USING FALSE MEMORIES TO CHARACTERIZE LEXICAL REPRESENTATIONS: A TEST CASE FROM ENGLISH

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ABSTRACT

The English phoneme /t/ is realized as [tʰ] word-initially ([tʰ]*ip*), but in many dialects it exhibits free variation word-finally (*ba*[t] ~ *ba*[ʔt̚] ~ *ba*[ʔ]). We examined whether listeners construct false memories at different rates for these two different types of words. We presented listeners with lists of spoken phonological neighbors, such as *lip, tin, type…* (neighbors of *tip*) and *fat, ban, bet…* (neighbors of *bat*), followed by two different memory tasks, recall and recognition. Results indicate significantly lower rates of false memories for words like *bat,* and different patterns of recall versus recognition indicate that two separate mechanisms contribute to this result. We suggest that free variation creates qualitatively distinctive lexical representations which resist false memories.

Keywords: free variation, lexical representations, memory

1. INTRODUCTION

The English phoneme /t/ is consistently realized as [tʰ] word-initially ([tʰ]*ip*), but in many dialects it exhibits free variation word-finally (*ba*[t] ~ *ba*[ʔt̚] ~ *ba*[ʔ]). It seems logical to suppose that such variation should have consequences for underlying lexical representations, but previous research suggests otherwise. For example, Sumner & Samuel [11] asked participants to listen to /t/-final words such as *flute,* and analyzed their reaction times to a printed semantic associate such as *music.* Results showed that tokens ending in [t] vs. [ʔt̚] vs. [ʔ] all primed the associate equally well, so the authors justifiably concluded that free variation does not, in fact, impact the activation of lexical representations.

Yet representations need not be characterized in terms of activation alone. Speech perception is a rich experience for the listener that, besides the speed and accuracy of word recognition, encompasses qualitative dimensions [5]. For example, Goldinger et al. [2] overlaid white noise of varying intensities onto spoken English words. Participants assigned significantly lower loudness ratings to noise on old words (that they had heard in an earlier exposure phase) compared to new words, indicating that the qualitative experience of familiarity influenced their perception. The literature contains many comparable findings [8], and our research is motivated by the idea that the representation for /t/ in *tip* may somehow differ from the representation for /t/ in *bat,* along a qualitative dimension.

We chose to explore the dimension of distinctiveness, specifically as revealed by memories. The beginning premise here is that lexical representations are a type of memory – that is, a stored representation built on the basis of events (such as speech) perceived in the past. Memories, however, are not static entities, and a great deal of previous research shows that people actively construct memories at each retrieval. To take a classic example, Loftus & Palmer [7] presented participants with a film of an automobile accident, and afterwards asked them "About how fast were the cars going when they hit each other?" where the underlined verb varied among *hit, smashed, collided, bumped, contacted.* Results showed that participants gave significantly higher speed estimates with *smashed* versus the other verbs. This suggests that they constructed a memory for the accident by combining events that they perceived while watching the film with other events that occurred afterwards. Subsequent research confirms this notion (for review, see [6]) but also demonstrates that memory construction is modulated by distinctiveness. That is, people generally resist integrating information about distinctive objects into a memory (e.g., "About how fast were the limousines going when they hit each other?"), reasoning that if they had actually perceived those objects (limousines), they should have a detailed recollection of them [4].

Importantly for our purposes, the constructive nature of memories is not limited to narrative events. People also construct memories for individual spoken words. For example, after hearing a list such as *thread, pin, sewing…,* participants claimed to remember the word *needle*, which did not appear on the list but is semantically related to the words that did [9]. Similarly, after hearing a list such as *bag, rack, book…,* participants claimed to remember the word *back*, which did not appear on the list but is a phonological neighbor of the words that did [10]. These studies, and many others, show that listeners can actively construct a memory for a word that they did not perceive by combining aspects of multiple words that they did, in fact, perceive. This "false memory" phenomenon is remarkably robust across experimental manipulations, but again is modulated by distinctiveness [3]. That is, while most listeners readily construct false memories for neutral words like *needle,* they resist doing so for distinctive words, such as those that are taboo (*hell*), mis-spelled (*dreem*), infrequent (*creed*), or concrete (*ice*). The general implication is that memories for words – that is, lexical representations – differ along a dimension of distinctiveness.

In the current study, we asked whether free variation affects the distinctiveness of lexical representations. To pursue this question, we examined whether English listeners construct false memories at different rates for words like *tip,* where initial /t/ is realized consistently, versus words like *bat,* where final /t/ is subject to variation. Following Sommers & Lewis [10], we presented listeners with lists of spoken words designed to induce false memories, such as *lip, tin, type…* (phonological neighbors of *tip*) and *fat, ban, bet…* (phonological neighbors of *bat*). We then presented listeners with two different memory tasks: recall, which taps explicit recollection, and recognition, which taps implicit sense of familiarity. To preview the results, false memory rates were higher for *tip* words compared to *bat* words, in both tasks. This suggests that free variation in final position does, in fact, create perceptual events that are distinctive for listeners, and highlights the need to characterize lexical representations along qualitative dimensions.

2. METHOD

In the false memory paradigm, lists of words are constructed around a critical lure, but crucially omit the lure itself. For example, the list *fat, bet, ban…,* is constructed so as to contain phonological neighbors of the critical lure *bat,* but crucially omits *bat* itself. For our experiment, we selected thirty-six English words to serve as lures, across three conditions: nine lures contained initial /t/ (*tip*), nine lures contained final /t/ (*bat*), and eighteen lures were baseline controls without /t/ (*ham*). All lures were mono-syllabic, and had a minimum of ten phonological neighbors. We defined "neighbor" as a word that differs in the identity of the initial, middle, or final phoneme; words that differ in the addition or deletion of a phoneme were excluded from this definition. The lures were balanced across conditions for frequency, familiarity, and (to the extent possible) neighborhood density, as shown in Table 1.

Table 1: Mean lexical statistics for lures.

Condition	Log Frequency	Familiarity (1 to 7)	Density
Control: *ham*	2.40	6.90	27.50
Initial /t/: *tip*	2.39	6.85	25.67
Final /t/: *bat*	2.41	6.94	30.78

For each lure such as *bat,* we constructed a list of ten neighbors, using approximately equal numbers of neighbors that differed in initial C (*fat, rat, that*), medial V (*bet, boot, bout*), and final C (*ban, bass, bath, badge*). Because a word's neighbors are a somewhat idiosyncratic property of the lexicon, it was not possible to completely balance them across conditions for frequency, familiarity, and density, although we did so to the extent possible, as shown in Table 2.

Table 2: Mean lexical statistics for neighbors.

Condition	Log Frequency	Familiarity (1 to 7)	Density
Control: *ham*	2.30	6.67	23.78
Initial /t/: *tip*	2.20	6.51	23.91
Final /t/: *bat*	2.38	6.73	25.68

A male native English speaker from the midwestern region of the U.S. recorded each word. For all words containing initial /t/, he produced a released and aspirated [t^h]. For all words containing final /t/, he produced a released [t]. This decision was motivated by a desire to focus exclusively on how initial versus final position for /t/ affects lexical representations; in order to assess this without confounding variables, we kept the phonetic realizations of /t/ across these positions relatively constant.

2.1. Participants

Participants were native speakers of the midwest variety of American English (n=74), between the ages of 18 and 30, approximately half female and half male.

2.2. Procedure

The thirty-six lists were divided into three sets of twelve, each containing three lists from the initial /t/ condition, three lists from the final /t/ condition, and six lists from the control condition. Each participant was randomly assigned to a set, and therefore listened to a total of twelve lists. The order of the twelve lists, as well as the order of the ten words within each list, was randomized for each participant.

During the experiment, participants were seated in a quiet laboratory in front of a computer equipped with a mouse, keyboard, and high-quality headphones. After listening to each list of ten spoken words, they did a recall task, in which they were given 45 seconds to type as many words as they could remember from the list. After all twelve lists, participants did a recognition task in which they listened to a spoken word, and made a yes/no judgment as to whether they had heard the word previously in the experiment. There were 96 items in the recognition task, which included thirty-six words that the participant actually heard (three from each of 12 heard lists, balanced across conditions), plus sixty that the participant had not heard. The unheard words were of two key types: twelve critical lures from the participant's own set (one from each of 12 heard lists), plus forty-eight foils consisting of twelve lures from other sets (one from each of 12 unheard lists), and thirty-six neighbor words from other sets (three from each of 12 unheard lists). The order of items in the recognition task was randomized for each participant.

3. RESULTS

Table 3 shows descriptive statistics for the recall task, where "Heard" refers to words that participants actually heard (*fat, bet, ban…*), "Unheard" refers to random words that participants typed even though they did not hear them (e.g., *random, arbitrary…*), and "Lure" refers to critical lures, which participants also did not hear (*bat*). For heard words, rates of recall are calculated as a proportion of words on the list, which was always ten. For example, if a participant typed five words that occurred on a list, her rate of heard recall would be 5/10 for that list, or 0.50 (in other words, she recalled half of the words she heard). For lures, rates are calculated as either 0 or 1. For example, if a participant typed the lure *bat*, her rate of lure recall would be 1 for that list. For unheard words besides lures, rates are calculated as a total proportion of typed words. For example, if a participant typed seven total words after a list, of which there were five heard, one lure, and one unheard, then her rate of unheard recall would be 1/7, or 0.14.

Table 3: Recall: mean (s.d.) rates of word recall.

	Heard	Unheard	Lure
Initial /t/	0.53 (0.11)	0.13 (0.11)	0.36 (0.23)
Final /t/	0.49 (0.12)	0.18 (0.12)	0.21 (0.23)
Control	0.48 (0.10)	0.17 (0.10)	0.34 (0.32)

Table 4 shows descriptive statistics for the recall task, where "Heard" refers to words that participants actually heard (*fat, bet, ban…*), "Unheard" refers to foils, and "Lure" refers to critical lures (*bat*). Rates are calculated as the proportion of times that participants responded 'yes' to a particular item type. For example, if a participant responded 'yes' to nine heard words and 'no' to three heard words, his rate for heard words in that condition would be 9/12, or 0.75.

Table 4. Recognition: Mean (s.d.) rates of 'yes' responses

	Heard	Unheard	Lure
Initial /t/	0.78 (0.19)	0.29 (0.18)	0.58 (0.33)
Final /t/	0.71 (0.17)	0.23 (0.17)	0.47 (0.30)
Control	0.70 (0.15	0.20 (0.16)	0.51 (0.24)

To analyze these results, we ran mixed-effects linear regression models, one for recall and one for recognition. For both, we used the function *lme* from the R package *nmle*, with predictor variables of word status (heard vs. unheard vs. lure) and /t/ position (control vs. initial vs. final), with participant as the error term. We used treatment coding such that "unheard" served as the baseline for word status and "control" served as the baseline for /t/ position.

For recall, word status exhibited a main effect. Compared to the unheard condition, recall rates were greater in both the heard condition ($\beta = 0.31$, $t = 11.11$, $p < 0.05$) and in the lure condition ($\beta = 0.17$, $t = 6.18$, $p < 0.01$). Word status and /t/ position also interacted, in two ways. Although rates increased overall in the lure condition compared to the unheard condition, this increase was smaller for final /t/ positions compared to the controls ($\beta = -0.14$, $t = -3.60$, $p < 0.01$). Furthermore, although rates increased overall in the heard condition compared to the unheard condition, this increase was larger for initial /t/ positions compared to the controls ($\beta = 0.09$, $t = 2.27$, $p < 0.05$). No other effects were significant.

For recognition, word status exhibited a main effect. Compared to the unheard condition, recognition rates were greater in both the heard condition ($\beta = 0.50$, $t = 15.51$, $p < 0.01$) and in the lure condition ($\beta = 0.31$, $t = 9.73$, $p < 0.01$). Position also exhibited a main effect. Compared to the controls, rates were greater in initial /t/ positions (β

= 0.09, t = 2.76, p < 0.01). No other effects were significant.

4. DISCUSSION

The false memory phenomenon was operative in our experiment, as shown by the fact that both recall and recognition results exhibited a main effect of word status. Critical lures were (falsely) remembered more often than we would otherwise expect – that is, recalled more often than unheard, random intrusions and recognized more often than unheard foils – replicating previous findings [3, 9, 10].

Given this, we turn to the question at hand, namely whether words with initial /t/ versus final /t/ differ in terms of their representations. Results from the recall task suggest that they do. Rates of recall for lures such as *bat* (0.21) were significantly lower than those for lures such as *tip* (0.36) or *ham* (0.34), as shown by the interaction between word status and /t/ position in our model. Thus, listeners seemed to resist constructing recollections specifically for those lures that end in /t/. Given previous research demonstrating that people generally resist constructing false memories for words that are distinctive, we could reasonably argue that words ending in /t/ are also somehow distinctive compared to those beginning in /t/, or those lacking /t/ altogether. Even if it turns out that "distinctiveness" is not the operative concept, however, it seems clear that the representations for *bat* words, on the one hand, versus *tip* and *ham* words, on the other, do indeed differ along some qualitative dimension.

Results from the recognition task also suggest that words with initial /t/ versus final /t/ differ in terms of their representations. Rates of recognition were significantly higher overall for words in initial /t/ condition compared to those in other conditions, as shown by the main effect of position in our model. The lack of interactions means that this effect was evident across the board, in heard words (*lip, tin, type…*), unheard words, and lures (*tip*). Note that in the recognition task, unheard words in the /t/ initial condition were either lures (*tuck*) or phonological neighbors (*luck, teak, tub…*) taken from a different stimulus set. Thus, listeners seemed to exhibit a heightened sense of implicit familiarity for any word that either begins with /t/ itself, or is a phonological neighbor of a word that begins with /t/, and this heightened sense is apparent for words they heard as well as words they did not hear. The recognition task, then, divides words according to a different metric than the recall task: here it is the representations for *tip* words, on the one hand, versus *bat* and *ham* words, on the other, which differ.

Taken together, the results from both recall and recognition strongly suggest that free variation creates qualitative differences in lexical representations, of a kind not revealed by studies that focus exclusively on speed and accuracy. But the results also pose questions. To begin with, the different patterns of results for recall versus recognition suggest that two separate mechanisms exert independent effects on lexical representations. One mechanism seems to treat final /t/ words as especially distinctive, while the other mechanism seems to treat initial /t/ words and their phonological neighbors as especially familiar. Further research is needed to tease these mechanisms apart, and to pinpoint the unique influence that each one exerts on lexical representations.

In addition, we made a methodological decision that could potentially influence the interpretation of our results. As described in Section 2, all final /t/ words in the experiment were realized with a released [t]. So, participants heard pronunciations like *fa*[t], *ra*[t], and *tha*[t] for neighbors; during the recognition task, they also heard pronunciations like *ba*[t] for lures. In everyday speaking, however, released [t] occurs in this position only 40% of the time; the rest of the time, unreleased [ʔt̚] or [ʔ] occur [1]. While we had reasoned that listeners' lexical representations generally derive their characteristics from repeated exposure to phonetic variants over the course of a lifetime, not from a single exposure during one experiment, it is nevertheless possible that the specific variants we exposed them to constituted a "distinctive" event for our participants, thus giving rise to lower rates of false recall. A follow-up study using pronunciations like *fa*[ʔt̚], *ra*[ʔt̚], and *tha*[ʔt̚] is currently underway, and will address this issue.

5. REFERENCES

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