing cognitive resources. In other words, if the transmission chains are too riddled with error to retain the representations that started the transmission chain, CAT reasons that large-scale cultural similarities instead arise because people make systematically patterned errors.

Cultural attraction theory thus expects that substantial portions of what we observe as widely shared or stable culture should consist of representations positioned near the latent areas of the space of possible representations (or *representation space* for short) where these systematic biases point the transmission chains. Cultural attraction theory terms these latent areas *cultural attractors*.[4] The causal factors that give rise to attractors are termed *factors of attraction* (Scott-Phillips et al. 2018). For example, one vein of CAT scholarship explains frequent similarities in the beliefs of unrelated religions by the ready memorability of "minimally counterintuitive" explanations that combine (i) broad consistency with our expectations about human-like agents—e.g., gods may have desires and emotions, and may can be pleased or displeased by our actions—with (ii) a small number of highly visible violations of those expectations—e.g., gods can be omniscient, omnipotent, or omnipresent (Acerbi and Mesoudi 2015; Boyer and Ramble 2001). Laboratory studies within this line of scholarship demonstrate that minimally counterintuitive ideas are highly likely to be remembered across retellings. This may also explain the persistence of folktales like Cinderella, which similarly combine consistency with expectations with a small number of prominent violations (Norenzayan et al. 2006). While CAT scholarship often focuses on factors of attraction that originate in universal cognitive mechanisms, factors of attraction may also come from the social world or the structure of physical reality, or—as in the case of our present study—they may emerge from the structure of the representation space itself.

Cultural attraction theory remains virtually unknown in sociology outside the work of Koch, Silvestro, and Foster (2020), who use it as a framework to explain the emergence and dynamics of music genres across time (see also Foster 2018). Cultural attraction theory could also provide cognitive sociologists with a useful theoretical framework for understanding the persistence, diffusion, and prevalence of widespread cultural representations, such as race, gender, and class stereotypes, political ideologies, moral justifications, or organizational forms. Thus, like Foster, we "urge more sociologists to become CAT-fanciers" (2018:146).

Cultural attraction theory suggests a research program with two core empirical steps: first, identifying attractors; and second, identifying the factors of attraction—

[4] Attractors are latent in peoples' mental representations, and are therefore elements of personal rather than public culture. Thus, we can speak of utterances (or other public representations) being *near* an attractor, but they are not the attractor *itself*.

i.e., the concrete mechanisms that cause these attractors to arise. In this way, the ultimate goal of CAT is to develop causal explanations of cultural phenomena (Heintz et al. 2019). Here, we apply CAT to the domain of cultural tastes, and document the presence and character of relevant cultural attractors.

The "Telephone Game"

Cultural attraction theory primarily deals with the macro-scale effects of long chains of cultural transmission. Despite an abundance of *formal* analyses of cultural attraction within these long-term transmission (e.g., Boyd and Henrich 2002; Truskanov and Prat 2018), efforts to empirically examine attraction within these long chains has been limited (Lerique and Roth 2018; Miton et al. 2015). However, there is plenty of related empirical work that studies biases within short transmission chains with four or fewer steps (e.g., Bangerter 2000; Hunzaker 2016; Kashima 2000; Mesoudi and Whiten 2004; Mesoudi et al. 2006). Much of this research employs a "telephone game" – a serial reproduction paradigm where each participant hears a story and retells it to the second participant from memory, who then retells it to the third, etc. The focus of this work is to understand the distortion of stories or facts from their original sources. This empirical work has identified a variety of content biases in cultural transmission, including a bias for recalling counter-intuitive information (Nyhof and Barrett 2001), a bias for assimilating specific details into more general scripts (Mesoudi and Whiten 2004), a bias for social information (Mesoudi et al. 2006), and a bias toward schema consistent information, such as stereotypes (e.g., Bangerter 2000; Bartlett 1932; Kashima 2000).

Although prior work using the telephone game has yielded a variety of insights into cultural transmission, its usefulness as a tool for understanding cultural attractors is limited by the small scale of the transmission processes it studies. As we noted above, for logistical reasons, these studies usually explore short transmission chains with four or fewer steps (Mesoudi and Whiten 2008). This approach has thus been useful for understanding the *short-term* change inherent within cultural transmission, and for identifying structurally simple factors of attraction that act in consistent ways at all steps in the transmission chain, such as persistent transmission biases, e.g., a bias that always shortens the information being transmitted. However, this approach cannot be used to study cultural attraction that arise not from biases in transmission but from the structure of the representational space *itself*—e.g., representations onto which transmission chains converge over the long term because these representations occupy a central position within the interlocking network of all cultural representations.

In this paper, we develop a novel computational method to identify cultural attractors of this type inductively in an empirically measured representational space. As we have argued elsewhere (Arseniev-Koehler and Foster 2020; Boutyline and Soter 2021), word embeddings trained on massive text corpora are cognitively realistic models of the sum total of cultural schemas that a naïve learner would acquire from the corpus in question. People rely on such cultural schemas to "fill in the blanks" in partially heard or partially remembered utterances. Cultural schemas are

thus one key source of persistent biases in the cultural transmission process (Bartlett 1932; Hunzaker 2016). We use a word embedding trained on a massive dataset of news articles collected by Google News (Mikolov, Chen et al. 2013) to construct a minimal but cognitively realistic model of this factor of attraction. We use this embedding to simulate long chains of imperfectly heard cultural transmissions. These chains begin with starting utterances about one of six sets of cultural objects. To orient our analyses, we will begin with these two broad research questions:

> *RQ1*. Is there evidence of cultural attractors? Specifically, can a substantial portion of the content of the utterances many steps into the transmission chain be explained by postulating the existence of a small number of attractors to which these utterances are pulled?
>
> *RQ2*. Are the attractors specific to the utterance that starts the transmission chain ("local attractors"), or are there relatively "global" attractors that eventually come to affect chains about cultural tastes independent of the specific starting utterances?

Cultural Tastes

Our empirical analyses identify attractors within the space of cultural tastes. We chose to focus our empirical attention on cultural tastes because tastes are (1) sociologically important and (2) intimately tied to cultural transmission. Tastes for food, music, pastimes, clothing, and manners—among many other domains—shape how people construe themselves and judge others. Similarity in taste creates positive social interactions, and thus affects the formation of friendships and the choice of romantic partners (Lewis et al. 2012; Lizardo 2006). Esoteric or otherwise difficult-to-acquire tastes are used to signal education, economic status, or membership in desirable groups. Distaste, on the other hand, can be used to draw a boundary between oneself and members of an outgroup (Bryson 1996), and creates a socially legitimate mechanism for excluding others. Tastes also affect what careers people pursue (Desmond 2008), while similarity in tastes can greatly affect which job candidates they choose to hire as colleagues (Rivera 2012). Since tastes reflect individuals' social origin, these processes often reinforce and replicate existing social hierarchies. They can also be used to create new social cleavages (Curl et al. 2018) such as the boundary between fashion-forward youngsters and their increasingly fashion-backward parents (Lizardo and Skiles 2015).

Tastes are also fundamentally tied to social transmission. To use tastes as a signal of their social background, individuals need to first become enculturated into them. To use them as a means of excluding members of a particular outgroup also requires some knowledge of that outgroup's tastes (Berger and Heath 2008; Bryson 1996). Since displaying the tastes of a high-status group can lead to material advantages, members of lower-status groups have a reason to learn and imitate the tastes of a high-status group. Conversely, to maintain the effectiveness of their tastes as markers of status, members of high-status groups must stay abreast of recent high-status cultural innovations (Lieberson 2000). Indeed, following the most recent fashions is itself a marker of membership in some high-status groups, not least because it requires one to dedicate significant time and energy to social transmission.

Continuous change in fashion combines with social pressures toward imitation and distinction to make tastes a particularly turbulent cultural domain. Cultural attractors in the realm of taste are thus particularly interesting because they may provide unseen points of stability within this turbulence. As utterances about tastes are imperfectly communicated and partly misunderstood, where does the accumulating error make these utterances drift? What are the areas of semantic space that utterances eventually circle around as a result? We explore these questions below.

Existing scholarship in the sociology of culture offers no immediate predictions about what cultural attractors we may find. However, this work has examined other persistent ways that cultural tastes are structured. The key structural unit here is the "habitus" (Bourdieu 1987; Elias 2000; Wacquant 2016)—a set of broadly applicable, deeply internalized implicit cultural models of a particular aesthetic, style, and way of being that individuals apply across many different areas of social life. Bourdieu (1987), for example, uses habitus to explain the rough coherence between French respondents' tastes in music, sports, food, furniture, and politics. To orient our research, we will thus ask whether the cultural attractors we find for utterances about cultural tastes share the characteristics often ascribed to habitus.

Habitus is gradually acquired by occupants of a social status or role, and thus "tends to produce practices patterned after the social structures that generated them" (Wacquant 2016:67). This process makes occupants of a social position acquire tastes for many cultural products and practices characteristic of that position, and thus increases the chances that they will seek to reproduce the same lifestyle and make ties to others of the same habitus. Like cultural attractors, habitus is thus a source of social inertia. Various scholarship has investigated the habitus associated with different social divisions such as social class (Wacquant 2016), gender (Desmond 2008), race and ethnicity (Watkins and Noble 2013), or sexuality (Sender 2001). We thus ask:

> *RQ3*. Do the attractors we find show separation along major social divisions such as social class, gender, or race and ethnicity?

METHODOLOGY

Our overall approach consists of two steps: we (1) simulate a series of transmission chains, and afterwards (2) analyze these transmission chains to answer our research questions. To describe our simulations, we begin with our conceptual model for these transmission chains.

Conceptual Model of Transmission Chains

To help ground our model, imagine the following concrete scenario, where a description of the menu at a new neighborhood restaurant is retold from neighbor to neighbor. Actor A meets the proprietor of the restaurant, who tells her what dishes the restaurant will be serving—thus producing a "seed utterance." Actor A recounts her recollection of these dishes to her neighbor (Actor B). Given limitations of mem-

ory and the imperfect ways that people understand one another, Actor A forgets specific items in the menu and uses her preexisting cultural schemas to fill in the gaps in her memory, thus inadvertently modifying the utterance (e.g., if the restaurant is a French bistro, she might insert a mention of wine even if the proprietor's description did not mention alcoholic drinks offered.) Since this menu is an easy topic for neighborhood small-talk, Actor B soon passes on his own imperfect recollection of A's account to another neighbor (Actor C), also using preexisting schemas to fill in his gaps in memory. Actor C soon conveys his own imperfect recollection of B's account to Actor D—and so the "transmission chain" continues, with the description of the menu iteratively modified in each transmission step.

Simulating an Actor Using a Word Embedding

We use a word embedding to simulate the actors within the transmission chains. Word embeddings model the meaning of words by representing them as vectors, so that words that appear in semantically similar contexts are close to one another in the embedding space (for sociological adaptation, see Kozlowski et al. 2019; Stoltz and Taylor 2020). A common approach to estimating word vectors is the Word2Vec algorithm (Mikolov, Chen et al. 2013; Mikolov, Sutskever et al. 2013), which uses an artificial neural network to learn word vectors by repeatedly (1) taking a passage from the corpus, (2) omitting a word from that passage, (3) attempting to guess the missing word based on the vectors of the context words, (4) assessing the correctness of its guess, and (5) adjusting the word vectors to make future guesses more accurate. As we have argued elsewhere, Word2Vec effectively constructs a cognitively plausible model of cultural schemas inherent in a corpus (Arseniev-Koehler and Foster 2020; Boutyline and Soter 2021).

Here, we use a 300-dimensional Word2Vec embedding trained on a massive collection of English-language news articles from Google News (Mikolov, Chen et al. 2013). Google has made this pre-trained word embedding publicly available, but it has not publicly shared the proprietary corpus used to estimate it. It has also not released any precise description of the specific news sources contained in this corpus. While this opacity is a limitation, we believe that it is outweighed by the high quality and extensive validation of this embedding.[5] The Google News corpus used to train this embedding consists of over 100 billion words of text (Mikolov, Chen et al. 2013). Since Word2Vec is an extremely "data-hungry" method, the unusually large scale of these news data means that the word embedding it estimated is also unusually reliable and accurate. Because of this, the Google News word embedding has become a widely used and well-validated model of the semantic space of contemporary American English across many academic disciplines (e.g., Arseniev-Koehler and Foster 2020; Bolukbasi et al. 2016; Caliskan et al. 2017; Kozlowski et al. 2019; Mikolov, Chen et al. 2013). For example, the associations of words with class, race, and gender in the Google News word embedding correlates strongly with ratings from survey respondents (Kozlowski et al. 2019).

[5] We consider the limitations of this embedding further in the Discussion.

Seed Utterances for Simulated Transmissions

To increase our control over the simulations, our seed utterances are keyword lists rather than complete sentences. The keywords in each utterance reference a different cultural domain. To select them, we searched for cultural domains that have been previously studied by sociologists and that contain cultural items corresponding to a diverse range of social groups. Crucially, these items also must be unambiguously identifiable with simple keywords. Thus, for example, we could not examine tastes in major film and novel genres because the main keywords here have many alternate meanings (e.g., action, horror, romance). We identified six domains—food, music, outdoor hobbies, self-expression, alcohol, and sports—that yielded clear lists of terms with sufficiently broad domain coverage. The resulting seed utterances are listed in Table I.

Simulating Each Transmission Chain

At the center of our simulation is a parsimonious model of a single step in the transmission chain. Each step represents one actor. First, the actor imperfectly hears the *previous utterance* (i.e., the utterance produced by the previous actor, or the seed utterance if this is the first transmission step). We model this imperfect reception by randomly omitting a single word in the previous utterance. We will use the term *incomplete utterance* to refer to the words that the actor actually heard (i.e., the previous utterance without the omitted word).

Second, the actor tries to understand the *gist* of the incomplete utterance. To simulate this step, we create a single vector representing the gist of the incomplete utterance using a method called Smooth-Inverse Frequency (SIF) embeddings (Arora et al. 2017). Smooth-Inverse Frequency embeddings estimate the specific meaning of an utterance by weighting the word-vectors in the utterance by frequency, where more frequent words (e.g., "she" or "in") are down-weighted relative to rarer ones (which are more likely to indicate specific topics—e.g., "vendor," "sculpture," or "bicycling"). Prior studies demonstrate that SIF embeddings perform well on a variety of linguistic tasks, such as sentiment analysis and evaluating

Table I. Starting utterances

Topic	Starting utterance
Food	barbecue burgers donuts pizza ramen sandwiches seafood sushi tacos tapas
Music	blues classical hip-hop jazz opera r&b rap reggae ska spirituals
Outdoor hobbies	backpacking biking birding camping fishing hiking hunting kayaking sailing surfing
Alcohol	beer champagne cider gin lager liquor mezcal tequila vodka whisky
Self-expression	beading calligraphy homebrewing knitting origami painting photography sculpture sewing woodworking
Sports	baseball basketball boxing football golf lacrosse nascar soccer tennis volleyball

the similarity between sentences. Thus, SIF is a validated approach for capturing the "gist" of an utterance (Arora et al. 2017; Ethayarajh 2018; for introduction, see Arseniev-Koehler et al. 2020).

Third, the actor makes a guess about the missing word. To simulate this step, we construct a probability distribution over the 1000 most likely words in the embedding that are not already in the incomplete utterance[6]. We do this by first calculating the cosine similarity of each of the 100,000 words in the embedding with the incomplete utterance's gist. Then, to translate the resulting set of cosine similarities into probabilities, we apply smoothed softmax (i.e., multinomial logit) to the 1000 highest cosine similarities[7]. Finally, we sample from this probability distribution to make a *guess* about the missing word. After the missing word is replaced with this guess, we call the result a *completed utterance*. After the simulated actor constructs a completed utterance, she imperfectly communicates this completed utterance to the next actor, and we repeat this process again.

For example, music-seeded chains[8] begin with the utterance "blues classical hip-hop jazz opera r&b rap reggae spirituals ska." In one simulation, the first transmission step omitted the word "reggae". Thus, the first actor heard the incomplete utterance: "blues classical hip-hop jazz opera r&b rap _____ spirituals ska." The actor then completed the utterance with the guess "hymn" (other possible guesses included "marching_band", "disco", and "mellow"). She then passed this completed utterance to the second actor, who in turn replaced "rap" with "hillbilly", producing the completed utterance "blues classical hip-hop jazz opera r&b hillbilly hymn spirituals ska."

We simulate a total of 1000 transmission steps from this seed utterance, thus constructing a chain consisting of a sequence of 1000 utterances. We then restart from the same seed utterance to simulate another transmission chain, repeating the process 250 times for this seed (for a total of 250 chains of 1000 steps each). We then do the same for each of the other five seed utterances. Thus, our entire simulation consists of 6 * 250 * 1000 = 1.5 million completed utterances.

Analyzing the Simulated Chains

After the simulations have completed, we analyzed them to answer our research questions. To locate the K attractors affecting these simulated transmission chains, we note that, in the presence of attractors, each i^{th} transmission step has some probability of "pulling" the transmission chain toward some attractor m_a. A subsequent step j could then pull the chain toward m_a or some other attractor m_b. Thus, we assume that the position $\boldsymbol{y} \in \mathbb{R}^n$ of an utterance inside the embedding can be partly

[6] We limit the embedding's total vocabulary to 100,000 most frequent terms. Additionally, to clean out the terms that came from article metadata, we remove terms which include any uppercase letters, a period, or a number, or which we have no lowercase letters.

[7] Softmax calculates the probability of each guess i as $\sigma(\boldsymbol{z})_i = (e^{\beta z_i})/(\sum_j^K e^{\beta z_j})$, where vector $\boldsymbol{z} \in \mathbb{R}^K$ contains the guesses' cosine similarities to the incomplete utterance. The $\beta > 0$ parameter controls how likely the actor is to pick the more probable guesses over the less probable ones. High values of β result in chains that rarely travel far from their starting points, whereas low values result in chains that skip haphazardly around the semantic space. We found that $\beta = 2$ produced a good balance.

[8] We use "X-seeded chains" as shorthand for transmission chains that start with seed utterance X.

expressed as a linear combination of the positions of some number of attractors $w \leq K$, such that $\boldsymbol{y} = \boldsymbol{Rx} + \boldsymbol{\varepsilon}$, where $\boldsymbol{R} \in \mathbb{R}^{n \times K}$ is a matrix containing the K attractors of length n in its columns and $\boldsymbol{x} \in R^K$ is a sparse vector containing w coefficients and $K - w$ zeroes. This is exactly the model estimated by the sparse dictionary learning algorithm k-SVD (Ahron et al. 2006; for application to word vectors, see Arseniev-Koehler et al. 2020).

Here, we use $w = 3$ and $K \leq 25$, though other values of w and K yield broadly similar results. To focus on the longer-run behavior of the transmission chains, we apply k-SVD to only the completed utterances produced during the final 250 transmission steps of each chain (beginning with step 751.) We fit the k-SVD model separately to the set of 250 transmission chains from each seed, so that each k-SVD model is fit to 250*250 = 62,500 utterances. Because k-SVD results are non-unique[9], we fit each k-SVD model 50 times, and select the attractors that were most reliably detected across the fits of one model.

For our purposes, two attractors are similar to the extent that they are surrounded by the same terms in the embedding space. Thus, to estimate the similarity p_{tr} of attractor m_t (the "target" attractor) to attractor m_r (the "reference" attractor), we calculate the proportion of nearest terms they share in common. Specifically, we take the $k_t = 15$ terms nearest to the target attractor, and calculate p_{tr} as the proportion of these terms that can be found within the $k_r = 30$ terms closest to the reference attractor. We consider two attractors to be "the same" if their similarity $p_{tr} > 0.5$.[10] We then calculate the *reliability* of each attractor m as the proportion of the 50 k-SVD models fits that contained at least one instance of this attractor. To arrive at our final attractor results, we merged all the instances of each attractor across all the k-SVD models where it appears.[11]

To answer RQ1—whether there are attractors present in the data—we examine how well our k-SVD models can describe the space of these transmission chains. Following Arseniev-Koehler et al. (2020), we compute the pseudo-R^2 for k-SVD (hereafter, simply R^2) by taking the estimated coefficients for each fitted model $\boldsymbol{y_i} = \boldsymbol{Rx_i} + \boldsymbol{\varepsilon_i}$ across all the utterances $i \in (1, \cdots, 62500)$ and partitioning the variance of each utterance vector $\boldsymbol{y_i}$ into explained variance ($\boldsymbol{Rx_i}$) and residual variance ($\boldsymbol{\varepsilon_i}$). R^2 is then the ratio of explained variance to total variance.

[9] K-SVD results are also invertible: if $(\boldsymbol{t}, \boldsymbol{\gamma})$ are an attractor vector and its corresponding utterance loadings, then $(-\boldsymbol{t}, -\boldsymbol{\gamma})$ would yield identical k-SVD fit. We used the pair with fewer negative loadings.

[10] We use $k_r > k_t$ to make the similarity measure less affected by minor differences in term order. Other values of k_r, k_t and the p_{tr} similarity cutoff yield broadly similar results. Tuning these parameters creates tradeoffs between (a) reliability and (b) sensitivity to differences between attractors. On one extreme, the method detects clearly distinct, highly reliable attractors, but may miss some weaker attractors. On the other, it will be less likely to miss these attractors, but some results will be less reliable and may contain substantive repeats. In pre-testing, we found that the values we use here yielded the best balance.

[11] Specifically, our algorithm calculated all pairwise attractor similarities p_{tr}, and merged each set M of attractors with similarity >0.5 into one attractor m. Our result tables report the most frequent nearest terms across each M (omitting keywords that differ only in tense, case, etc.). If two or more attractors in M come from one k-SVD model, we sum their strengths (defined below). We then average these strengths across k-SVD models to calculate the strength of m. This process correctly merged most conceptually identical attractors. In a few cases, pairs of reliable attractors with $p_{tr} < 0.5$ nonetheless had keywords that corresponded to conceptually identical topics. We then dropped the less reliable attractor in the pair.

To help characterize the *strength* of each attractor, we decompose the overall R^2 into the partial R^2 of each attractor, R_t^2. To do this, we also estimate the R^2 of K partial models, each of which omits one of the attractors by setting its corresponding coefficients to zero, and is otherwise a copy of the full model. R_t^2 is then the difference between the R^2 of the full model and R^2 of the partial model that omits attractor t.[12]

Our RQ2 asks whether any of the attractors we detected are "global" within the space of cultural tastes—i.e., whether they affect chains from all six cultural taste seeds we examine. To answer this question, we calculate a "*globality*" statistic for each attractor we identified with our k-SVD-based procedure. This is the proportion of all k-SVD model re-estimates for chains that began with a *different* seed utterance that detected the same attractor. So, for example, if we detect an attractor only in chains that began with one seed, its globality is 0. If we detect it in chains beginning with 50% of the other seeds with 100% reliability, its globality is 0.5. If we detect it in chains beginning with 50% of the other seeds but with only 10% reliability, its globality is 0.05.

Our RQ3 asks about the social character of the attractors. We will answer it by qualitatively examining our results.

RESULTS

We used the above approach to simulate 250 transmission chains for each of our six seed utterances. We describe results from three seeds in depth here (food, music, and outdoor hobbies, see Tables II-IV) and provide results for the others in Appendix Tables AI-AIII.

Evidence of Cultural Attractors

Our first research question asked: Is there evidence of cultural attractors? Specifically, can a substantial portion of the content of the utterances many steps into the transmission chain be explained by postulating the existence of a small number of attractors to which these utterances are pulled? To answer this question, we began with our six sets of 250 transmission chains (each set beginning with one seed utterance). For each set, we estimated 50 k-SVD models following the procedure we outlined above. Tables II–IV and AI–AIII report the attractors that this procedure identified for each seed with reliability > 0.5.

The proportion of variance explained by our k-SVD models offers a quantitative answer to RQ1. Across the 50 re-estimates, the models explained an average of 80.6% (sd = 1.3%), 76.9% (sd = 1%), and 79.6% (sd = 0.9%) of the variance in the positions of each utterance for transmission chains starting with seed utterances about food, music, and outdoor hobbies, respectively. An inspection of the "Strength" (average partial R^2) column in Tables II–IV and AI–AIII, which reports the proportion of variance in the position of the utterances explained by each attractor, further suggests that the bulk of this explained variance comes from just a hand-

[12] Note that, because attractors are not orthogonal, $\sum_t R_t^2$ does not exactly equal R^2 and may be greater than 1.

Table II. Attractors affecting *food*-seeded transmission chains

Mnemonic	10 Characteristic words & phrases	Reliability	Strength	Globality
Good food	polenta pesto salad ravioli fennel meatballs sour_cream fresh_herbs coleslaw basil	0.98	0.57	0.76
Disease	atherosclerosis inflammatory_bowel_disease insulin_resistance cardiovascular_disease fibrosis disease_progression tumors oxidative_stress metabolic statins	0.94	0.05	0.71
Aesthetic judgement	droll endearing pretentious dreamy charming melancholic clichéd self_consciously sardonic beguiling	0.90	0.06	0.80
Decorative	satin beaded sequins dresses sparkly velvet lacy leopard_print lace turquoise	0.90	0.01	0.50
Fast food	sandwiches burgers hamburgers cheeseburger buffet nachos steak_dinner pizza BBQ prime_rib	0.78	0.04	0.53
Contemptible	contemptible moronic idiotic spineless ignorant hypocritical craven gutless shameless dishonest	0.78	0.01	0.60
Soft drinks	drinks soda soft_drink beverages candy_bars cola beer beverage snacks candy	0.76	0.01	0.32
Plants	vines blooms plantings orchids seedling shrub flowering_plants ferns trees foliage	0.74	0.02	0.39
Animals	otters mammal birds critters species turtles fish carnivores alligators coyote	0.72	0.01	0.32
Biochemistry	molecules nanotubes substrate proteins membrane nanoscale quantum_dots atoms nanoparticles filaments	0.64	0.02	0.18
Alcoholic drinks	Beer vodka wine liqueur brandy drinks soda soft_drink whiskey beverages	0.60	0.01	0.29
Kitchen equipment	skillet mixing_bowl saucepan baking_sheet tub baking_soda plastic_wrap spoon spatula tablespoon	0.56	0.01	0.22
Gourmet Food	cuisine bistro dining restaurant chef gourmet wines eatery buffet tapas	0.56	0.01	0.19

ful of attractors. Thus, the patterns of transformation that utterances undergo during the transmission chain can be readily explained by postulating the presence of a small number of attractors affecting the transmission process.

To illustrate how attractors affect these simulated transmission chains, we plot three of the chains in Fig. 1. We created this figure using t-SNE, which constructs a mapping from the 300-dimensional embedding space to the 2-dimensional space of a figure so that, to the extent possible, objects that were distant in the embedding space remain distant in 2-dimensional space, and vice versa (Hinton and Salakhutdinov 2006). The meandering paths in the figure connect the location of the gist of the utterance at each step in the transmission chain. The four X's indicate the locations of four attractors from our main set of results.

The chain depicted in orange begins with the seed utterance about food (orange circle; see Table I). Its trajectory is then partly random. However, as the figure indicates, the chain does not move uniformly around the embedding space. Rather, its path forms two clusters. At first, it meanders in a cluster near the center of the figure. It then moves sharply upwards, and proceeds to meander in a second cluster nearer the top. Examining the utterances in the first cluster shows that they concern high

Table III. Attractors affecting *music*-seeded transmission chains

Mnemonic	10 Characteristic words & phrases	Reliability	Strength	Globality
Aesthetic judgement	droll pretentious clichéd endearing sardonic melodramatic charming hilariously witty goofy	1.00	0.42	0.75
Good food	broccoli soup sweet_potatoes onions asparagus polenta pesto green_beans salad berries	0.92	0.14	0.76
Melodies	melodies instrumentals harmonies compositions original_compositions saxophonist percussive orchestral vocalists jazzy	0.90	0.05	0.43
Affable	affable genial gregarious taciturn soft_spoken amiable mild_mannered talkative personable jovial	0.90	0.03	0.26
Disease	inflammatory_bowel_disease atherosclerosis cancers cardiovascular_disease gum_disease endometriosis sepsis thrombosis inflammation statins hypoglycemia	0.82	0.01	0.67
Assault	assaulted stabbed fatally_shot gunned_down pistol_whipped arrested apprehended chased attacked fatally_wounded	0.78	0.00	0.14
Mesmerizing	evocative beguiling captivating mesmerizing dreamy ethereal melancholic exquisite spellbinding poetic	0.74	0.06	0.10
Decorative	satin lacy fuchsia shimmering sparkly elegant turquoise luscious dainty beaded	0.72	0.04	0.49
Ideology	liberalism ideology materialism humanism cynicism fundamentalism ideologies irrationality fanaticism narcissism	0.72	0.01	0.03
Contemptible	hypocritical arrogant contemptible idiotic dishonest moronic disgraceful despicable ignorant irresponsible	0.66	0.05	0.55
Exclamations	giggling shrieked bellowing squealing screamed smirking muttering hollered bawling growling	0.64	0.01	0.09
Laughable	laughable ludicrous banal nonsensical clichéd moronic idiotic inane hackneyed pretentious	0.54	0.03	0.03
Informal / rude	dude fucking shit dork friggin cuz asshole lol weirdo wanna hey	0.52	0.01	0.01

status food. For example, at step 400, the utterance is: "lobster, quiche, salty, cumin, terra_cotta, cucumber, coconut_milk, floral, couscous, foods." Around step 600, the utterance shifts subtly to include nutritional terms like "calories" and "additives." Nutrition and health then quickly displace food to become the main topic of the chain, which at step 700 consists of "warfarin, blood_clots, bone_marrow_transplant, hydrogen_sulfide, antibiotic_resistance, pancreatitis, saturated_fat, chronic_lung, micrograms, kidney_stones." The two other chains in the figure, which begin with the music seed, also exhibit trajectories that shift between a small number of clusters. Moreover, different chains cluster around the same areas of the embedding, suggesting that these areas act as attractors that exercise a persistent pull on the transmission chains. Indeed, these clusters match the attractors identified by our method (marked with X's on the figure.)

Global attractors

Our second RQ asks whether there are any attractors that affect chains from all six seed utterances. To answer this question, we first estimated the "globality" of

Table IV. Attractors affecting *outdoor hobbies-seeded* transmission chains

Mnemonic	10 Characteristic words & phrases	Reliability	Strength	Globality
Good food	salad pesto ravioli polenta meatballs sour_cream fennel asparagus coleslaw veggies	1.00	0.54	0.67
Disease	cardiovascular_disease ischemic_stroke disease_progression atherosclerosis fibrosis tumors inflammatory_bowel_disease insulin_resistance coronary_artery_disease thrombosis	0.92	0.09	0.72
Aesthetic judgement	droll melancholic endearing beguiling pretentious sardonic poetic self_consciously melodramatic lyrical	0.90	0.05	0.80
Baseball	bases_loaded inning RBI_single leadoff_batter sacrifice_fly 3_pointers free_throws infield_single yard_touchdown bloop_single	0.82	0.01	0.32
Biochemistry	granules polymer membrane nanotubes water_soluble substrate nanoparticles molecules particles carbon_nanotubes	0.78	0.02	0.16
Alcoholic drinks	wine sparkling_wine beers whiskey ale chardonnay pinot_noir cognac brews liqueur	0.72	0.01	0.28
Decorative	satin lacy velvet turquoise sparkly shimmering silvery pastel beaded fuchsia	0.68	0.02	0.60
Fast food	sandwiches burgers hamburgers buffet cheeseburger pizza meal steak_dinner nachos meatloaf	0.62	0.04	0.55
Fish	fish sturgeon striped_bass otters crabs shrimp mussels trout crayfish bluefin_tuna	0.58	0.01	0.22
Exclamations	glared shrieked stared glanced ambled screamed crouched yelled hollered waved	0.54	0.00	0.26
Contemptible	moronic pompous humorless crass idiotic spineless contemptible sanctimonious ignorant cynical	0.52	0.02	0.42
Plants	grasses flowering_plants blooms vines trees wildflowers seedlings shrubs foliage plantings	0.52	0.02	0.43

each attractor. We also qualitatively compared the attractors we reported in Tables II–IV and AI–AIII, asking whether results from different seeds contained conceptually similar attractors. Table V summarizes these comparisons.

Some attractors we found appear largely local (i.e., only affecting chains that begin with one seed). For example, for food-seeded chains, the attractor we call "Kitchen equipment" is located in the embedding space near terms like skillet, mixing_bowl, and saucepan. For music-seeded chains, the "Mesmerizing" attractor is found near the terms evocative, beguiling, captivating, mesmerizing, dreamy and ethereal. These attractors have a globality score of 0.22 and 0.10, respectively, indicating that their effects on chains starting from other seeds are relatively modest. Our qualitative comparison in Table V also did not reveal any other instances of these attractors.

Conversely, our method identified two attractors that affected chains from all six seeds. We call the most prominent of these attractors "Good food." The version with the highest globality (0.76) and strength (0.57) was identified in food-seeded chains (Table II). The nearest terms to this attractor are: "polenta pesto salad ravioli fennel meatballs sour_cream fresh_herbs coleslaw basil quiche broccoli veggies asparagus flavorful." These terms largely fit into two categories: they appear to

Table V. Presence of attractors by seed utterance (✓), with count of seed utterances where it was present (Ct.) and average attractor strength across these seeds (R^2)

	Seed Utterance						Ct.	R^2
Attractor	food	music	outdoor hobbies	alcohol	self- expression	sports		
Good food	✓	✓	✓	✓	✓	✓	6	0.37
Disease	✓	✓	✓	✓	✓	✓	6	0.04
Aesthetic judgement	✓	✓	✓	✓	✓		5	0.15
Contemptible	✓	✓	✓		✓	✓	5	0.03
Decorative	✓	✓	✓	✓	✓		5	0.02
Fast food	✓		✓	✓	✓		4	0.03
Plants	✓		✓	✓	✓		4	0.03
Melodies		✓		✓	✓	✓	4	0.05
Biochemistry	✓		✓	✓			3	0.02
Alcoholic drinks	✓		✓	✓			3	0.01
Baseball			✓		✓	✓	3	0.12
Animals	✓			✓	✓		3	0.01
Affable		✓			✓		2	0.02
Exclamations		✓	✓				2	0.01
Soft drinks	✓				✓		2	0.01
Fish			✓	✓			2	0.01
Kitchen equipment	✓			✓			2	0.01
Assault		✓				✓	2	0.00
Gourmet Food	✓						1	0.01
Mesmerizing		✓					1	0.06
Laughable		✓					1	0.03
Informal / rude		✓					1	0.01
Ideology		✓					1	0.01
Beverage container				✓			1	0.01
Cooking					✓		1	0.05
American football						✓	1	0.06
Action						✓	1	0.05
Swimm. / running						✓	1	0.01
Basketball						✓	1	0.01
Injury						✓	1	0.01
Winners						✓	1	0.01
Cricket						✓	1	0.01
Golf						✓	1	0.01

describe either Italian dishes ("polenta", "pesto", "ravioli", "meatballs"); or vegetables or herbs ("salad", "veggies", "fennel", "broccoli", "fresh herbs", "basil"). We termed this attractor "Good food" because it unites Italian cooking and fresh vegetable dishes—two foods that have both high-status legitimacy and broad appeal. Results from the other five seeds also yielded reliable evidence of a "Good food" attractor located near the terms pesto, polenta, and salad. The fact that we reliably located this attractor in all sets of transmission chains—including those whose seeds have nothing to do with food—points to this attractor's global reach within the space of cultural tastes.

The second global attractor we located is further afield from cultural tastes. It describes chronic, serious medical conditions. In outdoor hobbies-seeded transmissions, this "Disease" attractor has globality = 0.72 and strength = 0.09, and is found near the terms "cardiovascular_disease ischemic_stroke disease_progression

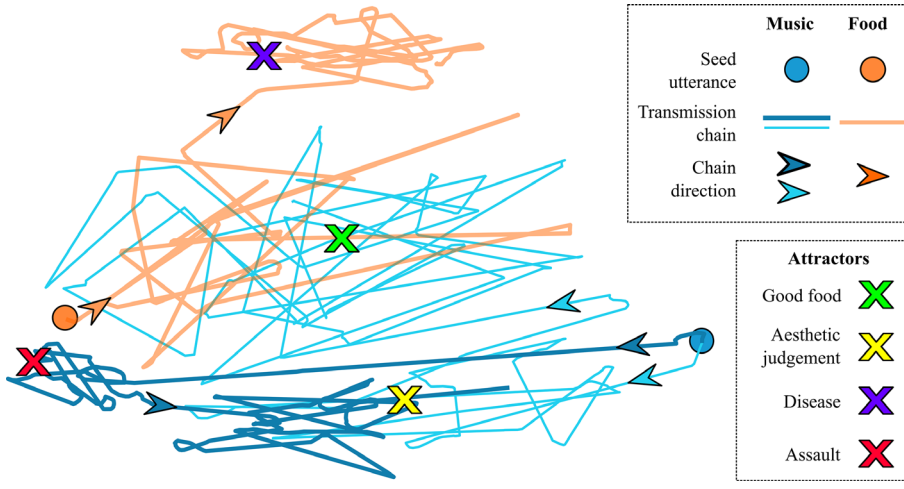

Fig. 1. Effects of four attractors on three transmission chains from our simulation. Two chains (dark blue and light blue) begin with the music seed (bottom right) and one chain (orange) begins with the food seed (bottom left). Arrows indicate chain direction. Mapping of embedding space to two-dimensional image created using t-SNE.

atherosclerosis fibrosis tumors inflammatory_bowel_disease insulin_resistance coronary_artery_disease thrombosis malignancies hypertension inflammation metabolic sepsis." As Table V indicates, we also located similar attractors for the other five seeds. But, although the "Disease" attractor is global, its effects on our simulated transmissions do not appear *strong*: across the six sets of chains, its average strength is only 0.04, indicating that it accounts for only a small portion of utterance positions. In contrast, the "Good food" attractor has an average strength of 0.37. Thus, within the context of cultural tastes, its effects appear relatively weak compared to those of "Good food."

Our k-SVD analyses thus found evidence of at least two attractors that affected all six sets of transmission chains, and one of these attractors—"Good food"—was both global and persistently strong. We therefore give an affirmative answer to RQ2.

Social Groups

Our RQ3 asks whether any of the attractors show differentiation by social class or other major social categories. The clearest evidence of such differentiation would come from our results containing "minimal pairs" of attractors that refer to the same type of cultural object (e.g., music) but differ in these objects' associations with social class, race, etc. (e.g., opera vs. country music). There appears to be one set of three attractors that meet this criterion. The first of these is the "Good food" attractor we discussed above. The second is a "Gourmet food" attractor we detected in food-seeded chains, which lies near "cuisine bistro dining restaurant chef gourmet wines eatery buffet tapas foodie appetizers sommelier desserts restaurateur." The third is a "Fast food" attractor we identified in food-, outdoor

hobbies-, alcohol-, and self-expression-seeded chains. In outdoor hobbies-seeded chains, its nearest terms are "sandwiches burgers hamburgers cheeseburger buffet nachos steak_dinner pizza BBQ prime_rib." In contrast to the "Good food" attractor, herbs and vegetables are notably absent from this list. Instead, the bulk of these terms appear to refer to high-calorie meat- and bread-heavy dishes found at major US fast-food establishments.

The terms surrounding all three attractors carry strong class connotations. Many of the terms found near the "Gourmet food" attractor refer to people engaged in high-status, highly legitimized food practices ("foodie, sommelier, chef, restauranteur"). The Italian cuisine and healthy dishes that characterize the "Good food" attractor also have a high amount of high-status cultural legitimacy (Gualtieri 2021). Relatedly, higher-SES individuals in the United States are more likely to consume fruits and vegetables (Darmon and Drewnowski 2008). "Fast food" has the opposite class connotations. The terms near this attractor refer to high-calorie, meat- and bread-heavy dishes, which various studies show that lower-SES Americans are more likely to consume than higher-SES ones (Darmon and Drewnowski 2008). Similarly, lower-SES Canadians are more likely than higher-SES ones to express a liking for corporate-branded food, including fast food (Baumann et al. 2019). In their interviews with high cultural capital respondents in the United Kingdom, Warde et al. (2008) found that their largely omnivorous subjects exhibited a strong and prominent dislike of fast food. The "Fast food" attractor is thus clearly distinguished from "Good food" and "Gourmet food" along class lines.

Aside from these three class-differentiated attractors, we did not find any other minimal pairs of attractors that were differentiated along the major social divisions usually studied in sociology. We reflect on this relative absence in the concluding discussion.

Additional Findings

Our results also contained repeated evidence of another kind of attractor with clear sociological relevance: attractors concerning social judgements. For example, the strongest and most reliable attractor for music-seeded chains (reliability = 100, strength = 0.42) was located near the terms "droll pretentious clichéd endearing sardonic melodramatic charming hilariously witty goofy dreamy beguiling cheesy cloying pompous humorless." Some of these terms judge an artwork as insufficiently original ("clichéd, cheesy"), overdone ("melodramatic, cloying"), or overly serious in its contents or intents ("pretentious, pompous, humorless"). Others instead judge it to be clever ("droll, witty, sardonic") or funny ("hilariously, goofy"). As Martin and Merriman (2015) argue, these types of aesthetic assessments are fundamentally *social* judgements, as they are inseparable from our judgments of others who do (or do not) share our opinion of the artworks in question (see also Bourdieu 1987). If person A loves romantic comedies, and person B finds them "clichéd, cheesy, and cloying", then B may think that A has bad taste. Thus, Martin and Merriman note that, when it comes to judgements of taste, "[t]wo questions are always asked and

must be answered together: What is it about X that makes us feel Y? And what about those tasteless jerks who don't feel Y in the presence of X?" (2015:136).

Indeed, it is likely not an accident that most of these keywords can be applied to both artworks and people. Continuing the example, if the same person A discovers how person B feels about romantic comedies, then A may think B is "pretentious, pompous, or humorless." Person A may then furthermore suspect that B prefers to watch films that (to A) seem pretentious, pompous, and humorless. These judgements would then, ceteris paribus, make it less likely that A and B would form a positive social or romantic tie. The "aesthetic judgements" attractor thus appears to sit near the point of semantic space where cultural tastes and social structure intersect. We found reliable evidence of similar "Aesthetic judgement" attractors for all seed utterances except sports. Across these seeds, it had an average strength of 0.15, which makes it the second-strongest attractor behind "Good food."

DISCUSSION

Public representations often diffuse through interpersonal communication—a process that subjects them to continuous distortion. One key distortion occurs when the person retelling an idea is unable to accurately recall all of its details—whether due to failures of memory, due to insufficient motivation to engage in detailed recall on the spot, or because she never fully heard all the details of the idea in the first place. In such situations, the person begins with whatever parts of the utterance are available, and uses her pre-existing cultural schemas to complete it (Bartlett 1932; Hunzaker 2016). Our approach builds on recent theoretical scholarship on cultural schemas in cognitive sociology to provide novel insights onto the transformative tendencies inherent in this process (Arseniev-Koehler and Foster 2020; Boutyline and Soter 2021). This theoretical scholarship has argued that word embeddings trained on large text corpora—e.g., the complete *New York Times* archives, or the full text of English-language *Wikipedia*—are cognitively realistic models of the cultural schemas that a naïve learner would acquire from reading through the corpus. Whereas prior empirical approaches to schemas generally approach them in isolation, word embeddings instead capture the *whole* semantic space containing a *vast number* of interrelated schemas. Our present work begins to explore the new empirical horizons opened up by this conception of cultural schemas.

We use a word embedding to simulate a "telephone game," where each actor partially hears an utterance and uses their cultural schemas to complete it. Whereas laboratory studies using the telephone game have explored the short-term change that happens within transmission chains of roughly four steps, our simulation-based approach let us examine transmission chains that extend out to one thousand steps, and thus explore previously unstudied long-term tendencies inherent in this process. We used this approach to explore transmission chains beginning with six different utterances about cultural tastes. We found that these chains were often pulled toward a small number of powerful "cultural attractors"— essentially points of least resistance in semantic space where transmission chains end up through accumulated

error alone. Moreover, we found that a number of these attractors operated globally within the space of cultural tastes—that is, they attracted transmission chains that began with any of the cultural taste seeds we examined (music, outdoor hobbies, food, alcohol, self-expression, and sports).

Our results thus demonstrate the macro-cultural consequences that arise when shared cultural schemas function as automatic pattern completion engines for distorted communications. Across many transmission steps, errors in the transmission process made utterances gradually lose their resemblance to the starting utterance—a result that mimics empirical findings from prior laboratory studies (e.g., Breithaupt et al. 2018). But the vast scale of our simulated transmission chains illustrated something that could not be easily observed within the short chains examined by laboratory work. Even in the absence of a simple persistent bias (e.g., a bias that consistently shortens the information being transmitted), the transmission chains do not become uniformly distributed across the semantic space. Instead, transmission errors often make transmission chains circle around a small number of common topics. Thus, as cultural attraction theory suggests, error-prone transmission did not result in the absence of widely shared public representations. Instead, it gave rise to new widespread representations that reflected the presence of cultural attractors—points of high centrality within the semantic network of interlocking cultural schemas used by the actors.

The strongest and most global attractor we found accounted for 37% of all utterance positions across the six sets of simulated transmission chains in our study. This attractor, which we termed "Good food," is surrounded by terms for Italian- and vegetable-based dishes—two high-status, uniformly esteemed forms of cooking. This was the single strongest attractor for food-, outdoor hobbies-, self-expression-, and alcohol-seeded chains; and the second strongest for sports- and music-seeded chains. Thus, no matter the kind of cultural taste was described in the seed utterance, cumulative patterns of mishearing utterances and completing them from preexisting cultural schemas appear to have a substantial chance of eventually transforming the seed utterance into one about high-status, uniformly-esteemed cuisine.

Our simulation results thus suggest that "Good food" may thus occupy a central position of stability within the semantic space of cultural tastes, where accounts of cultural taste that diffuse through word of mouth may be particularly likely to morph into statements about taste in food. Conversely, utterances about food may be particularly likely to *remain* about food. Per cultural attraction theory, this further suggests that public culture should be particularly full of descriptions of peoples' food tastes, and that individuals should know (or believe that they know) more about others' tastes in food than they do about others' tastes in other cultural products. Future work using other empirical approaches should investigate this supposition.

We also explored whether the attractors match sociological intuitions about what matters in the realm of cultural taste. And indeed, we located three different food-related attractors that appear to be differentiated along class lines. However, we did not find any clear reflection of other major social divisions. It was thus striking that the bulk of the attractors we located *did not* appear to be about major social

groups. Of the remaining attractors, none clearly related to social class, gender, race/ethnicity, sexuality, religion, immigration status, or any other major social category frequently studied by sociologists. Major institutions like family, religion or government were also overwhelmingly absent. Thus, aside from class, major social divisions appeared less relevant to the structure of these attractors than sociological intuitions may predict.

Whereas we observed limited evidence of attractors following major social divisions, we noted that many attractors pertain to social judgements. The most prominent one of these is "aesthetic judgements," which is found near terms like witty, pretentious, and clichéd. The prominence of this attractor suggests that, in long transmission chains, many utterances about the *contents* of cultural tastes may eventually be transformed into judgements of the *quality* of those tastes. This fits sociological intuitions about the close relationship between cultural tastes and the critiques of those tastes. Future work might investigate the extent to which character judgements organize our schemas of these taste items.

Limitations

One key limitation of our study is our use of simulated actors rather than the actual human subjects usually examined in laboratory designs. This use of simulation enabled us to examine aspects of long-term cultural transmission that laboratory designs cannot observe. However, like the products of any new methodology, our results should be validated empirically by other approaches. These future validation studies should use human subjects to verify the cultural change tendencies we observed in our simulations, such as the tendency of actors to transform statements about the content of cultural tastes into judgements of the quality of those tastes, or to transform utterances about other cultural tastes into statements about food.

Another limitation of our study comes from our use of a word embedding trained on Google News data as our model of shared cultural schemas. While this is a widely used and thoroughly validated embedding model, its basis in news articles may provide an alternate explanation for the prominence of good food and the absence of other major social divisions in our results. Since these source texts were largely written by journalists, our model of the semantic space may itself bear the marks of a journalistic habitus. The persistent tendency of diverse transmission chains to converge onto "Good food" may thus be a product of the centrality of high-status food tastes to journalistic discourse and may reflect the fact that high-status food tastes may be especially relevant to those who read and write news articles. It may then be the case that a more socially diverse set of source texts would have produced an embedding space that featured a more diverse set of attractors. Since this Google News embedding has been widely validated as a proxy for the semantics of general English-language users and not simply journalists, we do not believe that this counter-explanation is likely to hold. Nonetheless, to be certain, future work should repeat the analyses in this paper using word embeddings estimated from other corpora.

Other Applications

The simulation-based approach we introduced in this paper has applications beyond cultural taste. Its suitability to any given empirical domain depends partly on whether this domain prominently features long transmission chains that fit the two key assumptions of our simulation: (i) the actors regularly lose parts of the message being transmitted, and (ii) they use their preexisting cultural schemas to fill in missing information. The method is thus appropriate for studying many instances of casual interpersonal transmission through word-of-mouth networks (as opposed to online diffusion processes where the same information is copied or hyperlinked without being modified.) Word-of-mouth transmission includes the kind of small talk that has been studied for its role in transmitting opinions about commercial products (Berger and Schwartz 2011). It also includes "water cooler" conversations among colleagues that reproduce organizational narratives and diffuse gossip about coworkers (Dailey and Browning 2014; Laidre et al. 2013; Michelson et al. 2010). It may also be appropriate to the study of frequently retold narratives that communities use to make sense of themselves and others (e.g., Wortham et al. 2011). In these applications, the method can be used to make predictions about the changes that information might undergo across long chains of interpersonal transmissions, and thus reveal the cultural change tendencies latent in the cultural schemas within the domain in question.

REFERENCES

Acerbi, Alberto and Alex Mesoudi. 2015. "If We Are All Cultural Darwinians What's the Fuss about? Clarifying Recent Disagreements in the Field of Cultural Evolution." *Biology & Philosophy* 30: 4: 481–503. https://doi.org/10.1007/s10539-015-9490-2.

Ahron, Michal, Michael Elad, and Alfred Bruckstein. 2006. "K-SVD: An Algorithm for Designing Overcomplete Dictionaries for Sparse Representation." *IEEE Transactions on Signal Processing* 54: 11: 4311–4322.

Arora, Sanjeev, Yingyu Liang & Tengyu Ma. 2017. "A Simple but Tough-to-Beat Baseline for Sentence Embeddings." International Conference on Learning Representations (ICLR).

Arseniev-Koehler, Alina, Susan Cochran, Vickie Mays, Kai-Wei Chang, and Jacob G. Foster. 2020. "Integrating Topic Modeling and Word Embedding to Characterize Violent Deaths." *SocArXiv* 1–32: https://doi.org/10.31235/osf.io/nkyaq.

Arseniev-Koehler, Alina and Jacob G. Foster. 2020. "Machine Learning as a Model for Cultural Learning: Teaching an Algorithm What It Means to Be Fat." *ArXiv Preprint* 2003: 12133: 1–45. https://doi.org/10.31235/osf.io/c9yj3.

Bangerter, Adrian. 2000. "Transformation Between Scientific and Social Representations of Conception: The Method of Serial Reproduction." *British Journal of Social Psychology* 39: 4: 521–535. https://doi.org/10.1348/014466600164615.

Bartlett, Frederic Charles. 1920. "Some Experiments on the Reproduction of Folk-Stories." *Folklore* 31: 1: 30–47. https://doi.org/10.1080/0015587X.1920.9719123.

Bartlett, Frederic Charles. 1932. *Remembering: An Experimental and Social Study*. Cambridge: Cambridge University.

Baumann, Shyon, Michelle Szabo, and Josée Johnston. 2019. "Understanding the Food Preferences of People of Low Socioeconomic Status." *Journal of Consumer Culture* 19: 3: 316–339. https://doi.org/10.1177/1469540517717780.

Berger, Jonah. 2014. "Word of Mouth and Interpersonal Communication: A Review and Directions for Future Research." *Journal of Consumer Psychology* 24: 4: 586–607. https://doi.org/10.1016/j.jcps.2014.05.002.

Berger, Jonah and Chip Heath. 2008. "Who Drives Divergence? Identity Signaling, Outgroup Dissimilarity, and the Abandonment of Cultural Tastes." *Journal of Personality and Social Psychology* 95: 3: 593–607. https://doi.org/10.1037/0022-3514.95.3.593.

Berger, Jonah and Eric M. Schwartz. 2011. "What Drives Immediate and Ongoing Word of Mouth?" *Journal of Marketing Research* 48: 5: 869–880.
Bolukbasi, Tolga, Kai-Wei Chang, James Zou, Venkatesh Saligrama, and Adam Kalai. 2016. "Man Is to Computer Programmer as Woman Is to Homemaker? Debiasing Word Embeddings." *Adv. Neural Inf. Process. Syst.*
Bourdieu, Pierre. 1987. *Distinction: A Social Critique of the Judgement of Taste*. Cambridge, MA: Harvard University Press.
Boutyline, Andrei and Laura Soter. 2021. "Cultural Schemas: What They Are, How to Find Them, and What to Do Once You've Caught One." *American Sociological Review* 86: 4: 728–758.
Boyd, Robert and Joseph Henrich. 2002. "On Modeling Cognition and Culture: Why Cultural Evolution Does Not Require Replication of Representations." *Journal of Cognition and Culture* 2: 2: 87–112. https://doi.org/10.1163/156853702320281836.
Boyer, Pascal and Charles Ramble. 2001. "Cognitive Templates for Religious Concepts: Cross-Cultural Evidence for Recall of Counter-Intuitive Representations." *Cognitive Science* 25: 4: 535–564. https://doi.org/10.1207/s15516709cog2504_2.
Breithaupt, Fritz, Binyan Li, Torrin M. Liddell, Eleanor B. Schille-Hudson, and Sarah Whaley. 2018. "Fact vs. Affect in the Telephone Game: All Levels of Surprise Are Retold With High Accuracy, Even Independently of Facts." *Frontiers in Psychology* 9: 2210. https://doi.org/10.3389/fpsyg.2018.02210.
Bryson, Bethany. 1996. "'Anything But Heavy Metal': Symbolic Exclusion and Musical Dislikes." *American Sociological Review* 61: 5: 884–899. https://doi.org/10.2307/2096459.
Buskell, Andrew. 2017. "Cultural Attractor Theory and Explanation." *Philosophy, Theory, and Practice in Biology* 9(13). Retrieved June 26, 2021 (http://philsci-archive.pitt.edu/14544/).
Caliskan, Aylin, Joanna J. Bryson, and Arvind Narayanan. 2017. "Semantics Derived Automatically from Language Corpora Contain Human-like Biases." *Science* 356: 6334: 183–186.
Cerulo, Karen A. 2018. "Scents and Sensibility: Olfaction, Sense-Making, and Meaning Attribution." *American Sociological Review* 83: 2: 361–389. https://doi.org/10.1177/0003122418759679.
Claidière, Nicolas and Dan Sperber. 2007. "The Role of Attraction in Cultural Evolution." *Journal of Cognition and Culture* 7: 1–2: 89–111. https://doi.org/10.1163/156853707X171829.
Curl, Heather, Annette Lareau, and Wu Tina. 2018. "Cultural Conflict: The Implications of Changing Dispositions among the Upwardly Mobile." *Sociological Forum* 33: 4: 877–899.
Dailey, Stephanie L. and Larry Browning. 2014. "Retelling Stories in Organizations: Understanding the Functions of Narrative Repetition." *Academy of Management Review* 39: 1: 22–43. https://doi.org/10.5465/amr.2011.0329.
Darmon, Nicole and Adam Drewnowski. 2008. "Does Social Class Predict Diet Quality?" *The American Journal of Clinical Nutrition* 87: 5: 1107–1117. https://doi.org/10.1093/ajcn/87.5.1107.
Desmond, Matthew. 2008. *On the Fireline: Living and Dying with Wildland Firefighters*. Chicago, IL: University of Chicago Press.
Dodson, Chad S. and Daniel L. Schacter. 2001. "Memory Distortion," In Brenda Rapp (ed.), *Handbook of Cognitive Neuropsychology: What Deficits Reveal About the Human Mind*: pp. 445–460. New York, NY: Psychology Press.
Elias, Norbert. 2000. *The Civilizing Process: Sociogenetic and Psychogenetic Investigations*. Revised. Hoboken, NJ: Blackwell Publishing.
Ethayarajh, Kawin. 2018. "Unsupervised Random Walk Sentence Embeddings: A Strong but Simple Baseline," In Isabelle Augenstein, Kris Cao, He He, Felix Hill, Spandana Gella, Jamie Kiros, Hongyuan Mei, and Dipendra Misra (eds.), *Proceedings of The Third Workshop on Representation Learning for NLP*: pp. 91–100. Melbourne, Australia.
Foster, Jacob G. 2018. "Culture and Computation: Steps to a Probably Approximately Correct Theory of Culture." *Poetics* 68: 144–154. https://doi.org/10.1016/j.poetic.2018.04.007.
Gualtieri, Gillian. 2021. "Discriminating Palates: Evaluation and Ethnoracial Inequality in American Fine Dining." *Social Problems* (spaa075). https://doi.org/10.1093/socpro/spaa075.
Heintz, Christophe, Stefaan Blancke, and Thom Scott-Phillips. 2019. "Methods for Studying Cultural Attraction." *Evolutionary Anthropology: Issues, News, and Reviews* 28: 1: 18–20. https://doi.org/10.1002/evan.21764.
Hinton, Geoffrey and Ruslan Salakhutdinov. 2006. "Reducing the Dimensionality of Data with Neural Networks." *Science* 313: 5786: 504–507.
Hunzaker, M. B. Fallin. 2016. "Cultural Sentiments and Schema-Consistency Bias in Information Transmission." *American Sociological Review* 81: 6: 1223–1250. https://doi.org/10.1177/0003122416671742.
Kashima, Yoshihisa. 2000. "Maintaining Cultural Stereotypes in the Serial Reproduction of Narratives." *Personality and Social Psychology Bulletin* 26: 5: 594–604. https://doi.org/10.1177/0146167200267007.
Keysar, Boaz and Anne S. Henly. 2002. "Speakers' Overestimation of Their Effectiveness." *Psychological Science* 13: 3: 207–212. https://doi.org/10.1111/1467-9280.00439.

Kozlowski, Austin C., Matt Taddy, and James A. Evans. 2019. "The Geometry of Culture: Analyzing the Meanings of Class through Word Embeddings." *American Sociological Review* 84: 5: 905–949. https://doi.org/10.1177/0003122419877135.

Laidre, Mark E., Alex Lamb, Susanne Shultz, and Megan Olsen. 2013. "Making Sense of Information in Noisy Networks: Human Communication, Gossip, and Distortion." *Journal of Theoretical Biology* 317: 152–160. https://doi.org/10.1016/j.jtbi.2012.09.009.

Lerique, Sébastien and Camille Roth. 2018. "The Semantic Drift of Quotations in Blogspace: A Case Study in Short-Term Cultural Evolution." *Cognitive Science* 42: 1: 188–219. https://doi.org/10.1111/cogs.12494.

Lewis, Kevin, Marco Gonzalez, and Jason Kaufman. 2012. "Social Selection and Peer Influence in An Online Social Network." *Proceedings of the National Academy of Sciences* 109: 1: 68–72. https://doi.org/10.1073/pnas.1109739109.

Lieberson, Stanley. 2000. *Matter of Taste: How Names, Fashions, and Culture Change*. New Haven, CT: Yale University Press.

Lizardo, Omar. 2006. "How Cultural Tastes Shape Personal Networks." *American Sociological Review* 71: 5: 778–807. https://doi.org/10.1177/000312240607100504.

Lizardo, Omar. 2017. "Improving Cultural Analysis: Considering Personal Culture in Its Declarative and Nondeclarative Modes." *American Sociological Review* 82: 1: 88–115. https://doi.org/10.1177/0003122416675175.

Lizardo, Omar and Sara Skiles. 2015. "Musical Taste and Patterns of Symbolic Exclusion in the United States 1993–2012: Generational Dynamics of Differentiation and Continuity." *Poetics* 53: 9–21. https://doi.org/10.1016/j.poetic.2015.08.003.

Martin, John Levi. 2010. "Life's a Beach but You're an Ant, and Other Unwelcome News for the Sociology of Culture." *Poetics* 38: 2: 229–244. https://doi.org/10.1016/j.poetic.2009.11.004.

Martin, John Levi and Ben Merriman. 2015. "A Social Aesthetics as a General Cultural Sociology?" In Laurie Hanquint and Mike Savage (eds.), *Routledge International Handbook of the Sociology of Art and Culture*. Milton Park, Abingdon-on-Thames, Oxfordshire: Routledge.

Mazzarol, Tim. 2011. "The Role of Word of Mouth in the Diffusion of Innovation," In Michael Hülsmann and Nicole Pfeffermann (eds.), *Strategies and Communications for Innovations: An Integrative Management View for Companies and Networks*: pp. 117–131. Berlin, Heidelberg: Springer.

Mesoudi, Alex and Andrew Whiten. 2004. "The Hierarchical Transformation of Event Knowledge in Human Cultural Transmission." *Journal of Cognition and Culture* 4: 1: 1–24. https://doi.org/10.1163/156853704323074732.

Mesoudi, Alex and Andrew Whiten. 2008. "The Multiple Roles of Cultural Transmission Experiments in Understanding Human Cultural Evolution." *Philosophical Transactions of the Royal Society B: Biological Sciences* 363: 1509: 3489–3501. https://doi.org/10.1098/rstb.2008.0129.

Mesoudi, Alex, Andrew Whiten, and Robin Dunbar. 2006. "A Bias for Social Information in Human Cultural Transmission." *British Journal of Psychology* 97: 3: 405–423. https://doi.org/10.1348/000712605X85871.

Michelson, Grant, Ad van Iterson, and Kathryn Waddington. 2010. "Gossip in Organizations: Contexts, Consequences, and Controversies." *Group & Organization Management* 35: 4: 371–390. https://doi.org/10.1177/1059601109360389.

Mikolov, Tomas, Ilya Sutskever, Kai Chen, Greg S. Corrado, and Jeff Dean. 2013. "Distributed Representations of Words and Phrases and Their Compositionality," In Christopher Burges, Leon Bottou, Max Welling, Zoubin Ghahramani, and Kilian Weinberger. *Advances in Neural Information Processing Systems 26*: pp. 3111–3119. Red Hook, NY: Curran Associates, Inc.

Mikolov, Tomas, Kai Chen, Greg Corrado, and Jeffrey Dean. 2013. "Efficient Estimation of Word Representations in Vector Space." *ArXiv [Cs.CL]* 1301.3781.

Miton, Helena, Nicolas Claidière, and Hugo Mercier. 2015. "Universal Cognitive Mechanisms Explain the Cultural Success of Bloodletting." *Evolution and Human Behavior* 36: 4: 303–312. https://doi.org/10.1016/j.evolhumbehav.2015.01.003.

Norenzayan, Ara, Scott Atran, Jason Faulkner, and Mark Schaller. 2006. "Memory and Mystery: The Cultural Selection of Minimally Counterintuitive Narratives." *Cognitive Science* 30: 3: 531–553. https://doi.org/10.1207/s15516709cog0000_68.

Nyhof, Melanie and Justin Barrett. 2001. "Spreading Non-Natural Concepts: The Role of Intuitive Conceptual Structures in Memory and Transmission of Cultural Materials." *Journal of Cognition and Culture* 1: 1: 69–100. https://doi.org/10.1163/156853701300063589.

Ridgeway, Cecilia L. 2009. "Framed Before We Know It: How Gender Shapes Social Relations." *Gender & Society* 23: 2: 145–160. https://doi.org/10.1177/0891243208330313.

Rivera, Lauren A. 2012. "Hiring as Cultural Matching: The Case of Elite Professional Service Firms." *American Sociological Review* 77: 6: 999–1022. https://doi.org/10.1177/0003122412463213.

Schacter, Daniel L. 1989. "Memory," In Michael Posner (ed.), *Foundations of Cognitive Science*: pp. 683–725. Cambridge, MA: MIT Press.

Schegloff, Emanuel A. 1987. "Some Sources of Misunderstanding in Talk-in-Interaction." *Linguistics* 25: 1: https://doi.org/10.1515/ling.1987.25.1.201.
Scott-Phillips, Thom, Stefaan Blancke, and Christophe Heintz. 2018. "Four Misunderstandings About Cultural Attraction." *Evolutionary Anthropology: Issues, News, and Reviews* 27: 4: 162–173. https://doi.org/10.1002/evan.21716.
Sender, Katherine. 2001. "Gay Readers, Consumers, and a Dominant Gay Habitus: 25 Years of the Advocate Magazine." *Journal of Communication* 51: 1: 73–99. https://doi.org/10.1111/j.1460-2466.2001.tb02873.x.
Sperber, Dan. 1996. "Review of: Explaining Culture: A Naturalistic Approach." *Mind* 110: 439: 845–854. https://doi.org/10.1093/mind/110.439.845.
Sperber, Dan. 1997. "Selection and Attraction in Cultural Evolution," In Maria Luisa Dalla Chiara, Kees Doets, Daniele Mundici, and Johan van Benthem (eds.), *Structures and Norms in Science*: pp. 409–426. Dordrecht: Springer Netherlands.
Stoltz, Dustin and Marshall Taylor. 2020. "Cultural Cartography with Word Embeddings." *ArXiv Preprint* 2007.04508: 1–70.
Trester, Anna Marie. 2013. "Telling and Retelling Prankster Stories: Evaluating Cleverness to Perform Identity." *Discourse Studies* 15: 1: 91–109. https://doi.org/10.1177/1461445612466472.
Truskanov, Noa and Yosef Prat. 2018. "Cultural Transmission in an Ever-Changing World: Trial-and-Error Copying May Be More Robust than Precise Imitation." *Philosophical Transactions of the Royal Society B: Biological Sciences* 373: 1743: 20170050. https://doi.org/10.1098/rstb.2017.0050.
Wacquant, Loïc. 2016. "A Concise Genealogy and Anatomy of Habitus." *The Sociological Review* 64: 1: 64–72. https://doi.org/10.1111/1467-954X.12356.
Warde, Alan, David Wright, and Modesto Gayo-Cal. 2008. "The Omnivorous Orientation in the UK." *Poetics* 36: 2–3: 148–165. https://doi.org/10.1016/j.poetic.2008.02.004.
Watkins, Megan and Greg Noble. 2013. *Disposed to Learn: Schooling, Ethnicity and the Scholarly Habitus*. London: A&C Black.
Wortham, Stanton, Elaine Allard, Kathy Lee, and Katherine Mortimer. 2011. "Racialization in Payday Mugging Narratives." *Journal of Linguistic Anthropology* 21: s1: E56–75. https://doi.org/10.1111/j.1548-1395.2011.001097.x.

APPENDIX

Table AI. Attractors affecting *alcohol* -seeded transmission chains

Mnemonic	10 Characteristic words & phrases	Reliability	Strength	Globality
Good food	pesto salad fresh_herbs basil polenta fennel asparagus veggies sour_cream broccoli	1.00	0.51	0.75
Fast food	hamburgers burgers cheeseburgers sandwiches pizza buffet steak_dinner donuts hotdogs dinner	0.86	0.01	0.49
Disease	atherosclerosis tumors inflammatory_bowel_disease cardiovascular_disease insulin_resistance fibrosis metabolic cancers inflammation oxidative_stress	0.84	0.04	0.71
Melodies	melancholic melodic lyricism jazzy lilting tuneful droll soulful poetic percussive	0.82	0.03	0.49
Aesthetic judgement	droll endearing charming sardonic humorless pompous pretentious cartoonish clichéd melodramatic	0.74	0.03	0.74
Alcoholic drinks	wine beer brandy liqueur vodka drinks whiskey wines sparkling_wine cocktails	0.70	0.01	0.29
Animals	otters birds critters mammal alligators reptile raptor species insects fish	0.68	0.01	0.36
Biochemistry	carbohydrate fructose saturated_fat fats calorie nutritional snack_foods processed_foods caffeine fatty_acids	0.68	0.01	0.18
Decorative	satin shimmering beaded pastel decorative silvery velvet vases translucent floral	0.64	0.01	0.61
Plants	seedling vines blooms plantings shrub foliage flowering_plants flowering fungicides crops	0.58	0.02	0.40
Beverage containers	cans bottles tub dispenser tins cardboard_box jar jugs ice_cubes trays	0.56	0.01	0.12
Fish	fish crabs striped_bass sturgeon otters grouper tuna rockfish shrimp mussels	0.52	0.01	0.19
Kitchen equipment	skillet tablespoon sauté mixing_bowl saucepan tablespoons baking_sheet Whisk dough braised	0.52	0.01	0.20

Table AII. Attractors affecting *self-expression*-seeded transmission chains

Mnemonic	10 Characteristic words & phrases	Reliability	Strength	Globality
Good food	tangy creamy flavorful buttery pesto polenta delicious ravioli salad quiche	1.00	0.34	0.67
Affable	gregarious affable genial mild_mannered amiable soft_spoken easygoing jovial personable feisty	0.96	0.01	0.29
Aesthetic judgement	droll sardonic melodramatic clichéd bombastic endearing pretentious melancholic beguiling self_consciously	0.90	0.17	0.76
Animals	otters alligators birds turtles mammal fish gators critters reptile crocodiles	0.90	0.01	0.38
Fast food	sandwiches burgers hamburgers meal buffet BBQ barbeque breakfast pizza entrees	0.86	0.03	0.49
Cooking	tablespoons lemon_juice cornstarch tangy creamy baking_soda polenta sauce vinaigrette pesto	0.84	0.05	0.15
Contemptible	contemptible hypocritical ignorant spineless dishonest craven moronic idiotic despicable gutless	0.84	0.03	0.60
Decorative	satin shimmering turquoise lacy elegant beaded velvet fuchsia lush exquisite	0.82	0.02	0.50
Baseball	inning leadoff_batter 3_pointers strikeouts baserunners leadoff_hitter bases_loaded unearned_runs treys free_throws	0.76	0.00	0.29
Disease	atherosclerosis tumors inflammation cardiovascular_disease ischemic_stroke inflammatory_bowel_disease periodontal_disease thrombosis fibrosis coronary_artery_disease	0.72	0.02	0.75
Melodies	melodies instrumentals original_compositions compositions percussion harmonies jazzy lyricism orchestral piano	0.70	0.04	0.43
Soft drinks	soda apple_juice chocolate fruit_juices soft_drink fruit_juice orange_juice ice_cream juice beverages	0.68	0.02	0.28
Plants	berries seedlings flowering_plants vines plantings orchids blooms asparagus strawberries sweet_potatoes	0.60	0.05	0.42

Table AIII. Attractors affecting *sports*-seeded transmission chains

Mnemonic	10 Characteristic words & phrases*	Reliability	Strength	Globality
Swimming / running	individual_medley meter_hurdles medley_relay yard_freestyle breaststroke yard_breaststroke freestyle backstroke meter_freestyle yard_backstroke	0.96	0.01	0.00
Basketball	layup 3_pointer reverse_layup turnaround_jumper baseline_jumper putback pointer free_throws jumper dunk basket	0.94	0.01	0.00
Injury	rib injury groin_injury sprained_ankle calf_strain knee_sprain groin_strain knee_injury ankle_sprain ankle_injury	0.92	0.01	0.00
Baseball	RBI_single infield_single sacrifice_fly inning bloop_single bases_loaded leadoff_double leadoff_batter wild_pitch groundout	0.90	0.36	0.08
Golf	birdie foot_birdie_putt foot_putt double_bogey birdie_putt foot_eagle_putt bogeyed par_putt eagle_putt	0.88	0.01	0.00
Action	flicked glanced lofted ricocheted deflected scooted darted cannoned dribbled volleyed	0.86	0.05	0.01
Winners	undefeated semifinals quarterfinal defending_champions winless finals championship semi_finals unbeaten crowned_champions	0.86	0.01	0.00
Contemptible	arrogant moronic contemptible hypocritical ignorant craven idiotic egotistical obnoxious dishonest	0.82	0.03	0.61
Assault	stab_wounds stabbed pistol_whipped assaulted sexually_assaulted stabbing multiple_stab_wounds assailant gunshot_wounds allegedly_assaulted	0.76	0.00	0.02
American Football	wide_receivers offensive_linemen wideouts defensive_linemen defensive_backs kickoff_returns cornerbacks offensive_lineman linebackers wideout	0.74	0.06	0.00
Disease	cardiovascular_disease atherosclerosis hypertension statins inflammatory_bowel_disease heart_disease metabolic_syndrome ischemic_stroke tumors coronary_artery_disease	0.74	0.04	0.55
Melodies	lyrical jazzy melodic melancholic tuneful soulful musicality percussive dreamy earthy	0.70	0.08	0.50
Cricket	leg_spinner paceman batsman left_armer allrounder seamer wicketkeeper left_arm_spinner left_arm_seamer fast_bowler	0.70	0.01	0.00
Good food	buttery delicious tangy luscious crunchy creamy tart zesty flavorful yummy pesto deliciously salad delectable polenta	0.64	0.11	0.34

*For "Good food" attractor, we included 5 additional phrases to illustrate similarity to the "Good food" attractors in Tables II–IV and AI–AII.