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Phonological Priming Effects on Word Retrieval and Tip-of-the-Tongue Experiences in Young and Older Adults

Lori E. James
Claremont Graduate University

Deborah M. Burke
Pomona College

In a repetition priming paradigm, young and older participants read aloud prime words that sometimes shared phonological components with a target word that answered a general knowledge question. In Experiment 1, prior processing of phonologically related words decreased tip-of-the-tongue states (TOTs) and increased correct responses to subsequent questions. In Experiment 2, the priming task occurred only when the participant could not answer the question. Processing phonologically related words increased correct recall, but only when the participant was in a TOT state. Phonological priming effects were age invariant, although older adults produced relatively more TOTs. Results support the transmission deficit model that the weak connections among phonological representations that cause TOTs are strengthened by production of phonologically related words. There was no evidence that phonologically related words block TOT targets.

The tip-of-the-tongue state (TOT) is a relatively common type of speech error in which a word retrieval failure is coupled with a strong feeling of knowing and often with a considerable sense of frustration at the inaccessibility of the desired word. Typically, a person can access semantic and syntactic properties of the TOT word and partial phonological properties such as initial sound or number of syllables, although the complete phonology remains inaccessible (e.g., A. S. Brown, 1991; R. Brown & McNeill, 1966; Koriat & Lieblich, 1974; Miozzo & Caramazza, 1997; Vigliocco, Antonini, & Garrett, 1997). Resolution of a TOT is as compelling as the TOT onset when it occurs spontaneously, with the target word popping into mind at a time when retrieval attempts have been abandoned (Burke, MacKay, Worthley, & Wade, 1991; A. S. Brown, 1991; Reason & Lucas, 1984). In this article, we investigate the phonological encoding processes that are fundamental to speech production and are implicated in the cause of TOTs and their spontaneous resolution. We also investigate the role of phonological encoding processes in aging effects. TOTs are a hallmark of old age, increasing in frequency with normal aging in both experimental and naturalistic studies (A. S. Brown & Nix, 1996; Burke et al., 1991; Cohen & Faulkner, 1986; Heine, Ober, & Shenaut, 1999; Maylor, 1990b; Rastle & Burke, 1996) and ranking as older adults' most annoying cognitive failure (Lovelace & Twohig, 1990).

TOTs are a valuable source of information about the nature of the processes and architecture of the speech production system. They require production models, for example, to account for successful selection of semantic and lexical information but failed selection of phonological information during word retrieval (e.g., Bock & Levelt, 1994; Caramazza, 1997). Models of speech production generally agree that semantic, lexical, and phonological information are represented in independent systems and that production begins with conceptualization processes that involve activation of semantic information and then selection of a syntactically specified lexical representation, followed by retrieval of corresponding phonological components of the word (e.g., Bock & Levelt, 1994; Burke et al., 1991; Caramazza, 1997; Dell, 1986; Harley & Bown, 1998; Levelt et al., 1991; MacKay, 1987; Martin, Weisberg, & Saffran, 1989). The vulnerability of phonological retrieval to failure has been explained in the transmission deficit (TD) model of TOTs in terms of the strength of the connections that transmit priming[1] to phonological representations (Burke et al., 1991; MacKay & Burke, 1990). This model is a detailed version of an insufficient activation model of TOTs wherein retrieval fails because of incomplete activation of representations

Lori E. James, Department of Psychology, Claremont Graduate University; Deborah M. Burke, Department of Psychology, Pomona College.

Lori E. James is now at the Department of Psychology, University of California, Los Angeles.

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Correspondence concerning this article should be sent to Deborah M. Burke, Department of Psychology, Pomona College, 550 Harvard Avenue, Claremont, California 91711. Electronic mail may be sent to dburke@pomona.edu.

[1] *Priming* has several different meanings in current cognitive psychology. The theoretical mechanism of priming is subthreshold excitation (MacKay, 1987), which is similar to spreading activation in some models. We indicate this meaning by, for example, *transmission of priming*. The experimental manipulation of priming occurs when target words are preceded by identical or related words. We indicate this meaning by using the phrase *priming condition*. The empirical effect of priming is a change in the availability of target information that is caused by prior processing of identical or related information. We indicate this meaning by using the phrase *priming effects*.

(e.g., Bowles, Obler, & Poon, 1989; A. S. Brown & Nix, 1996; R. Brown & McNeill, 1966; Cohen & Faulkner, 1986; Harley & Bown, 1998; Meyer & Bock, 1992; Yaniv & Meyer, 1987; see A. S. Brown, 1991, for a review).

According to the TD model, TOTs occur when the strength of the connections among phonological nodes is too weak to transmit sufficient priming for activation of the complete phonology of the TOT target word. The TD model is based on a general interactive activation model of language production and perception, node structure theory (NST), in which priming is a form of subthreshold excitation that prepares a node for activation or retrieval. The strength of the connections to nodes determines the rate and amount of priming transmitted to them and is an important determinant of what information in memory becomes available (MacKay, 1987). Recent and frequent activation of nodes—in production of a word, for example—strengthens connections, therefore increasing priming transmission, whereas aging weakens connections, reducing priming transmission (Burke & MacKay, 1997; Burke et al., 1991; MacKay & Burke, 1990). Because connection strength declines over time in the absence of activation, the TD account explains why TOTs, although they involve familiar words (see A. S. Brown, 1991), are more likely for low- than for high-frequency words and are also likely for words that have not been used recently (Burke et al., 1991; Harley & Bown, 1998; Rastle & Burke, 1996). The architecture of the phonological system renders it more vulnerable to TDs than the semantic system does, because phonological nodes are generally linked by single connections rather than by the multiple converging connections that characterize the semantic system (see Burke et al., 1991; Laver & Burke, 1993; MacKay & Abrams, 1996). This explains why access to phonology declines with aging (as indicated by increased TOTs) but access to the meaning of words, as measured by vocabulary tests (e.g., Schaie, 1996) or experimental semantic retrieval tasks (e.g., Light, 1992), does not decline, at least until very old age.

We test the TD model of TOTs using a repetition priming paradigm in which participants read prime words that share phonological components with a target word that answers a general knowledge question. We constrain repetition effects to the phonological level by eliminating overlap between the prime and the target at the perceptual,[2] lexical, and semantic levels. For example, representations for the prime word *pellet* and the target word *velcro* shown in Figure 1 overlap only at the phonological level, in this case at the nodes for /ɛl/. Darker lines indicate phonological connections strengthened by production of *pellet.* Inasmuch as a TOT for *velcro* is caused by transmission deficits among phonological connections for /ɛl/, strengthening these connections by saying *pellet* should reduce the likelihood of a TOT for *velcro* or increase the likelihood of resolution if a TOT for *velcro* has already occurred. Indeed, these predicted results would support the proposal that "spontaneous" resolution of TOTs in everyday life is triggered by phonological priming. It has been suggested that a TOT target word pops into mind "spontaneously" when phonological components of the word occur inadvertently during conversation and provide a boost in priming to the phonological nodes suffering from TDs (Burke et al., 1991; Seifert, Meyer, Davidson, Patalano, & Yaniv, 1994; Yaniv & Meyer, 1987).

Nonperceptual repetition priming effects on word production are well established, but only when repetition at a lexical level is involved. For example, young adults' picture naming is facilitated by prior production of the picture name in response to a printed word or definition (A. S. Brown, Neblett, Jones, & Mitchell, 1991; Durso & Johnson, 1979; Park & Gabrieli, 1995; Wheeldon & Monsell, 1992). Similarly, correct responses to general knowledge questions increase with prior processing of the responses (e.g., Blaxton, 1989; Kelley & Lindsay, 1993; Yaniv, Meyer, & Davidson, 1995), and this priming effect is invariant with aging (Rastle & Burke, 1996; Small, Hultsch, & Masson, 1995). The type of prior processing of target words influences priming effects for responses to general knowledge questions and provides evidence for the phonological locus of the retrieval failure in TOTs. Prior semantic processing increases correct production of targets more than prior phonological processing does, but the two types of processing are equally effective in reducing TOTs, presumably because both require pronunciation, which strengthens phonological connections (Rastle & Burke, 1996).

Only a few studies, however, have investigated phonological priming effects on production while eliminating prime–target overlap at the lexical level. These studies provide little evidence of priming effects. Prior production of a homophone in response to a definition (e.g., *One grows at the end of each finger*) speeds naming of a subsequent picture (e.g., *nail* [e.g., *hammer*]), but the effect is marginally significant and holds only for homophones that are spelled the same, not for differently spelled homophones (e.g., *son/sun;* Wheeldon & Monsell, 1992). Valentine, Moore, and Bredart (1995) found that prior production of homophones of the surnames of people (e.g., *bush* [e.g., *shrub*]) produced no significant priming effect on naming latency of pictures of famous people (e.g., Bush).

The duration of the prime-to-target-generation interval in these studies is standard for repetition priming paradigms, ranging from several minutes to 20 min or more. The mechanism responsible for a priming effect, were it to be observed, is a relatively long-term change in connection strength, which is the mechanism of interest in the present research (MacKay, 1987; Valentine et al., 1995; Wheeldon & Monsell, 1992). In contrast, researchers using a very brief prime-to-target-generation interval of a few hundred milliseconds reported that phonologically related prime words facilitated picture naming, and they attributed this to a different mechanism: a very short-lived residual priming in nodes that are common to the prime and target or that spread from prime to target (Collins & Ellis, 1992; McEvoy, 1988; Meyer & Schriefers, 1991; Schriefers, Meyer, & Levelt, 1990). Repetition priming paradigms, including the present research, are generally designed to eliminate the contribution of this mechanism through the delay between prime word processing and the target production task (see Wheeldon & Monsell, 1994, for discussion of this issue).

Another approach to investigating phonological priming effects on production has yielded quite different results. In this approach, participants are presented definitions of low-frequency words, followed by a word cue related to the target word. In studies in which cuing occurred before the participant answered the questions, Meyer and Bock (1992) reported that phonologically related cue words sharing the initial sound, number of syllables, and stress

[2] There was no perceptual overlap, because the target word was not presented.

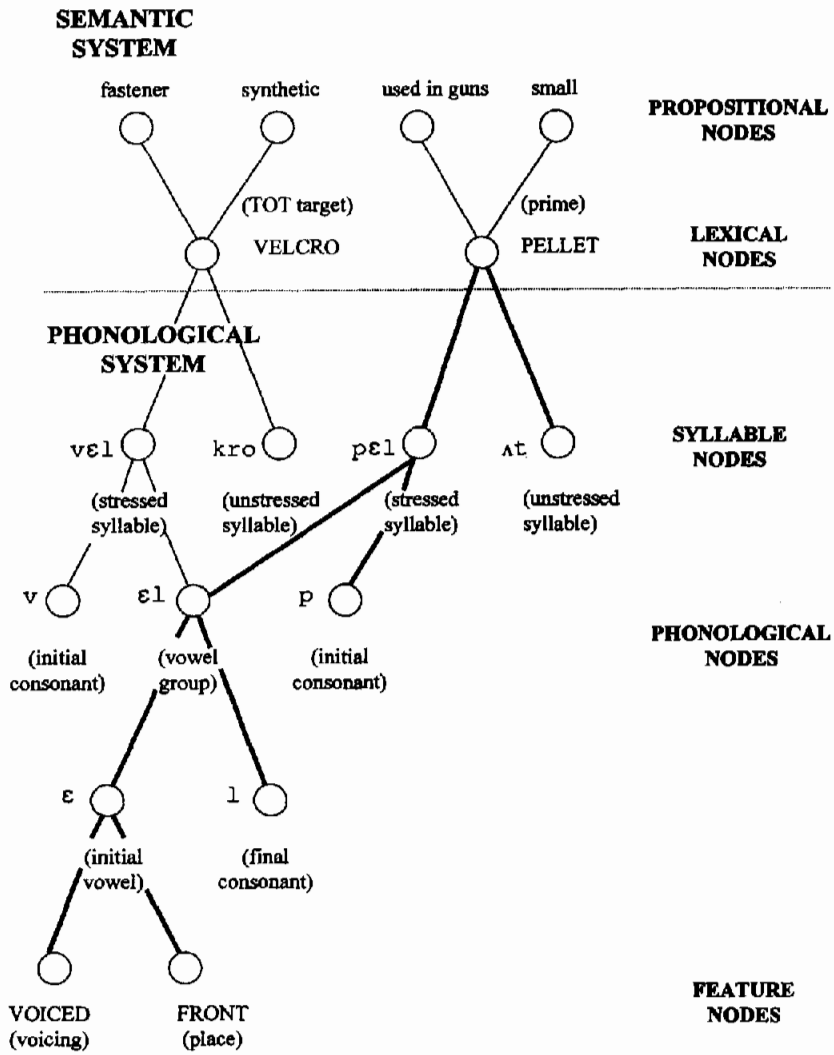

Figure 1. Semantic and phonological nodes representing the prime word *pellet* and the target word *velcro*. Many nodes necessary for producing these words have been omitted for simplification. Note that the representations for the two words overlap only at the phonological level. Phonological connections strengthened by saying *pellet* have been darkened. TOT = tip-of-the-tongue state.

pattern with the target word increased production of targets more than unrelated or semantically related cue words did. Using similarly constructed phonological cues, Perfect and Hanley (1992) also obtained a beneficial effect on target production, although it was smaller and only compared with unrelated cues. These studies, however, reported little effect of phonologically related cues on TOTs. Meyer and Bock (1992) found a marginally significant reduction in TOTs with phonologically related as compared with unrelated cues, and Perfect and Hanley (1992) reported no reduction compared with an unrelated or no-cue condition. In studies in which cuing occurred after a participant had failed to produce the correct response to a definition, there was no difference in the number of TOTs remaining after phonologically related and unrelated cues (Meyer & Bock, 1992). Correct responses, however, increased with presentation of a phonologically similar word (Kozlowski, 1977; Meyer & Bock, 1992), the initials for proper names (e.g., Brennen, Baguley, Bright, & Bruce, 1990), or the initial letters of the target word (e.g., Freedman & Landauer, 1966; Gruneberg & Monks, 1974; Hanley & Cowell, 1988; Heine et al., 1999).

As Meyer and Bock (1992) pointed out, facilitatory effects in these cuing paradigms may reflect strategic retrieval processes, not processes involved in normal word retrieval. A single prime, or cue, was presented with each question, and participants knew that the prime was sometimes related to the target and that it might aid recall of the target. Participants may have used this information to improve performance—for example, by generating word candidates sharing phonology with the prime or by rejecting responses dissimilar in sound to the prime. The present research aims to determine whether phonological priming effects on responses to general knowledge questions are obtained in a procedure that minimizes strategic processes and is more similar to repetition

priming paradigms such as the one established by Wheeldon and Monsell (1992).

Different predictions for the effects of phonologically related words on production are made by an alternative inhibition explanation of TOTs, in which TOTs are caused by blocking of the intended word by a more accessible alternative word that comes to mind first (e.g., A. S. Brown, 1979; Jones, 1989; Jones & Langford, 1987; Reason & Lucas, 1984; Roediger, 1974; Woodworth, 1929; see A. S. Brown, 1991, for a review). These alternative words usually share initial phonemes and number of syllables with the intended word (Burke et al., 1991; Kohn et al., 1987). According to the inhibition hypothesis, processing a word that is phonologically related to the intended word blocks its retrieval, increasing the probability of a TOT. Jones (1989; Jones & Langford, 1987; see also Maylor, 1990a) provided support for this hypothesis, reporting that TOT-inducing questions that were presented with a word that was phonologically related to the answer produced more TOTs than did questions presented with a word that was not phonologically related. Two studies, however, provide evidence that this influential result occurred because specific questions were assigned to only one cue word condition and the questions assigned to the phonologically related word condition produced more TOTs than did questions assigned to other conditions, independent of prime word (Meyer & Bock, 1992; Perfect & Hanley, 1992). These two studies provide no evidence that phonologically related words impair retrieval. Despite the absence of supporting evidence and the availability of counterevidence, the blocking explanation of TOTs has a tenacious hold and is widely cited (e.g., Schacter, 1999).

There is, however, evidence that once a TOT occurs, an alternative word that comes to mind spontaneously delays resolution. Burke et al. (1991) reported that young and older adults took considerably longer to resolve naturally occurring TOTs that were accompanied by persistent alternate words, most of which shared phonological features with the target, than to resolve TOTs without persistent alternates. Similarly, laboratory-induced TOTs were much less likely to be resolved during the experiment if they occurred with persistent alternates than if they did not. Burke et al. argued that persistent alternates are a consequence, not a cause, of TOTs and are activated when the target word cannot be retrieved. Once the persistent alternate is activated, its lexical node is more accessible than the target's until the effects of the recent activation of the alternate subside (see Burke et al., 1991). It is an interesting paradox that spontaneously occuring persistent alternates delayed TOT resolution, whereas in another study, phonologically related words presented by the experimenter facilitated TOT resolution (e.g., Meyer & Bock, 1992). In Experiment 2, we examine further the effect of related words on TOT resolution.

The present research is designed to test the TD model's prediction that production of words that are phonologically related to a target word reduces TOTs for the target or increases resolution if a TOT for the target has already occurred. Within this framework, the mechanism responsible for improved target retrieval is a relatively long-term change in connection strength that occurs without the participant's awareness. To investigate this process, it is essential to eliminate retrieval or guessing strategies that are based on prime words, because these might mimic positive priming effects. Previous studies of the effects of phonologically related words on the production of answers to questions have presented a single cue word that is phonologically related on 33% or more of the trials. We designed our experiment with the paramount goal of measuring priming effects without the participant's awareness of the relation between prime words and targets, thereby eliminating retrieval strategies. Several aspects of our methodology are critical for this goal.

First, for a given target word, processing of prime words was accomplished in a pronunciation rating task that was introduced as a task completely separate from the question answering. Second, the priming stimulus for a single question was not a single word but 10 words that participants read aloud and rated on pronunciation difficulty. On half of the trials, the 10 words were all phonologically unrelated to the target; on the other half of the trials, 5 of the words were unrelated and 5 were phonologically related to the target. This relatively large number of words for a single target disguises prime–target relatedness and makes quite onerous any attempt at strategic use of the words, if they can be remembered. Moreover, there were no clues to which list contained related words, no clues to which words, if any, were related, and no indication that any word was ever related to the target word. Third, the relatedness between target and prime words was difficult to notice even if the target was produced, because a related prime word and the target often overlapped only in one or two phonemes, and most were not initial phonemes. The related words could not be distinguished from the unrelated words, because they were not related to each other any more than the unrelated words were related to each other: Phonological segments repeated among related words on a list as little as possible, and any overlap in phonemes among list words occurred equally often on related and unrelated lists. For example, in the related list shown in Figure 2 for the target *abdicate*, related words *indigent* and *tradition* overlap with each other, but so do unrelated words *tappet* and *velvet*. Related words *truncate* and *locate* overlap, but *truncate* and *tradition* also overlap in components that are not shared with the target. Thus, repeated phonological components within a list are not a clue to the phonology of the target, nor do they identify the related words. The unrelated list for *abdicate* was as follows: *vector, rejoicing, serious, tappet, liniment, velvet, procedure, reread, publish, older*. These unrelated words overlapped, eliminating overlap as a clue to relatedness (e.g., *tappet* and *velvet, vector* and *velvet, rejoicing* and *reread, procedure* and *publish*). Finally, the presentation rate for prime words was brisk, allowing little time for strategies.

Experiment 1

In this experiment, we presented the pronunciation task before each question to examine the effect of phonologically related prime words on correct responses and TOTs in both young and older adults. Although processing prior to the production task is standard in repetition priming paradigms, this procedure has not been used in studies of phonological effects on TOTs, with one exception (Jones, 1989). The TD model predicts an increase in correct recall through a decrease in TOTs, because the prime words strengthen phonological connections that are vulnerable to TDs.

As for aging and priming effects, no age differences were obtained in two studies showing repetition priming effects on responses to general knowledge questions (Rastle & Burke, 1996;

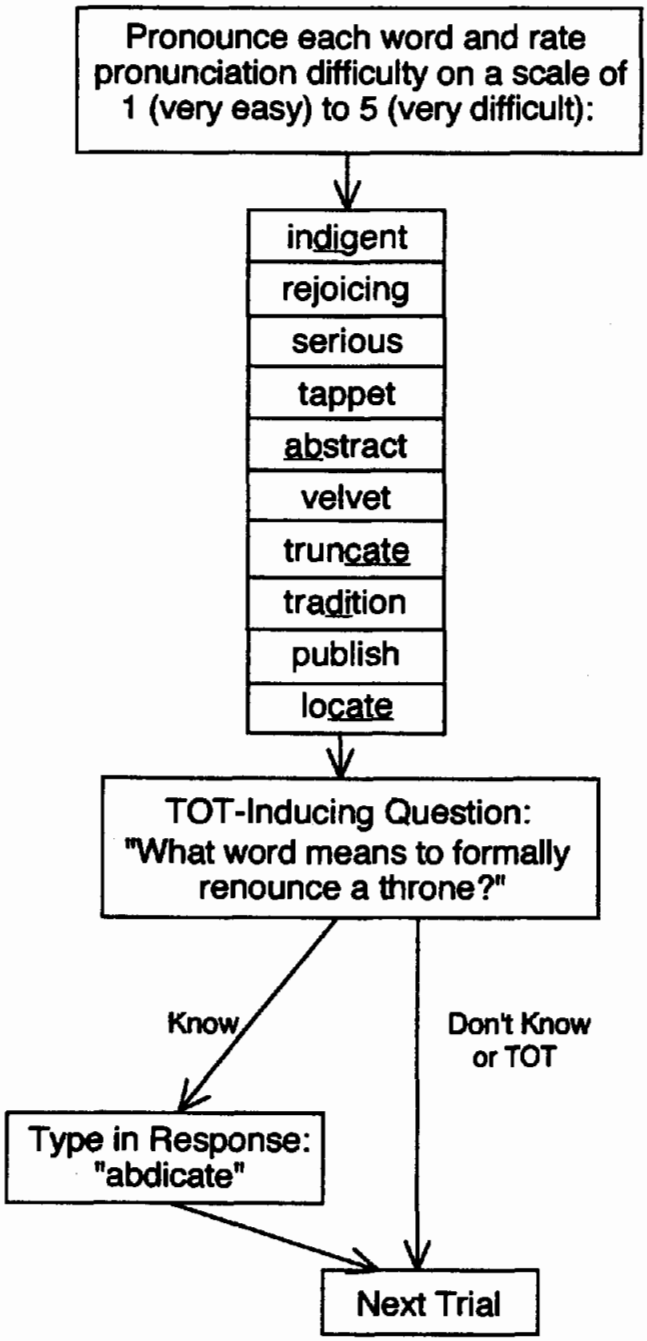

Figure 2. Example of presentation of general knowledge questions and phonological processing task in Experiment 1. A related list of words is displayed, with the phonological components overlapping the target word underlined. They were not underlined in the experiment. TOT = tip-of-the-tongue state.

Small et al., 1995). Repetition priming effects in general show little age difference in individual studies, although slightly smaller effects for older adults emerge in meta-analyses (e.g., LaVoie & Light, 1994). Under the TD model, repetition at the lexical or phonological level improves retrieval by strengthening existing connections, a process that is age invariant (MacKay & Burke, 1990). Thus, although older adults are more susceptible to TOTs because they are more likely to suffer TDs, the benefit from phonological priming should be equivalent in young and older adults, and any age difference in TOTs should remain.

The results are also relevant to the inhibition hypothesis, which predicts a decrease in correct recall and an increase in TOTs following phonologically similar prime words. Although this hypothesis has received little support in previous studies, strategic use of phonologically related cue words may have offset any negative effect. Researchers have proposed that inhibitory processes are less efficient in old age (Hasher & Zacks, 1988); thus, any blocking effect by related prime words should be smaller for older than for young adults within this framework.

Method

Participants. Participants were 36 young (M = 19.4 years old, SD = 1.3) and 36 healthy older adults (M = 72.0, SD = 5.1). Young adults participated for credit in introductory psychology courses, and older adults were paid for their participation. Mean score on the Nelson–Denny (J. I. Brown, 1960) vocabulary test was lower for young (M = 17.4, SD = 2.8) than for older participants (M = 21.6, SD = 3.0), $t(67) = 6.04$, $p < .001$. Mean years of education was 13.4 (SD = 1.2) and 16.5 (SD = 3.6) for young and older adults, respectively. All participants were native English speakers.

Materials. We selected 114 questions, each answered by a single low-frequency word, from a pool of questions used in previous studies to induce TOT states (e.g., Burke et al., 1991; Yaniv & Meyer, 1987). When relevant data were available, we selected questions that elicited comparable numbers of TOTs in young and older adults, so as to maximize the number of TOTs elicited in the experiment. For each of the 114 target words, two lists of 10 words each were compiled. A related list contained 5 words that were phonologically related to the target and 5 words that were phonologically unrelated to the target, and an unrelated list contained 10 words unrelated to the target. All list words were semantically unrelated to the target. The phonologically related words were selected from the dictionary on the basis of sharing one or more phonemes with the target word. Syntactic class of prime words was not controlled, but, on average, 3.1 out of the 5 phonologically related prime words shared syntactic class with the target word. The Appendix presents the target words and phonologically related prime words used in Experiments 1 and 2 and indicates overlap in phonemes and grammatical class.

Certain constraints were placed on the selection of phonologically related words to minimize participants' awareness of the words' phonological similarity to the target words. For two-syllable targets, only one of the five related words shared a whole syllable with the target word; the other four related words shared only parts of syllables (e.g., the initial or final phoneme of the first syllable). For targets with three or more syllables, most related list words shared only one syllable with the target. The five unrelated words in the related list were matched with the phonologically related words on number of syllables and frequency (Francis & Kucera, 1982) but shared no phonology with the target. The unrelated list contained the five unrelated words from the related list and five new unrelated words that were matched on number of syllables and frequency. For each participant, half the questions were associated with a related list and half with an unrelated list, with the assignment of questions to list type counterbalanced over participants.

A multiple-choice recognition test included the question and four possible answers: the target, a phonologically related word (not a prime word), a semantically related word, and an unrelated word.

Procedure. A Macintosh computer presented instructions and stimuli and also recorded responses. The instructions informed participants that

"an answer is on the 'tip of your tongue' (TOT) if you know you know the answer but you cannot produce the answer at this moment. You are only in a TOT state if you are SURE you know the correct answer. Being able to recognize the correct answer if it were presented to you is NOT the same as being in a TOT state." The instructions also indicated that the pronunciation task was unrelated to the general knowledge questions.

The events on a trial are shown in Figure 2. A related or unrelated list of words was presented one word at a time on the monitor. Participants pronounced each word aloud and rated it on pronunciation difficulty, with 1 being *very easy* and 5 being *very difficult.* Each word remained on the screen for 4 s or until the participant gave a response, whichever came first. Immediately after the 10th word, a question appeared on the computer monitor, and participants responded by typing on the keyboard *1, 2,* or *3* to indicate "TOT," "don't know," or "know," respectively. After a "know" response, participants typed in the word, and immediately the next trial began with presentation of the pronunciation list for the next question. After a "TOT" or "don't know" response, the next trial began immediately with presentation of the pronunciation list. Each question was presented only once, and no backtracking or changing previous responses was possible. After 2 practice trials and the first 60 experimental trials, participants took a break, during which they completed a background questionnaire and the vocabulary test. Then they performed the remaining 54 trials. Following all trials, questions that had elicited a "TOT" response were presented in the paper-and-pencil multiple-choice recognition test. Participants were told to circle the word for which they were having a TOT, to verify that their TOT state was for the intended target word.

Results and Discussion

Table 1 presents the percentages of correct "know," "TOT," and "don't know" responses following related (primed) and unrelated (unprimed) lists by age group. The analysis of "know" responses excludes trials on which a participant responded "know" and typed an incorrect answer. Such incorrect "know" responses occurred on 9.2% and 15.7% of the trials for young and older adults, respectively. The analysis of "TOT" responses excludes trials on which a participant responded "TOT" but did not select the target word on the multiple-choice test. Such incorrect "TOT" responses occurred on 5.0% and 3.9% of trials for young and older adults, respectively. An analysis of variance (ANOVA) with Age and Prime Condition as factors was performed on number of responses, separately for "know" and "TOT" responses. Because the different types of responses are not independent, we limit the analyses to these primary measures. We report analyses by participant (F_1) and by item (F_2).

More correct "know" responses followed related than unrelated lists, $F_1(1, 70) = 12.19$, $MSE = 21.23$, $p < .01$; $F_2(1, 113) = 25.20$, $MSE = 3.38$, $p < .01$, and older adults produced more correct "know" responses than young adults did, $F_1(1, 70) = 4.19$, $MSE = 112.87$, $p < .05$; $F_2(1, 113) = 9.72$, $MSE = 15.85$, $p < .01$. There was no Prime Condition × Age interaction, $F_1(1, 70) = 0.003$, $MSE = 21.23$; $F_2(1, 113) = 0.01$, $MSE = 3.36$. As can be seen in Table 1, the priming effect (the difference between primed and unprimed "know" responses) was virtually identical for young and older adults: 4.6 and 4.8, respectively. The unbiased effect size for the age difference in priming effects, calculated following the procedures of Wolf (1986) and Hedges (1984), was essentially zero ($d = .006$), suggesting that the absence of a significant age interaction with prime condition was not a power problem. Fewer TOTs followed related than unrelated lists, $F_1(1, 70) = 6.34$, $MSE = 7.18$, $p < .05$; $F_2(1, 113) = 6.78$, $MSE = 2.17$, $p < .05$. This effect is more apparent in absolute number of TOTs than in percentage, with the young adult $M = 5.86$ and 6.69 and the old adult $M = 6.44$ and 7.86 for related and unrelated lists, respectively. The effect of age on number of TOTs was not significant, $F_1(1, 70) = 1.04$, $MSE = 26.43$; $F_2(1, 113) = 2.61$, $MSE = 3.23$, both $ps > .10$, and there was no Age × Prime Condition interaction, $F_1(1, 70) = 0.43$, $MSE = 3.06$; $F_2(1, 113) = 0.49$, $MSE = 0.88$, both $ps > .40$. As can be seen in Table 1, the priming effect was slightly smaller for young than for older adults: 1.4 and 2.5, respectively. The unbiased effect size for the age difference in priming effects ($d = .155$), is small (Cohen, 1992). To obtain significance with a small effect size at $p = .05$ and a .80 level of power requires 393 participants per group (Cohen, 1992).

Although TOTs usually increase in old age, the lack of age differences here is unsurprising, because we selected questions that produced the most TOTs and the smallest age difference in TOTs in previous studies. Nonetheless, TOTs can only occur when a word is not immediately recalled, and older adults produced more correct answers than young adults did. To adjust for any possible age differences in opportunity for TOTs, we calculated TOTs as a proportion of unsuccessful retrievals (e.g., incorrect "know," in-

Table 1
Percentages of Response Types as a Function of Prior Phonological Priming: Experiment 1

	Age group							
	Young				Old			
	Primed		Unprimed		Primed		Unprimed	
Type of response	%	*SD*	%	*SD*	%	*SD*	%	*SD*
Correct know	40.9	11.9	36.3	11.6	47.4	17.8	42.6	15.2
TOT	10.3	6.2	11.7	6.3	11.3	8.6	13.8	7.4
Don't know	34.9	9.5	37.5	11.2	21.8	11.2	24.0	14.0
TOT/incorrect[a]	16.9	8.6	18.1	8.7	20.5	11.8	24.6	12.6

Note. One hundred fourteen questions were presented, 57 primed and 57 unprimed (see text for explanation). Percentages do not sum to 100% because incorrect knows and incorrect TOTs are excluded. TOT = tip-of-the-tongue state.

[a] TOTs as a percentage of the sum of incorrect responses (don't know, TOT, incorrect TOT, and incorrect know).

correct "TOT," correct "TOT" and "don't know" responses; A. S. Brown & Nix, 1996; Burke et al., 1991). The proportion of TOTs (converted in Table 1 to percentage) was lower following related than unrelated lists, $F_1(1, 70) = 5.09$, $MSE = 0.00$, $p < .05$; $F_2(1, 113) = 6.43$, $MSE = 0.00$, $p < .05$. This relative proportion of TOTs was greater for older than for young adults, $F_1(1, 70) = 5.23$, $MSE = 0.02$, $p < .05$; $F_2(1, 113) = 3.53$, $MSE = 0.00$, $p = .06$.

In summary, prior processing of phonologically related words increased correct retrieval of target words and reduced TOTs. The pattern of priming effects is consistent with the TD model that production strengthens connections in the phonological system, reducing deficits in transmission of priming and thereby reducing TOTs for words that share the same connections (see Figure 1). There was no age difference in phonological priming effects on production of correct responses or TOTs, and the age difference in TOTs as a proportion of incorrect responses remained in the primed condition. Under the TD model, the baseline strength of connections is reduced by aging, making older adults more susceptible to retrieval failures. Within this framework, the age invariance in priming effects indicates that increments in connection strength caused by activation are similar across age. The age invariance in priming effects also is inconsistent with a strategic basis for priming, because episodic recall declines with age (e.g., Burke & Light, 1981), so young adults would be more successful than older adults in remembering list words after the question was presented, and this would yield greater cuing effects, were such a strategy used. Finally, both the age invariance in priming effects and their positive nature provide no support for inhibitory effects of phonologically related words.

Experiment 2

In Experiment 2, the pronunciation task was presented after the general knowledge question and only when there was no word produced in response to the question. When participants responded "TOT" or "don't know," they performed the pronunciation rating task and then attempted to answer the question again. According to the TD model, processing phonologically related words should increase the strength of the weak phonological connections that cause TOTs and thereby promote retrieval and resolution of the TOT. In addition to the theoretical implications, observing this predicted effect would provide insight into a possible mechanism producing "spontaneous" resolution of naturally occurring TOTs, namely that they are triggered by phonological priming from language input. On the other hand, if phonologically related words block target retrieval either through inhibition (Jones, 1989) or through their increased accessibility (Burke et al., 1991), then they should reduce TOT resolution.

Method

Participants. Participants were 18 young adults ($M = 18.6$ years old, $SD = 1.4$) and 18 healthy older adults ($M = 71.8$, $SD = 5.1$). Young adults received credit in introductory psychology courses, and older adults were paid for their participation. The mean score on the Nelson–Denny vocabulary measure was lower for young ($M = 17.4$, $SD = 2.0$) than for older participants ($M = 22.5$, $SD = 1.3$), $t(33) = 8.78$, $p < .001$. Mean years of education was 13.1 ($SD = 1.1$) and 17.1 ($SD = 2.3$) for young and older adults, respectively. All participants were native English speakers.

Materials. We selected 80 general knowledge questions from the same sources as in Experiment 1; in some cases, these were the same questions used in Experiment 1. The phonologically related and unrelated lists and the multiple-choice recognition test were constructed as in Experiment 1 (see Appendix). For each participant, half the questions were associated with a related list and half with an unrelated list, with the assignment of questions to list type counterbalanced over participants. This assignment was done in advance of the participants' responses, but it determined which prime condition was presented when a "TOT" or "don't know" response was given.

Procedure. The computer program designed for Experiment 1 was modified so that each trial began with the general knowledge question. Participants indicated on the keyboard one of three responses: "know," "don't know," or "TOT," as in Experiment 1. After a "know" response, participants typed in the word. After a "TOT" or "don't know" response, a related or unrelated list of words was presented one word at a time. Participants pronounced each word aloud and rated it on pronunciation difficulty, with 1 being *very easy* and 5 being *very difficult.* Then the question was re-presented. Participants who now knew the answer typed in the word and proceeded to the next trial, and participants who still had a TOT or did not know the answer went immediately to the next trial. No backtracking or changing previous responses was possible.

Participants were given 2 practice trials, followed by 80 experimental trials. After completing a background questionnaire and the vocabulary measure, participants were re-presented the questions that had elicited a "TOT" response on their second presentation. Questions that were not answered on this postsession presentation were presented in a multiple-choice recognition test. All other aspects of the procedure followed Experiment 1.

Results and Discussion

Table 2 presents the percentage of correct "know," "TOT," and "don't know" responses on the initial presentation of the questions by age group. The analysis of "know" responses excludes trials on which a participant responded "know" and typed an incorrect answer (10.4% and 16.3% of the trials for young and older adults, respectively). The analysis of "TOT" responses excludes trials on which a participant responded "TOT" initially but produced an incorrect answer on a subsequent presentation of the question or did not select the target word on the multiple-choice test (6.9% and 8.0% of the trials for young and older adults, respectively).

One-way ANOVAs on the number of responses were performed separately for "know" and "TOT" responses, with Age as a factor

Table 2
Percentages of Response Types for Initial Presentation of Questions: Experiment 2

	Age group			
	Young		Old	
Type of response	%	*SD*	%	*SD*
Correct know	36.0	12.0	40.4	12.8
TOT	7.9	4.8	11.4	7.5
Don't know	38.8	11.6	24.0	11.2
TOT/incorrect[a]	12.4	7.3	19.1	11.0

Note. Percentages do not sum to 100% because incorrect knows and incorrect TOTs are excluded. TOT = tip-of-the-tongue state.
[a] TOTs as a percentage of the sum of incorrect responses (don't know, TOT, incorrect TOT, and incorrect know).

and using both participants (F_1) and items (F_2) as units. Older adults produced more "know" responses than young adults did, but this difference was smaller than in Experiment 1 and was not significant, $F_1(1, 34) = 1.12$, $MSE = 98.78$, $p = .30$; $F_2(1, 79) = 2.18$, $MSE = 11.40$, $p = .14$. Older adults produced more TOTs than young adults did, although the effect reached significance only in the item analysis, $F_1(1, 34) = 2.75$, $MSE = 25.29$, $p < .11$; $F_2(1, 79) = 6.63$, $MSE = 1.91$, $p < .02$. As in Experiment 1, the proportion of unsuccessful retrievals (incorrect "know," "don't know," correct "TOT," and incorrect "TOT" responses) that were correct TOTs was greater for older than for young adults, $F_1(1, 34) = 4.59$, $MSE = 0.01$, $p < .05$; $F_2(1, 79) = 8.41$, $MSE = 0.03$, $p < .01$. These proportions are shown as percentages in Table 2.

The effect of priming on the resolution of "TOT" and "don't know" responses is shown in Table 3 for each age group. These data combine responses on the second and the final (end of session) presentations of the questions. Three young participants were excluded from this analysis because they had no TOTs in one of the prime conditions. An ANOVA with age, prime condition (related, unrelated), and original response ("don't know," "TOT") as variables was performed on the proportion of correct responses. The analysis was performed with participants, but not question, as the unit, because so few questions elicited TOTs for both young and older adults in both the primed and the unprimed conditions (see R. Brown & McNeill, 1966, and Burke et al., 1991, for a discussion of the fragmentary data problem characteristic of TOTs). More resolutions followed "TOT" than "don't know" responses, $F(1, 31) = 165.51$, $MSE = 0.06$, $p < .001$, and related than unrelated lists, $F(1, 31) = 7.75$, $MSE = 0.04$, $p < .01$. As can be seen in Table 3, the priming effect depended on original response, occurring for TOTs but not for "don't know" responses, $F(1, 31) = 7.19$, $MSE = 0.04$, $p < .02$. There was no significant Age × Prime Condition interaction, $F(1, 31) = 0.39$, $MSE = 0.04$, and no other significant main effects or interactions. As can be seen in Table 3, the priming effect was slightly larger for young than for older adults. The unbiased effect size for the age difference in priming effects ($d = .219$) is a small effect size (Cohen, 1992), which requires approximately 393 participants per group to reach significance at $p = .05$ and a .80 level of power (Cohen, 1992). However, it is important to note that the direction of the age difference in priming effects was in the opposite direction from that in Experiment 1.

Because of the small number of TOTs in the primed and unprimed conditions in Table 3, we also conducted a sign test to determine whether the number of participants who recalled more targets in the primed condition than in the unprimed condition was greater than chance. Excluding ties, 9 out of 13 young adults recalled more targets in the primed than in the unprimed condition ($p = .13$), and 12 out of 15 older adults did so ($p < .05$). For both ages combined, 21 out of 28 participants showed the priming effect ($p < .01$).

There is no evidence that the related prime condition improved retrieval following "don't know" responses. We evaluated the possibility that the related prime condition increased the frequency that "don't know" responses were changed to correct "TOT" responses on the second or third question presentation. If the related prime condition increased priming at the lexical level in cases in which participants believed they did not know the target word, then an increase in TOTs would occur (cf. Meyer & Bock, 1992). However, this occurred very infrequently, on less than 3.5% of trials in any condition or age, and there was no significant effect of age or condition. The lack of benefit from the related prime condition following a "don't know" response contrasts with Kozlowski's (1977) finding that a rhyming cue word increased target recall by the same amount both when participants were in a TOT state and when the answer was unknown. Kozlowski told participants that the cue word rhymed with the target sometimes, and a rhyme cue was presented on half of the trials. Thus, it seems likely that participants were able to use the cue in guessing strategies and to guess the correct answer regardless of whether or not they were in a TOT state. The absence of any effect of the related prime condition following "don't know" responses in the present study is consistent with participants being unaware of the relation of list words to the target.

Anecdotal comments during participant debriefing were also consistent with participants' lack of awareness. Some participants reported that they thought the purpose of the list words was to *distract* them from trying to answer the question and make retrieval more difficult (e.g., "I thought the list words were to confuse me"). There was nothing in their spontaneous comments to suggest that the participants had gleaned the structure of the lists or had used a cuing strategy. When debriefed about the phonological relatedness, 1 participant replied, "I noticed that once after I remembered the word." Not one participant reported using list words as cues.

Given the absence of any indication that the benefit from the related prime condition was a consequence of strategies, the results support the TD hypothesis that TOTs are caused by weak phonological connections that can be strengthened by activation of the relevant phonological nodes, enabling production of the target.

Table 3
Percentage Correct Recall of Target Words and Priming Effect (PE) Following TOT or Don't Know Responses as a Function of Phonological Priming Condition: Experiment 2

	Age group					
	Young			Old		
Initial response	Primed	Unprimed	PE	Primed	Unprimed	PE
TOT	69.7	47.5	22.2	73.6	57.8	15.8
Don't know	2.9	2.1	0.8	7.3	8.4	−1.1

Note. TOT = tip-of-the-tongue state.

These findings support the argument that "spontaneous" resolution of TOTs may be triggered by language input involving critical phonological components of the TOT target. Older adults reported more TOTs, but the effect of phonological processing was invariant across age, suggesting that phonological activation produced a comparable change in connection strength in young and older adults. The data provide no support for the view that phonologically related words block target retrieval.

General Discussion

The results demonstrate that processing phonologically related words reduces TOTs and increases retrieval of answers to general knowledge questions, under conditions that minimize the opportunity for strategic processes. In Experiment 1, prior production of words that were phonologically related to a target word increased production of the target in response to a general knowledge question and decreased the probability of TOT. Older adults produced relatively more TOTs than young adults did, but because priming effects were age invariant, the age difference remained in the primed condition. In Experiment 2, production of phonologically related words after the onset of a TOT increased the probability of resolution of the TOT. There was no comparable positive priming effect on retrieval following a "don't know" response. Older adults again produced more TOTs, and priming effects on resolution were age invariant. These results contribute to our understanding of the mechanism that produces TOTs and age-related changes in TOTs and highlight the significance of priming effects in speech production.

Interpretation of these results in terms of general language processes would be precluded if there were evidence that the results were influenced by strategies that are not part of normal language processing. The evidence suggests, however, that the experimental paradigm was successful in avoiding contamination by strategies. First, if related lists increased correct responses in Experiments 1 and 2 because participants compared possible responses with memorized list words or guessed the target on the basis of memorized list words, this effect should certainly be smaller in older than in young adults, contrary to the findings. Older adults would be less able to remember list words because of age-related declines in episodic recall (e.g., Burke & Light, 1981). Second, the lack of priming effects on target retrieval following "don't know" responses in Experiment 2 provides counterevidence to the use of strategies to guess the target. Finally, anecdotal comments during participant debriefing were consistent with participants being unaware of the relation of lists to targets.

Transmission Deficits Versus Blocking as a Cause of TOTs

The results support the TD hypothesis that TOTs are caused by weak phonological connections that transmit insufficient priming to retrieve the phonology corresponding to an activated lexical representation for the target word. Processing phonologically related words counteracts these TDs by activating phonological representations shared with the target, thereby strengthening connections and enabling target retrieval. The representations for prime and target words overlap only at the phonological level (see Figure 1). Thus, the facilitatory priming effect locates the TOT deficit in these phonological connections under the TD model. The present research does not identify which aspects of the phonological overlap between prime and target words are critical for priming effects, but recent research in a similar paradigm has shown larger priming effects when words overlap in the initial rather than in the middle or final syllable (White & Abrams, 1999).

Would this increase in phonological connection strength be expected to facilitate lexical selection, for example, by improving target retrieval following a "don't know" response that occurs when no lexical node has been activated? Lexical selection is driven primarily by top-down semantic processes triggered by the question; phonological processes may play a role in lexical selection under interactive models of production but not sequential stage models. In stage models of production (e.g., Levelt, 1989; Levelt et al., 1991), lexical and phonological retrieval are modular, sequential stages; lexical access is accomplished on the basis of semantic information without input from the phonological system, so changes in phonological connections have no impact. In NST and other interactive activation models (e.g., Cutting & Ferreira, 1999; Dell, 1986; Dell & O'Seaghdha, 1991; MacKay, 1987; Martin et al., 1989), priming spreads bidirectionally between lexical and phonological levels during lexical selection. Strengthening phonological connections relevant to the target word increases transmission of priming back up to the target lexical node during lexical selection. In a "don't know" state in which no word is selected, however, there is no basis for assuming that the target lexical node is even competing for lexical selection. Thus, it is unsurprising that phonological priming produced no improvement in correct retrieval following "don't know" responses in Experiment 2.

The results provide no support for an inhibitory effect of phonologically related words on target retrieval. Some investigators have suggested that phonologically related alternate words that come to mind during a TOT are blockers that cause the TOT by inhibiting the intended word (e.g., Jones, 1989; Reason & Lucas, 1984). The only direct evidence that phonologically related words increase TOTs (Jones, 1989; Jones & Langford, 1987) appears to be a consequence of the specific questions assigned to this condition (see Meyer & Bock, 1992; Perfect & Hanley, 1992). Thus, despite the strong phenomenological experience that alternate words block target retrieval, direct experimental tests of an inhibition model of TOTs have yielded negative results. Nonetheless, further research on inhibitory effects may be motivated by findings that semantic similarity between prime and target words under certain conditions slows naming latency (Wheeldon & Monsell, 1994), increases naming errors (e.g., Vitkovitch & Humphreys, 1991), and increases TOTs without reducing correct recall (Meyer & Bock, 1992). Moreover, resolution time was longer for naturally occurring TOTs with a persistent alternate word that came repeatedly to mind. Alternate words shared initial phoneme, number of syllables, and syntactic class with target words at greater than chance probability (Burke et al., 1991), but their semantic overlap has not been evaluated. No research has yet constrained overlap between a phonologically related prime word and the target on all the dimensions shown to be important in naturally occurring persistent alternates. It remains for future research to determine under what conditions phonologically related words, shown to facilitate TOT resolution in the present research, impede TOT resolution as do spontaneous persistent alternates.

Locus of Priming Effects

Wheeldon and Monsell (1992) reported faster picture-naming latency with prior production of a picture name, (e.g., *sun*) but not a homophone of the picture name (e.g., *son*). On the basis of these findings, they suggested that priming effects on word production require prime–target overlap at the lexical level, which does not occur with homophone primes. The present results, however, demonstrate priming effects that depend on overlap at the phonological, not the lexical, level. The discrepancy between the Wheeldon and Monsell (1992) results and the present results is likely because of the difference in the frequency of occurrence of the target words in the two studies. That is, priming at the phonological level may only be observed in production tasks that involve words with weak phonological connections—for example, low-frequency words with relatively rare phonological components. TOTs are more likely for low- than for high-frequency words and for words with few rather than many phonological neighbors (Harley & Bown, 1998), because the infrequent activation of phonological components of these words makes them vulnerable to TDs. Such words are expected to benefit from activation of phonological components by pronunciation of a phonologically related prime word. In contrast, Wheeldon and Monsell (1992) used words that name common objects (e.g., *sun*) and are unlikely candidates for weak phonological connections, because of their relatively high frequency of occurrence. Such words may show no measurable long-term priming effect from phonologically related words, because their connection strength at the phonological level is very high. It is important to note that this argument holds for longer term priming effects based on changes in connection strength; it does not apply to short-lived priming effects occurring with brief prime–target intervals and resulting from a spread of priming from prime to target nodes. There is considerable evidence that the latter mechanism produces phonological priming effects on high-frequency words (e.g., Collins & Ellis, 1992; Schriefers et al., 1990).

Priming, Aging, and Word Retrieval

Evidence for older adults' word retrieval problems extends beyond studies of TOTs: In their spoken discourse, older adults produce more pronouns and ambiguous references, as compared with young adults (Cooper, 1990; Heller & Dobbs, 1993; Pratt, Boyes, Robins, & Manchester, 1989), and more disfluencies such as filled pauses, repetitions, and hesitations, phenomena that appear to be linked to word retrieval difficulties (Cooper, 1990; Kemper, 1992). Under the TD model, word retrieval failures increase in old age, because aging reduces the strength of connections in memory. Diverging one-to-one connections, such as those involved in top-down phonological encoding (see Figure 1), are especially sensitive to TDs caused by weakened connections, because there are not additional sources of priming to compensate for reduced transmission (e.g., Burke et al., 1991; MacKay & Abrams, 1996; MacKay & Burke, 1990). We now consider what the age invariance in priming effects indicates about the nature of age differences in TDs.[3]

Repetition priming effects rarely vary with age in individual studies, although small declines in older adults' priming effects emerge in meta-analyses. Some of the declines can be attributed to contamination by episodic memory, which declines with age, but this factor alone cannot explain the extant results, which are not well understood (Fleischman & Gabrieli, 1998; LaVoie & Light, 1994). In the present research, the unbiased effect size for age differences in priming effects was virtually zero for correct recall (Experiment 1) and was in the category of small effect sizes (Cohen, 1992) for TOTs in Experiments 1 and 2. However, these age differences for TOT priming effects were in opposite directions, with young adults showing smaller priming effects than older adults in Experiment 1 and larger effects in Experiment 2.

The lack of reliable age differences in priming effects on TOTs has clear implications within the TD model. First, it suggests that the increment in connection strength that occurs after activation of the phonological nodes is unaffected by aging. Second, it is consistent with older adults suffering not only more frequent TDs than young adults do but also more severe TDs. Age differences in TOTs remained in the related prime condition in Experiment 1. This would be expected if phonological activation increased connection strength, and thus priming transmission, the same amount across age: More TDs would remain in older than in young adults, because their deficits were more severe and the increased strength still did not allow a critical level of priming transmission. More frequent TDs are consistent with the greater frequency of TOTs with aging, and more severe TDs are consistent with older adults' reduced access to partial phonological information during a TOT relative to young adults (A. S. Brown & Nix, 1996; Burke et al., 1991; Heine et al., 1999; Maylor, 1990a).

Priming and "Spontaneous" Resolution of TOTs

The percentage of TOTs that are resolved spontaneously through "pop-ups" varies from 17% to 61% in studies of naturally occurring TOTs (Burke et al., 1991; Cohen & Faulkner, 1986; Heine et al., 1999; Reason & Lucas, 1984) and is somewhat lower when TOTs are induced in the laboratory (Burke et al., 1991; Read & Bruce, 1982; see A. S. Brown, 1991, for a review). For older adults, the majority of their naturally occurring TOTs are resolved spontaneously, and they report that this is their preferred mode of resolution (Burke et al., 1991; Heine et al., 1999). Spontaneous resolutions are an enigmatic experience and an intriguing problem in terms of mechanism. The present results support the view that "spontaneous" resolution is triggered when the person inadvertently perceives or produces a word that contains the missing phonology. This activates inaccessible phonological components and may eliminate TDs. The person may experience the TOT resolution as spontaneous if he or she is unaware of the phonological similarity between the triggering word and the target word (e.g., Burke et al., 1991; Seifert et al., 1994; Yaniv & Meyer, 1987).

Under this explanation, spontaneous resolution of TOTs is an instance of a provocative phenomenon in problem solving—namely, the sudden appearance in consciousness of a solution to a

[3] It is important to note that under additive factors logic, two variables that affect the same stage of processing are expected to interact, leading to the prediction that age and phonological relatedness would interact. This logic, however, is based on models with sequentially ordered discrete stages and does not necessarily apply to interactive processing models such as NST (e.g., McClelland, 1979).

problem that had eluded conscious effort (e.g., Polya, 1957). Our results support the view that for some types of problems, the "subconscious work" (Polya, 1957, p. 198) underlying resolution involves a mental operation wherein critical components of the solution become more accessible when relevant stimuli are encountered in the environment. The solution appears spontaneous and unexpected, because it was triggered by a repetition priming process that occurs without awareness (cf. Posner, 1973; Yaniv & Meyer, 1987; see Seifert et al., 1994, for empirical and anecdotal evidence for spontaneous solutions in problem solving).

The paradigm used in Experiment 2 differs in an important way from spontaneous resolutions of TOTs that occur in everyday life. In Experiment 2, the question was re-presented, whereas naturally occurring "pop-ups" are reported as occurring when attention is no longer directed toward resolving the TOT experience (e.g., Burke et al., 1991). How can target retrieval occur when there is no top-down conceptual process driving it? An important problem for future research is investigating whether or not phonological priming effects on TOTs extend to spontaneous retrieval of the target word in the absence of the question.

References

Blaxton, T. (1989). Investigating dissociations among memory measures: Support for a transfer-appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 657–668.

Bock, K., & Levelt, W. (1994). Language production: Grammatical encoding. In M. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 945–984). San Diego, CA: Academic Press.

Bowles, N. L., Obler, L. K., & Poon, L. W. (1989). Aging and word retrieval: Naturalistic, clinical and laboratory data. In L. W. Poon, D. C. Rubin, & B. A. Wilson (Eds.), *Everyday cognition in adulthood and late life* (pp. 244–264). Cambridge, England: Cambridge University Press.

Brennen, T., Baguley, T., Bright, J., & Bruce, V. (1990). Resolving semantically-induced tip-of-the-tongue states for proper nouns. *Memory and Cognition, 18,* 339–347.

Brown, A. S. (1979). Priming effects in semantic memory retrieval processes. *Journal of Experimental Psychology: Human Learning and Memory, 5,* 65–77.

Brown, A. S. (1991). The tip of the tongue experience: A review and evaluation. *Psychological Bulletin, 10,* 204–223.

Brown, A. S., Neblett, D. R., Jones, T. C., & Mitchell, D. B. (1991). Transfer of processing in repetition priming: Some inappropriate findings. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 514–525.

Brown, A. S., & Nix, L. A. (1996). Age-related changes in the tip-of-the-tongue experience. *American Journal of Psychology, 109,* 79–91.

Brown, J. I. (1960). *The Nelson–Denny Reading Test.* Boston: Houghton Mifflin.

Brown, R., & McNeill, D. (1966). The "tip of the tongue" phenomenon. *Journal of Verbal Learning Behavior, 5,* 325–337.

Burke, D. M., & Light, L. (1981). Memory and aging: The role of retrieval processes. *Psychological Bulletin, 90,* 513–554.

Burke, D. M., & MacKay, D. G. (1997). Memory, language and ageing. *Philosophical Transactions of the Royal Society: Biological Sciences, 352,* 1845–1856.

Burke, D. M., MacKay, D. G., Worthley, J. S., & Wade, E. (1991). On the tip of the tongue: What causes word finding failures in young and older adults? *Journal of Memory and Language, 30,* 542–579.

Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology, 14,* 177–208.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112,* 155–159.

Cohen, G., & Faulkner, D. (1986). Memory for proper names: Age differences in retrieval. *British Journal of Developmental Psychology, 4,* 187–197.

Collins, A. F., & Ellis, A. W. (1992). Phonological priming of lexical retrieval in speech production. *British Journal of Psychology, 83,* 375–388.

Cooper, P. V. (1990). Discourse production and normal aging: Performance on oral picture description tasks. *Journal of Gerontology: Psychological Sciences, 45,* P210–P214.

Cutting, C. J., & Ferreira, V. S. (1999). Semantic and phonological information flow in the production lexicon. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 318–344.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review, 93,* 283–321.

Dell, G. S., & O'Seaghdha, P. G. (1991). Mediated and convergent lexical priming in language production: A comment on Levelt et al. (1991). *Psychological Review, 98,* 604–614.

Durso, F. T., & Johnson, M. K. (1979). Facilitation in naming and categorizing repeated pictures and words. *Journal of Experimental Psychology: Human Learning and Memory, 5,* 449–459.

Fleischman, D. A., & Gabrieli, J. D. E. (1998). Repetition priming in normal aging and Alzheimer's disease: A review of findings and theories. *Psychology and Aging, 13,* 88–119.

Francis, W. N., & Kucera, H. (1982). *Frequency analysis of English usage: Lexicon and grammar.* Boston: Houghton Mifflin.

Freedman, J. L., & Landauer, T. K. (1966). Retrieval of long-term memory: "Tip-of-the-tongue" phenomenon. *Psychonomic Science, 4,* 309–310.

Gruneberg, M. M., & Monks, J. (1974). "Feeling of knowing" and cued recall. *Acta Psychologica, 38,* 257–265.

Hanley, J. R., & Cowell, E. S. (1988). The effects of different types of retrieval cues on the recall of names of famous faces. *Memory & Cognition, 16,* 545–565.

Harley, T. A., & Bown, H. E. (1998). What causes a tip-of-the-tongue state? Evidence for lexical neighbourhood effects in speech production. *British Journal of Psychology, 89,* 151–174.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 22, pp. 193–225). San Diego, CA: Academic Press.

Hedges, L. R. (1984). Advances in statistical methods for meta-analysis. In J. W. Yeaton & P. M. Wortman (Eds.), *Issues in data synthesis* (pp. 25–42). San Francisco: Jossey-Bass.

Heine, M. K., Ober, B. A., & Shenaut, G. K. (1999). Naturally occurring and experimentally induced tip-of-the-tongue experiences in three adult age groups. *Psychology and Aging, 14,* 445–457.

Heller, R. B., & Dobbs, A. R. (1993). Age differences in word finding in discourse and nondiscourse situations. *Psychology and Aging, 8,* 443–450.

Jones, G. V. (1989). Back to Woodworth: Role of interlopers in the tip of the tongue phenomenon. *Memory & Cognition, 17,* 69–76.

Jones, G. V., & Langford, S. (1987). Phonological blocking in the tip of the tongue state. *Cognition, 26,* 115–122.

Kelley, C. M., & Lindsay, D. S. (1993). Remembering mistaken for knowing: Ease of retrieval as a basis for confidence in answers to general knowledge questions. *Journal of Memory and Language, 32,* 1–24.

Kemper, S. (1992). Adults' sentence fragments: Who, what, when, where, and why. *Communication Research, 19,* 444–458.

Kohn, S. E., Wingfield, A., Menn, L., Goodglass, H., Berko Gleason, J., & Hyde, M. (1987). Lexical retrieval: The tip-of-the-tongue phenomenon. *Applied Psycholinguistics, 8,* 245–266.

Koriat, A., & Lieblich, I. (1974). What does a person in a "TOT" state

know that a person in a "don't know" state doesn't know? *Memory & Cognition, 2,* 647–655.

Kozlowski, L. T. (1977). Effects of distorted auditory and of rhyming cues on retrieval of tip-of-the-tongue words by poets and nonpoets. *Memory & Cognition, 5,* 477–481.

Laver, G. D., & Burke, D. M. (1993). Why do semantic priming effects increase in old age? A meta-analysis. *Psychology and Aging, 8,* 34–43.

LaVoie, D., & Light, L. L. (1994). Adult age differences in repetition priming: A meta-analysis. *Psychology and Aging, 9,* 539–553.

Levelt, W. J. M. (1989). *Speaking: From intention to articulation.* Cambridge, MA: MIT Press.

Levelt, W. J. M., Schriefers, H., Vorberg, D., Meyer, A. S., Pechmann, T., & Havinga, J. (1991). The time course of lexical access in speech production: A study of picture naming. *Psychological Review, 98,* 122–142.

Light, L. (1992). The organization of memory in old age. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 111–166). Hillsdale, NJ: Erlbaum.

Lovelace, E. A., & Twohig, P. T. (1990). Healthy older adults' perceptions of their memory functioning and use of mnemonics. *Bulletin of the Psychonomic Society, 28,* 115–118.

MacKay, D. G. (1987). *The organization of perception and action: A theory for language and other cognitive skills.* New York: Springer-Verlag.

MacKay, D. G., & Abrams, L. (1996). Language, memory and aging: Distributed deficits and the structure of new versus old connections. In J. E. Birren & W. K. Schaie (Eds.), *Handbook of the psychology of aging* (4th ed., pp. 251–265). San Diego, CA: Academic Press.

MacKay, D. G., & Burke, D. M. (1990). Cognition and aging: A theory of new learning and the use of old connections. In T. Hess (Ed.), *Aging and cognition: Knowledge organization and utilization* (pp. 213–263). Amsterdam: North Holland.

Martin, N., Weisberg, R. W., & Saffran, E. M. (1989). Variables influencing the occurrence of naming errors: Implications for a model of lexical retrieval. *Journal of Memory and Language, 28,* 462–485.

Maylor, E. A. (1990a). Age, blocking and the tip of the tongue state. *British Journal of Psychology, 81,* 123–134.

Maylor, E. A. (1990b). Recognizing and naming faces: Aging, memory retrieval and the tip of the tongue state. *Journal of Gerontology: Psychological Sciences, 45,* P215–P225.

McClelland, J. L. (1979). On the time relations of mental processes: An examination of systems of processes in cascade. *Psychological Review, 86,* 287–330.

McEvoy, C. L. (1988). Automatic and strategic processes in picture naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 618–626.

Meyer, A. S., & Bock, K. (1992). The tip-of-the-tongue phenomenon: Blocking or partial activation? *Memory & Cognition, 20,* 715–726.

Meyer, A. S., & Schriefers, H. (1991). Phonological facilitation in picture–word interference experiments: Effects of stimulus onset asynchrony and types of interfering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 1146–1160.

Miozzo, M., & Caramazza, A. (1997). Retrieval of lexical–syntactic features in tip-of-the-tongue states. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 1410–1423.

Park, S. M., & Gabrieli, J. D. E. (1995). Perceptual and nonperceptual components of implicit memory for pictures. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 1583–1594.

Perfect, T. J., & Hanley, J. R. (1992). The tip-of-the-tongue phenomenon: Do experimenter-presented interlopers have any effect? *Cognition, 45,* 55–75.

Polya, G. (1957). *How to solve it.* New York: Doubleday Anchor Books.

Posner, M. I. (1973). *Cognition: An introduction.* Glenview, IL: Scott, Foresman and Company.

Pratt, M. W., Boyes, C., Robins, S., & Manchester, J. (1989). Telling tales: Aging, working memory, and the narrative cohesion of story retellings. *Developmental Psychology, 25,* 628–635.

Rastle, K. G., & Burke, D. M. (1996). Priming the tip of the tongue: Effects of prior processing on word retrieval in young and older adults. *Journal of Memory and Language, 35,* 586–605.

Read, J. D., & Bruce, D. (1982). Longitudinal tracking of difficult memory retrievals. *Cognitive Psychology, 14,* 280–300.

Reason, J. T., & Lucas, D. (1984). Using cognitive diaries to investigate naturally occurring memory blocks. In J. E. Harris & P. E. Morris (Eds.), *Everyday memory actions and absent-mindedness* (pp. 53–70). London: Academic Press.

Roediger, H. L. (1974). Inhibiting effects of recall. *Memory & Cognition, 2,* 261–269.

Schacter, D. L. (1999). The seven sins of memory: Insights from psychology and cognitive neuroscience. *American Psychologist, 54,* 182–203.

Schaie, K. W. (1996). *Intellectual development in adulthood.* Cambridge, England: Cambridge University Press.

Schriefers, H., Meyer, A. S., & Levelt, W. J. M. (1990). Exploring the time course of lexical access in language production: Picture–word interference studies. *Journal of Memory and Language, 29,* 86–102.

Seifert, C. M., Meyer, D. E., Davidson, N., Patalano, A. L., & Yaniv, I. (1994). Demystification of cognitive insight: Opportunistic assimilation and the prepared-mind perspective. In R. J. Sternberg & J. E. Davidson (Eds.), *The nature of insight* (pp. 65–124). Cambridge, MA: MIT Press.

Small, B. J., Hultsch, D. F., & Masson, M. E. J. (1995). Adult age differences in perceptually based, but not conceptually based implicit tests of memory. *Journal of Gerontology: Psychological Sciences, 50B,* P162–P170.

Valentine, T., Moore, V., & Bredart, S. (1995). Priming productions of people's names. *The Quarterly Journal of Experimental Psychology, 48A,* 513–535.

Vigliocco, G., Antonini, T., & Garrett, M. F. (1997). Grammatical gender is on the tip of Italian tongues. *Psychological Science, 8,* 314–317.

Vitkovitch, M., & Humphreys, G. W. (1991). Perseverant responding in speeded naming of pictures: It's in the links. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 664–680.

Wheeldon, L. R., & Monsell, S. (1992). The locus of repetition priming of spoken word production. *The Quarterly Journal of Experimental Psychology, 44A,* 723–761.

Wheeldon, L. R., & Monsell, S. (1994). Inhibition of spoken word production by priming a semantic competitor. *Journal of Memory and Language, 33,* 332–356.

White, K. K., & Abrams, L. (1999, November). *The role of syllable phonology and aging in priming tip-of-the-tongue resolution.* Poster session presented at the annual meeting of the Psychonomic Society, Los Angeles, CA.

Wolf, F. M. (1986). *Meta-analysis: Quantitative methods for research synthesis.* Beverly Hills, CA: Sage.

Woodworth, R. S. (1929). *Experimental psychology.* New York: Holt Press.

Yaniv, I., & Meyer, D. E. (1987). Activation and metacognition of inaccessible stored information: Potential bases for incubation effects in problem solving. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 187–205.

Yaniv, I., Meyer, D. E., & Davidson, N. S. (1995). Dynamic memory processes in retrieving answers to questions: Recall failures, judgments of knowing, and acquisition of information. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 1509–1521.

(Appendix follows)

Appendix

Target Words That Answered General Knowledge Questions in Experiments 1 and 2 and Five Phonologically Related Prime Words for Each

Target word	Number of words in target grammatical class	Phonologically related words
gourmet	3	*gr*avity, d*ur*ation, earthly, calu*m*et, gains*ay*
velcro	2	*v*enerable, p*el*let, dec*r*eed, overth*r*ow, mistle*toe*
onomatopoeia	3	*on*yx, man*i*cure, diplo*m*atic, co*p*ious, uto*pia*
bandanna	4	*band*oleer, *ban*jo, se*d*entary, ret*ina*, mar*ina*
Nairobi	2	*n*icety, *n*europathic, he*r*oic, chu*bby*, bumble*bee*
Columbus	5	*col*ogne, *con*niver, *alumnus*, omni*bus*, amoe*bas*
tarot	4	*t*apestry, *t*riple, *l*aryngitis, *car*otene, radi*o*
Lindbergh	3	*l*ithoid, p*ind*ling, re*b*ound, in*s*ert, ice*berg*
cartographers	5	*car*dinal, *car*nage, pa*r*egoric, pho*tography*, go*phers*
zealot	5	*z*ephyr, Zionism, *v*elocity, patri*ot*, predi*cate*
mausoleum	4	*maw*kish, in*s*ipidity, re*c*iprocity, o*l*eander, petro*latum*
anagram	5	*an*nex, *an*imosity, fe*m*inism, re*l*ative, holo*gram*
gerrymander	3	*ger*iatric, *aman*uensis, e*man*cipate, p*ander*, phil*ander*
ornithology	5	*or*ison, car*n*ival, an*n*iversary, an*thologist*, tri*logy*
pasteurization	4	*pass*enger, en*ch*ilada, corrobo*r*atory, frust*ration*, mobili*zation*
abacus	3	*ab*rogate, *ab*ject, element, cau*cus*, hibis*cus*
Bering	4	*b*ellows, m*err*iment, sarcasm, face*t*, asser*ting*
adumbrate	2	*ad*versary, cal*umn*y, fath*om*less, cele*brate*, cali*brate*
serrated	1	*ser*vant, enunci*at*ing, applic*at*or, visi*ted*, bonne*ted*
vaudeville	1	*vaul*ted, generate, in*v*ert, medie*val*, personn*el*
detonate	3	*det*riment, *det*eriorate, ne*onate*, notarize, illumi*nate*
squander	3	*s*uffering, *sch*ema, p*on*tificate, fu*nd*ing, cul*ture*
contraband	2	*con*duit, *con*flagration, ext*r*adite, ost*r*acize, dis*band*
chameleon	3	*ca*cophony, *ca*nonical, *amel*iorate, batta*lion*, medal*lion*
Alcott	4	*al*derman, *ab*scissa, re*l*ish, declare, ferre*t*
palindrome	3	*pal*isade, *pal*lid, *paren*thetic, fasci*n*ation, hippo*drome*
ellipsis	4	*il*legible, phi*lipp*ic, ca*lyps*o, emphas*is*, cirrhos*is*
intransitive	3	*in*vasion, *in*ane, quie*t*ness, preven*tive*, declara*tive*
locust	2	*lo*nesome, m*o*mentary, whis*k*er, recipro*c*ate, sentimental*ist*
Galapagos	4	*ga*rage, phy*lo*geny, im*pe*tus, fandan*gos*, for*goes*
jettison	0	pala*t*ine, hesi*t*ant, pri*son*, med*icine*, *j*ewel
perjury	2	*per*vade, *per*manent, in*juri*ous, obitu*ary*, treas*ury*
marsupials	5	*mar*quee, in*sou*ciance, o*pi*um, princip*als*, co*rals*
amnesty	2	*am*persand, *u*niversal, ba*nis*ter, pa*sty*, te*sty*
bola	3	*bo*vine, *bi*otin, *h*otel, se*l*ective, *media*
ephemeral	4	*E*piscopal, *e*bullient, *effem*inate, aerobically, *general*
photosynthesis	4	*photo*gravure, biochemical, immobility, anti*thesis*, paraly*sis*
sextant	3	*se*condary, *se*mblance, re*s*train, phea*sant*, fei*nt*
callous	2	*ca*binet, fa*l*low, me*l*anin, prestig*ious*, *c*offee
stamina	4	*stam*pede, italicized, fidel*i*ty, alum*ina*, prolegome*na*
Centaur	2	*s*eldom, re*n*ovation, nocturnal, limb*er*, cons*ort*
philatelist	3	*ph*ysician, equi*lat*eral, vio*l*ate, imperi*alist*, fore*st*
Armstrong	2	*ar*dent, der*m*atologist, in*s*truct, fore*s*ight, a*long*
origami	4	*or*atorio, ris*i*bility, conglo*m*erate, pas*trami*, sturd*y*
marinade	2	*mar*row, *mar*athon, imitate, concomitant, sere*nade*
silo	5	*si*nus, *s*cripture, m*i*nority, para*l*lel, pi*cot*
catharsis	3	*ca*vort, *ca*tastrophe, le*thor*gic, parenthe*sis*, homeostas*is*
papyrus	4	*pa*goda, *pa*lladium, im*pi*ety, amo*tous*, phosph*orus*
abdicate	2	*ab*stract, in*di*gent, tra*d*ition, trun*cate*, l*ocate*
cosmonaut	4	*cos*metic, *co*stume, ther*mo*cline, presu*mably*, jugger*naut*
hemorrhage	1	*hem*lock, *hem*isphere, deade*n*, manne*r*ism, cou*rage*
anemometer	5	*an*swer, *an*cestry, o*r*ifice, organi*zer*, wai*ter*
caption	3	*ca*ribou, *h*aphazard, *u*proarious, *on*ion, infec*tion*
Himalayas	4	*hym*nology, le*v*itation, ci*t*izen, sa*l*acious, galle*rias*
akimbo	2	*ac*rylic, *ac*cumulate, photo*ch*emical, place*bo*, mam*bo*
fluoridation	5	*fluor*oscope, gen*er*ator, affi*dav*it, nutri*tion*, ammuni*tion*
plagiarize	3	*pla*cate, *play*ful, tra*g*edy, memo*rize*, caute*rize*
nepotism	5	*nep*tunium, quie*tude*, ca*p*illary, despo*tism*, optim*ism*
metamorphosis	2	*met*al, immem*or*ial, de*mor*alize, em*phas*ize, hypothe*sis*
tranquilize	4	*tran*scend, *tran*sport, *aqui*line, colon*ize*, mechan*ize*
Sirhan	2	*s*eriate, *s*cepter, p*ee*rless, in*h*ale, pylon
reiterate	3	*r*ejoinder, *r*edouble, habi*t*able, be*rate*, satu*rate*
hemophilia	4	*hea*ter, de*m*olition, reaffi*li*ate, memora*bilia*, pi*zza*
barnacle	2	*bar*barous, *car*nival, de*n*igrate, ramsha*ckle*, semi*circle*
Brando	4	*bras*sy, *br*istle, *man*drake, cre*do*, tombo*lo*
planetarium	3	*plan*tigrade, *jan*itor, dysen*tery*, courteous, sep*tum*
labyrinth	4	*labe*faction, *lab*danum, impossible, hyac*inth*, nineteen*th*
antibiotics	3	*an*alects, *an*gelic, sym*bi*osis, forgo*t*ten, co*mics*

Appendix (*continued*)

Target word	Number of words in target grammatical class	Phonologically related words
reincarnation	2	*re*frain, disin*fest*, in*car*cerate, de*na*ture, dic*tion*
vigilante	4	*vi*gor, *vi*negar, *lan*ceted, fatal*ity*, sentimental*ity*
ruble	3	*ru*diment, *r*oast, d*u*bious, so*b*er, tenta*cle*
misogynist	2	*mi*kado, o*mi*nous, ex*ogen*ous, expansio*nist*, *mi*rage
hospice	1	*hos*tler, *do*cile, de*port*, *rap*id, top*less*
affirmation	3	*affer*ent, in*er*tia, mam*mal*ian, na*tion*, improvisa*tion*
serendipity	4	*se*ricin, di*en*cephalon, un*dip*lomatic, gra*vity*, final*ity*
kleptomania	3	*cle*ment, fronto*gen*esis, exclam*a*tion, felo*n*ious, dystop*ia*
valedictory	2	*val*iant, gratulate, bene*dic*tion, salutat*ory*, sloppy
zodiac	4	*zo*ology, in*de*cent, co*de*ine, at*tack*, mani*ac*
Houdini	4	*hoo*ligan, i*de*ation, re*dee*ming, polygy*ny*, euph*ony*
negotiable	1	*neg*lect, car*go*, ma*chi*nery, augmen*table*, rum*ble*
spelunkers	4	*spi*cule, *spi*rula, bil*in*gual, wor*kers*, undertak*ers*
moraine	2	*mo*ralize, *mu*rky, su*r*face, ter*rain*, pro*fane*
tarantula	2	*tyran*nical, *te*lepathy, vir*tu*al, en*chan*t, umbre*lla*
actuary	1	*ac*robat, *ac*quiesce, re*choo*sing, ordin*ary*, downy
etymology	4	*e*tamine, family, d*emo*lish, metallur*gy*, anth*ology*
spatula	4	*spas*modic, m*atch*book, canopy, can*nula*, para*bola*
indigenous	2	*in*timacy, *in*definite, re*di*gitize, philos*o*phy, mucila*ginous*
pediatrician	5	*pea*nut, eu*di*ometer, la*di*no, mortic*ian*, malnu*trition*
anachronism	4	*ana*logize, *a*phasia, gar*ri*son, busi*ness*man, bap*tism*
omnivore	3	*om*budsman, *o*minous, re*ne*gade, ci*ne*ma, im*port*
metronome	2	*met*ric, *me*dicate, de*tri*ment, in*tra*dermal, rote*none*
malevolence	4	*ma*ture, *me*chanic, *e*leven, pes*tilence*, incandes*cence*
Comaneci	2	*co*lon, de*man*ding, immedi*a*te, blot*chy*, maria*chi*
filament	4	*fili*buster, ap*a*thetic, mi*ra*cle, pepper*mint*, parch*ment*
anthrax	2	*an*alyze, *a*tom, e*nthr*all, re*thr*ow, backp*acks*
tsunami	2	*soo*ner, *su*perb, hyp*no*tic, gastr*onomy*, en*emy*
perpendicular	1	*per*mutation, app*end*age, ad*dic*tion, gran*ul*ate, in*sular*
aspergillum	4	*a*sterisk, su*per*lative, flage*llat*e, marjo*ram*, eardr*um*
Struthers	3	*stru*ctural, bre*th*ren, mo*thy*, hoard*ers*, goblin*s*
gargoyle	3	*gar*lic, *g*asoline, h*ar*vest, embr*oil*, rec*oil*
trellis	5	*trea*sure, *tre*molite, *fe*lony, o*li*ve, mal*ice*
Hancock	3	*han*dle, *ha*ppy, b*an*dage, recall, roadblo*ck*
hypochondriac	3	*hy*phenate, re*po*sal, mito*chondri*a, taw*dri*est, tamara*ck*
kaleidoscope	4	*col*lage, *ca*boose, en*li*ghten, bal*da*chin, peri*scope*
Mitchell	3	*mi*tigate, *mi*driff, *ri*ches, gam*ble*, driv*el*
procrastination	3	*pro*duce, in*cras*sate, ma*ta*dor, ema*nat*ing, satur*ation*
hieroglyphics	3	*hy*giene, neu*ro*sis, fe*ro*cious, a*gli*mmer, speci*fics*
euphemism	5	*eu*calyptus, in*fi*delity, con*fi*dant, pessi*mism*, manner*ism*
primogeniture	5	*pri*vateer, a*gen*da, agronomy, lite*rature*, ama*teur*
rhetorical	4	*re*flective, *re*verse, *to*lerate, myth*ical*, asthma*tical*
Orwell	3	*or*pine, ner*vous*, per*cent*, in*ward*, ho*tel*
ambergris	4	*a*mericium, *a*matory, ham*bur*ger, reim*burs*ement, pedi*grees*
demagogue	2	*dem*ocratic, *dem*olition, eloquent, irrit*a*ble, polli*wog*
insomnia	4	*in*terim, *in*capable, po*ny*tail, regal*ia*, echolal*ia*
haiku	4	*high*light, p*i*racy, ba*con*, mer*can*tile, men*u*
liaison	4	*li*nking, rad*ia*tion, geo*me*try, re*gis*try, artis*an*
jargon	3	*j*amboree, *far*cical, conglomerate, be*gun*, insurrec*tion*
ruddy	0	*ru*pture, *su*bmerge, spi*der*, scarcity, posse
numismatics	1	*nu*merical, *nu*clear, im*me*asurable, dra*mat*ically, class*ics*
ingot	3	*i*lliterate, *an*chor, le*gal*, mas*ter*, fri*gate*
pristine	1	*pro*clivity, r*i*sky, mi*s*taken, dain*tier*, de*mean*
jurisdiction	4	*ju*venile, mini*s*try, in*dic*ative, elimina*tion*, transac*tion*
soliloquy	3	*sa*fari, *sili*cious, inexpli*ca*ble, chronology, co*lloquy*
covenant	4	*co*verlet, operative, sacch*a*rin, rem*nant*, domi*nant*
pylon	2	*pur*chase, li*on*ize, fear*less*, fal*len*, discre*tion*
Cyprus	2	*si*dle, *sc*avenger, b*i*sected, im*pr*int, amor*phous*
traduce	2	*tr*eacle, br*o*ther, in*dic*t, pro*fuse*, embarra*ss*
milliner	4	*mil*lion, *mil*itant, habitation, operate, foreig*ner*
Androcles	3	*an*cestor, *an*adem, hy*dra*zide, manga*nese*, displ*ease*

Note. Phonemes shared by target and related words are italicized. Related list words were presented in random order with five phonologically unrelated prime words.

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