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Syntactic Class Influences Phonological Priming of Tip-of-The-Tongue Resolution

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Abstract

When having tip-of-the-tongue (TOT) experiences, phonologically related words have both facilitated and impeded word retrieval. This experiment examined whether phonologically related words' syntactic class (part of speech) is responsible for these differential effects. Sixty college students saw general knowledge questions whose answers were designated target words and responded "know", "don't know", or "TOT". Following "TOT" and "don't know" responses, participants saw five words, one of which was a prime. Primes contained the target's first syllable and either shared or did not share the target's part of speech. Following presentation of the primes, retrieval of the target was attempted again. Different part-of-speech primes facilitated resolution of TOTs, whereas same part-of-speech primes had no effect, relative to phonologically unrelated words. These results support Node Structure Theory's most-primed-wins principle and the Transmission Deficit model account of TOTs and detail the importance of syntactic class in selecting words that are candidates for speech production.

Syntactic Class Influences Phonological Priming of Tip-of-The-Tongue Resolution

A tip-of-the tongue (TOT) state is a well-known phenomenon that refers to a temporary inability to retrieve a known word (e.g., R. Brown & McNeill, 1966). This frustrating experience has motivated considerable research in the past 25 years and led to the development of several theories regarding why TOTs occur. One of the predominant theoretical explanations is the Transmission Deficit (TD) model, which proposes that TOTs are caused by weakened connections between a word and its phonology or sounds (e.g., Burke, MacKay, Worthley, & Wade, 1991; MacKay & Burke, 1990). The TD model therefore suggests a solution for resolving TOTs, i.e., strengthening the weak phonological links will increase retrieval of the missing word. Previous research has tested this prediction by inducing TOTs, presenting words containing various phonological features of the unretrieved word, and then asking participants to attempt word retrieval again. These studies showed that phonologically related words presented during TOT states increase word retrieval (e.g., Abrams, White, & Eitel, 2003; James & Burke, 2000; White & Abrams, 2002).

However, phonologically related words can also inhibit or delay TOT resolution. TOTs are often accompanied by “blockers” or “persistent alternates”, which refer to incorrect words that come to mind involuntarily and typically share phonological features with the unretrieved word (e.g., MacKay & Burke, 1990).

Research has demonstrated that when TOTs are accompanied by an alternate word, TOTs are *less* likely to be resolved, and even when resolved, retrieving the intended word takes longer relative to TOTs that occur without alternate words in mind (Burke et al., 1991). These results are consistent with an inhibition model of TOTs, where TOTs are caused by an alternate word, which comes to mind first and suppresses retrieval of the desired word (e.g., Jones, 1989).

The present experiment attempted to resolve these paradoxical findings by testing a specific hypothesis unique to Node Structure Theory (NST; MacKay, 1987) and the TD model. This hypothesis predicts that a word's syntactic class plays a pivotal role in determining the impact that phonologically related words will have on resolution of TOT states. Specifically, Burke et al. (1991, p.570) suggested that "for subjects in the TOT state, presenting a word that is phonologically related and in a different domain (syntactic class) from the target will facilitate resolution, whereas a phonologically related word in the same domain as the target will delay resolution." To understand from where this prediction is derived, a brief overview of NST and the TD model is given below.

NST arranges conceptual representations, or nodes, into a hierarchical network of multi-level systems, including semantic, syntactic, and phonological systems. Within this theory, word retrieval occurs as a function of two processes, node priming and node activation. Node priming is a sub-threshold excitation that spreads between connected nodes, whereas node activation is the point at which a

node receives enough priming to enable retrieval. As a corollary of NST, the TD model suggests that TOTs occur when a word's lexical node is activated, but connections to the word's phonological nodes are weakened (due to infrequent or nonrecent use). The result of this weakening of connections is that the lexical node is unable to transmit sufficient node priming to enable activation of the phonology and achieve word retrieval. Similar explanations for the cause of TOT states have been proposed by other interactive models of speech production (e.g., Dell, 1986) as well as discrete two-stage theories that characterize a TOT state as a failure to retrieve the phonological word form following successful lemma retrieval (e.g., Levelt, 1989).

The role of syntactic class in TOT resolution is detailed by the "most-primed-wins" principle (Burke et al., 1991; MacKay, 1987; MacKay & Burke, 1990), which states that when nodes in the same syntactic domain receive simultaneous priming, only the node receiving the most priming can be activated at any given point in time. In other words, if a phonologically related word is activated and is the same part of speech as the unretrieved TOT word, then the phonologically related word's activation level must subside before the TOT word can be activated, delaying resolution of the TOT state. In contrast, presenting a phonologically related word that is a different part of speech will not interfere with retrieval of the TOT word. In fact, a phonologically related word will facilitate retrieval of the TOT word by transmitting bottom-up priming to other

lexical nodes connected to it. Since the TOT word is connected phonologically to the related word and is in another syntactic domain, it will then accumulate enough priming to become activated and retrieved. (See MacKay & Burke, 1990, and Burke et al., 1991, for more details on the theory and these predictions).

NST and the TD model also predict that the frequency of phonologically related words presented during TOTs will interact with the proposed syntactic category effects. The lexical node for a high-frequency word has stronger connections to its phonological nodes, enabling it to remain activated for a longer period of time. Thus, a high-frequency, phonologically related word that shares syntactic domain with the TOT word should decrease TOT resolution more than a low-frequency word because the competing word remains activated longer, preventing activation of the target. Conversely, a high-frequency, phonologically related word in a different syntactic domain is expected to increase TOT resolution because of the stronger transmission of priming to its connected nodes, some of which are the target's first-syllable phonology, which should then achieve sufficient priming for activation of the entire target. Providing support for this prediction independent of syntactic domain, Vitevitch and Sommers (2003, Experiment 3) showed that target words with high neighborhood frequency (the mean frequency of all of the words that phonologically resembled the target) were produced more quickly and accurately than targets with low neighborhood frequency in a picture naming task. Whether phonological inhibition effects can

be obtained as a function of frequency (and/or syntactic class) has yet to be demonstrated.

The predictions made by NST and the TD model are not easily derived from other theories. Theories that view the TOT state as a metacognitive phenomenon (e.g., Schwartz, 1999) do not detail the relationships between semantics, syntax, and phonology, making these theories unable to generate predictions about TOT resolution as a function of syntactic class. Furthermore, whereas other theories of language production (e.g., Dell, 1986; Levelt, 1989) explain the etiology of TOT states, these theories do not clearly specify a mechanism for detailing when facilitative versus inhibitory effects will occur in TOT resolution, or in some cases, in speech production more generally. Using NST and the TD model, the present experiment attempts to precisely specify the conditions under which phonologically related words delay or possibly inhibit TOT resolution experimentally, similar to the role that persistent alternates play in naturally occurring TOTs.

Method

Participants

Sixty participants were recruited from undergraduate classes at the University of Florida. All were between the ages of 17 and 21 (41 female, 19 male, mean age 18.8 years, *SD* = 1.0) and were either native English speakers or had experience speaking English most of their life.

Materials

An attempt to induce a TOT state occurred through presentation of a definition-like question eliciting a target word. Seventy-nine of the 96 questions were chosen from previous studies (e.g., Burke et al., 1991; Jones, 1989), and 17 new questions and targets were created. All target words were 2-5 syllables in length, low in Francis and Kucera (1982) frequency (all were 0 to 13 per million, except one at 21 per million and one at 42 per million), and none were proper names.

For each target word, two phonological primes were created: one that was the same part of speech as the target and one that was a different part of speech. A phonological prime contained the same first syllable as the target but did not overlap in phonology with the rest of the word whenever possible.[1] None of the primes contained a word from another part of speech within it; for example, “acrobatic" was not used because it contains the entire phonology of “acrobat”. In addition to the primes, a phonologically unrelated word was created for each

target as a control. These words shared syntactic class with the target half the time. Both the primes and the control word contained the same number of syllables. Across all stimuli, the word frequencies of the primes and control words were relatively similar: The frequencies of same part-of-speech primes ranged from 0 to 275, M = 23.8, SD = 46.8; the frequencies of different part-of-speech primes ranged from 0 to 244, M = 19.1, SD = 38.8; and unrelated controls' frequencies ranged from 0 to 297, M = 38.4, SD = 62.3). Example stimuli are shown in Table 1.

Following each question, participants saw a five-word list containing a prime that shared part of speech with the target, a prime that did not share part of speech, or an unrelated control word intermixed with four unrelated filler words. The prime and control words were presented as either the second, third or fourth word in the list and were equally distributed across the positions. None of the filler words in each presented list began with the same letter, and no filler word shared any phoneme with its corresponding target or overlapped in first-syllable phonology with any other target. None of the words in each list contained an obvious semantic relationship with each other or with the target.[2]

The experiment was run on Pentium II, 350 MHz PC-compatible computers using a computer program written in Visual Basic 5.0.

Design and Procedure

The experiment used a single-factor design, with Prime Condition (same part-of-speech primes, different part-of-speech primes, and unrelated controls) as a within-participants factor.[3] Participants were given written and verbal instructions describing a TOT as a certainty of knowing the correct answer, accompanied by a feeling of not quite being able to retrieve it. A general knowledge question was then presented in random order, with instructions at the bottom of the screen to say either "know," "don't know," or, "TOT." Following a "don't know" or "TOT" response, the list of four filler words intermixed with a word from one of the three prime conditions was presented one word at a time, centered on the screen. If the participant initially responded "know," they were prompted to give the answer and then saw a list of five words that always contained a control word.

To disguise the relation between the primes and the targets, participants were told that the word lists were relevant to an unrelated study involving people's knowledge about words' grammar and frequency of occurrence. After presentation of each word, participants were instructed to verbally indicate its part of speech (noun, verb, adjective, or other) as well as the frequency with which they encountered the word in everyday life using a scale of 1 (never having encountered the word) to 7 (on a daily basis). After these ratings were completed for all five words, participants either saw the next question (if they initially responded "know"), or they saw the same question again (if they had initially

responded “don’t know” or “TOT”). If they now knew the answer, they verbally stated the word. After all 96 questions had been presented, a recognition test was administered to determine whether or not the participant had experienced unresolved TOTs for the intended target. This test consisted of the questions for which the participant never retrieved an answer, along with four possible answers to choose from: the target, a word phonologically similar to the target, a word semantically related to the target, and a word unrelated to the target. Following the recognition test, a post-experiment questionnaire was administered verbally to assess participants’ awareness of the phonological relationship between the primes and the targets as well as intentional use of that knowledge to aid in target retrieval. The experimenter was responsible for typing in all responses, and all sessions were recorded on cassette tape.

Results

Post-Experiment Questionnaire

The responses on the post-experiment questionnaire revealed that only one participant was aware that some of the primes contained the same letters or sounds as the targets; however, this participant reported being unable to intentionally using this knowledge during retrieval attempts and therefore was not excluded from analyses. One participant was excluded from all analyses because of recent participation in an experiment that used similar general knowledge questions and targets.

Initial Responses

For initial responses to the general knowledge questions, 41% were “don’t know” responses, 34.5% were correct “know” responses, and 8% were correct “TOT” responses. A response was considered correct if the participant produced the correct answer after an initial or second “know” response or if they chose the correct answer for an unresolved TOT on the recognition test. Incorrect “know” responses (13.8%) and incorrect TOT responses (2.7%) were excluded from all statistical analyses.

Target Retrieval Following TOTs

Because the control words shared syntactic class with the target only half the time, a paired samples t-test was conducted on TOT resolution following lists containing control words. Lists containing controls that were the same part of speech as the target were compared with controls that were a different part of speech. Twenty-three participants could not be included in this analysis because they did not have any correct TOT responses preceding both types of control lists. The t-test was not significant, $t(35) = .184$, $p > .10$, as TOT resolution following presentation of same part-of-speech control words ($M = 27.3\%$) was equivalent to TOT resolution following presentation of different part-of-speech control words ($M = 28.9\%$). Therefore, the two types of control word lists were collapsed into a single unrelated condition for the remaining analyses.

For TOT responses, the mean percent of target retrieval and standard deviations following each priming condition are displayed in the top half of Table 2. A single-factor, repeated measures ANOVA was performed on percent correct retrieval of the target. This analysis was performed by participants and by items. Nine participants (15%) were unable to be included in the ANOVA, as were 52 items (54%), for not having at least one correct TOT in each of the three levels of Prime Condition. The effect of Prime Condition was significant in the subject analysis only, $F1(2, 98) = 3.24$, $MSE = 7.0$, $p < .05$, $F2 < 1$, although the trend in the item analysis was in the same direction as the participant analysis.[4] Post-hoc tests on the participant analysis revealed significant priming ($p < .05$), such that there was greater retrieval of the target following different part-of-speech primes relative to unrelated control words. Target retrieval following different part-of-speech primes was also greater than retrieval following same part-of-speech primes. In contrast, resolution of TOTs was equivalent for same part-of-speech primes and unrelated words ($p > .10$). To increase power in the item analysis to detect significant priming for different part-of-speech primes, pairwise comparisons were conducted between each type of prime and the unrelated control words. Paired-sample t-tests revealed marginally significant priming for different part-of-speech primes, $t(53) = 1.92$, $p < .06$, but not for same part-of-speech primes, $t(57) = .52$, $p > .10$, consistent with the participant analysis.

Target Retrieval Following Don't Knows

To examine whether the above priming effect was unique to TOT resolution, the same repeated-measures ANOVAs were conducted for percent correct retrieval of targets following "don't know" responses. The means and standard deviations are displayed in the bottom half of Table 2. Although no participants were eliminated from the participant analysis, 4 items (4%) were unable to be included for not having a "don't know" response in each of the three levels of Prime Condition. The ANOVA revealed no effect of Prime Condition in either the participant analysis, $F1 < 1$, or the item analysis, $F2 < 1$.

Correlations between Prime Frequency and Target Retrieval

To assess whether prime frequency influenced TOT resolution, Pearson correlations were computed between the primes' Francis and Kucera (1982) frequency ratings and the percent correct target retrieval following TOT responses. For same part-of-speech primes, there was a significant negative correlation, $r(150) = -.18$, $p < .05$, whereas there was a significant positive correlation for different part-of-speech primes, $r(147) = .17$, $p < .05$. In contrast, there was no significant correlation for unrelated controls, $r(154) = .09$, $p > .10$.

Correlations between Prime Position and Target Retrieval

Because the prime was presented in one of three list positions (second, third, or fourth word), it was possible that the prime's position influenced TOT resolution. Given the small number of TOT responses, it was not feasible to

conduct an ANOVA with list position as an additional factor; however, Pearson correlations were computed between the primes' position and the percent correct target retrieval following TOT responses. For same part-of-speech primes, there was a significant positive correlation, $r(151) = .20$, $p < .05$, whereas there was no significant correlation for either different part-of-speech primes, $r(148) = -.07$, $p > .10$, or unrelated controls, $r(154) = -.09$, $p > .10$. Means and standard deviations for each prime type and list position are shown in Table 3.

Discussion

The results demonstrate that presentation of phonologically related words does not always facilitate TOT resolution. As predicted by NST and the TD model (e.g., Burke et al., 1991; MacKay, 1987; MacKay & Burke, 1990), syntactic class of phonologically related words played a significant role, where only different part-of-speech primes facilitated TOT resolution relative to unrelated words. These results are consistent with other findings of phonological priming of TOT resolution (e.g., Abrams et al., 2003; James & Burke, 2000; White & Abrams, 2002) and extend earlier studies by illustrating that only a single presentation of a prime is needed to increase word retrieval, supporting the TD model's idea that recent presentation of words serves to strengthen connections to their phonological nodes. Furthermore, this phonological priming effect only occurred following TOT responses; retrieval of targets following "don't know" responses did not benefit from presentation of any phonologically

related word, also consistent with previous research (James & Burke, 2000; White & Abrams, 2002).

In contrast, presenting same part-of-speech primes had no effect on TOT resolution, such that resolution of TOTs following same part-of-speech primes was equivalent to TOT resolution following unrelated words, despite the shared phonology between the primes and targets. Consistent with the predictions of NST and the TD model, same part-of-speech primes "delayed" TOT resolution, resulting in no increased resolution relative to unrelated words. Interestingly, same part-of-speech primes did not inhibit TOT resolution, which would have resulted in fewer TOTs resolved relative to unrelated words. To achieve inhibition, a same part-of-speech prime must be a strong competitor of the target, which will enable the competitor to maintain its activation level for a longer period of time and result in inhibition of TOT resolution. The correlation analyses provide some evidence of factors that may lead to an inhibitory effect in TOT resolution for same part-of-speech primes: high word frequency and early list position. The Francis and Kucera (1982) frequency of the same part-of-speech primes *negatively* correlated with TOT resolution. This correlation indicates that more frequent same part-of-speech primes were less likely to lead to TOT resolution, as predicted by the TD model (e.g., MacKay & Burke, 1990). Theoretically, high-frequency primes take more time to decrease their activation levels, which must happen before the target can be activated, leading to a

reduction in retrieval of the target. By virtue of weaker connections, low-frequency primes can become deactivated relatively quickly, making them less competitive with the target for retrieval. The majority of same part-of-speech primes in this experiment were low frequency (i.e., 75% had a frequency less than 20), which may have also contributed to same part-of-speech primes not inhibiting TOT resolution overall. Another possibility is that some high-frequency primes produced inhibition, but the inhibition effect was cancelled out by low-frequency primes that produced facilitation.

A prime's position in the word list also significantly correlated with TOT resolution but positively: the earlier in the list the same part-of-speech prime occurred, the less likely the TOT was to be resolved. This finding is important because it suggests that for a same part-of-speech prime to compete with the TOT word, it must be presented quickly after the TOT occurs. Within NST and the TD model, some of the TOT word's phonological nodes may receive sufficient priming to become activated, even if the entire word cannot be retrieved. The activated phonological nodes then transmit priming bottom-up to all lexical nodes containing this phonology. Thus, as the interval between the onset of the TOT and the presentation of the prime increases (e.g., by presenting the prime later in the list), there is a greater likelihood that the bottom-up priming transmitted from the activated phonological nodes will have accumulated on a phonologically related word in a different syntactic domain, resulting in facilitation and making the same

part-of-speech prime less able to accumulate the most node priming to become a competitor. In contrast, early presentation of a same part-of-speech prime allows the prime to quickly become the most-primed word in its syntactic domain, preventing activation of the target and delaying TOT resolution. These findings cannot be explained by two-stage theories of language production (e.g., Levelt, 1989), which do not have a mechanism for allowing activation to spread "backward" from the phonology to the word-form level.

In contrast to same part-of-speech primes, a different part-of-speech prime's frequency and prime position had alternative relationships with TOT resolution. The frequency of different part-of-speech primes *positively* correlated with TOT resolution, consistent with the idea that primes outside of the target's domain can facilitate retrieval by transmitting node priming to phonologically related words, one of which is the target. Despite their opposite directions, the correlations for same and different part-of-speech primes were equivalent in magnitude, suggesting that frequency's influence was of similar strength in both conditions. Unlike word frequency, a prime's serial position had no relationship with TOT resolution for different part-of-speech primes. Since primes are in a different syntactic class, they are not competitors with the TOT word for retrieval, making the timing of their presentation irrelevant to TOT resolution.

In sum, the present experiment resolves a debate that has existed for decades: Do phonologically related words facilitate or impede TOT resolution?

The answer is that part of speech mediates the relationship between phonological priming and word retrieval during TOT states, a finding that is of considerable importance in understanding when blocking effects do and do not occur in speech production. The results of the present experiment also speak more generally to the role of syntactic class and its relevance to lexical retrieval in speech production. Syntactic class activates words that are candidates for production so that phonologically similar words within the same syntactic class compete with each other, whereas phonologically similar words in different syntactic classes facilitate word retrieval. This finding supports the existence of a fundamental syntactic mechanism for language production proposed within NST, where word order is controlled by activating only those words that are in the appropriate syntactic class.

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Author Notes

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Footnotes

[1]Abrams et al. (2003) showed that a single-phoneme prime was not sufficient for priming TOT resolution. Therefore, for six targets whose first syllable was a single phoneme, we included the next phoneme in both primes; for example, for the target “atone”, the primes were constructed to include the first phoneme of the second syllable, i.e., “attenuate” and “atrocity”. Most importantly, same part-of-speech primes and different part-of-speech primes contained the same amount of overlap for these targets.

[2]To ensure that primes in the same syntactic class as the target were no more semantically related to the targets than the primes in a different syntactic class, eight additional participants (who were not in the actual experiment) were shown the targets paired with the corresponding same part-of-speech prime as well as the targets paired with the different part-of-speech prime. All participants rated both pairs, but half rated the same part-of-speech primes first, and the other half rated the different part-of-speech primes first. Participants were instructed to "think carefully about the meanings of both words" and to rate each pair of words on a scale from 1 (not at all related) to 7 (identical in meaning) in terms of the words' overlap in their meanings. A paired samples t-test compared the mean ratings for the two types of primes and found no significant difference between the targets' semantic relation to same part-of-speech primes (M = 1.19) and different part-of-

speech primes (M = 1.14), $t(7) = 1.49$, $p > .10$, with both types of primes demonstrating virtually no semantic relation to the targets.

[3]Prime frequency was not manipulated as a variable because TOTs occur on a relatively small proportion of trials in experimental research (approximately 8-18% of retrieval attempts; A. Brown, 1991). A 3 (Prime Condition) x 2 (Prime Frequency) design would have resulted in only one or two correct TOTs in each of the six cells, which would increase within-participant variability and reduce statistical power (see also R. Brown & McNeill, 1966, and Burke et al., 1991).

[4]Item analyses in TOT research are not typically reported because many stimuli are eliminated due to insufficient TOTs in all conditions, resulting in low statistical power to detect significance in item analyses.

Table 1

Example Target Words, Primes, and Unrelated Control Words Shown with Part of Speech and Francis and Kucera (1982) Frequency

	Target	Same Part-of-Speech Prime	Different Part-of-Speech Prime	Unrelated Control Word
Word	**intransitive**	**incredible**	**insecticide**	**dictionary**
Part of Speech	adjective	adjective	noun	noun
Frequency	0	23	3	59
Word	**canonize**	**cancel**	**candid**	**hectic**
Part of Speech	verb	verb	adjective	adjective
Frequency	2	17	3	3
Word	**rosary**	**robot**	**robust**	**fever**
Part of Speech	noun	noun	adjective	noun
Frequency	3	4	0	19
Word	**actuary**	**acrobat**	**accurate**	**stimuli**
Part of Speech	noun	noun	adjective	noun
Frequency	0	1	35	0

Table 2

Target Word Retrieval (in %) Following Primes and Unrelated Control Words After an Initial "TOT" or "Don't Know" Response

Initial Response Priming Condition	*Mean Retrieval (Participant Analysis)*	*SD*	*Mean Retrieval (Item Analysis)*	*SD*
TOT				
Same Part-of-Speech Primes	26.0	28.6	23.1	33.2
Different Part-of-Speech Primes	37.1	37.6	30.2	36.5
Unrelated Control Words	25.0	28.6	22.0	35.3
Don't Know				
Same Part-of-Speech Primes	5.2	7.4	5.6	11.1
Different Part-of-Speech Primes	5.2	6.8	6.6	13.0
Unrelated Control Words	4.7	7.3	5.6	11.2

Table 3

Target Word Retrieval (in %) After an Initial "TOT" Response as a Function of Prime Type and List Position

Priming Condition / List Position	*Mean Retrieval*	*SD*
Same Part-of-Speech Primes		
Second Position	17.5	38.5
Third Position	21.3	41.3
Fourth Position	40.0	49.5
Different Part-of-Speech Primes		
Second Position	36.6	48.8
Third Position	33.3	47.6
Fourth Position	28.0	45.4
Unrelated Control Words		
Second Position	33.3	47.8
Third Position	23.5	42.7
Fourth Position	22.0	41.9