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Phonologically Mediated Priming of Preexisting and New Associations in Young and Older Adults

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Two experiments investigated phonologically mediated priming of preexisting and new associations in word retrieval. Young and older adults completed paired word stems with the first word that came to mind. Priming of preexisting associations occurred when word-stem pairs containing homophones (e.g., *beech-s*____) showed more completions with the target (e.g., sand) relative to unrelated pairs (e.g., *batch-s*____), with more priming for subordinate than dominant homophones. Priming occurred for new associations independent of dominance, such that word-stem pairs containing homophones (e.g., *beech-l*_____ and *beach-l*_____) were completed with the same word (e.g., *laugh*) more often than unrelated pairs (e.g., *beech-l*_____ and *batch-l*_____). No age differences in phonologically mediated priming were found for either type of association, suggesting age equivalence in the utilization of bottom-up phonological connections.

Research on phonologically mediated priming of visual stimuli has shown that a word's meaning can be accessed through its phonology (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994). For example, people are faster to recognize the word *sand* when it is preceded by the word *beech* relative to an unrelated word such as *batch*, suggesting that the phonological code for *beech* is activated prior to its lexical representation. Interestingly, phonological mediation has only been studied in word recognition, leaving a question as to whether priming will occur in word retrieval. Phonologically mediated priming in word recognition only occurs at very brief prime-target intervals (e.g., the effect disappears after a 250 ms stimulus onset asynchrony (SOA; Lesch & Pollatsek, 1993). Therefore, phonologically mediated priming may be unobservable in word retrieval tasks because retrieval occurs across longer intervals and is more effortful than recognition (i.e., a to-be-retrieved word is searched for instead of simply identified).

The purpose of this paper is to explore phonological mediation in word retrieval as a function of the priming of preexisting semantic associations versus the priming of new semantic associations. Phonologically mediated priming in word recognition has only tested priming across preexisting semantic associations (e.g., *beech* primes *sand*, which is semantically related to the phonologically identical *beach*). However, we used a word retrieval paradigm to test new semantic associations, e.g., whether *beech* can also prime an unrelated word (e.g., *laugh*) that has been newly associated with *beach*. The difference between retrieval of preexisting associations and retrieval of new associations is especially relevant to older adults, who generally exhibit greater difficulty with new learning (e.g., MacKay & Burke, 1990). However, this claim is supported by studies that individually test one type of information (e.g., preexisting) or another (e.g., new). The present studies directly compared older adults' retrieval of preexisting and new associations using the same associative priming paradigm.

Furthermore, phonologically mediated priming has never been examined in older adults, despite many age-related studies involving other types of priming. There is reason to suspect possible deficits with retrieval of phonology in old age because weak connections from phonology to words are proposed as a cause of age-related increases in word retrieval failures, such as tip-of-the-tongue (TOT) states (Burke, MacKay, Worthley, & Wade, 1991). However, TOTs are most likely to occur for words that are not used very often or have not been used recently. One possibility is that older adults have retrieval deficits only for infrequently and nonrecently used words; the retrieval of more common words may be age-invariant.

Hypotheses about phonologically mediated priming of preexisting and new associations can be generated from Node Structure theory (NST; MacKay, 1987), a theoretical framework of language perception and production. NST is a connectionist framework that represents words, their semantic

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representations, phonology, and orthography in a hierarchical system of nodes (Figure 1). In NST, a strong connection exists between two words that have been previously related,

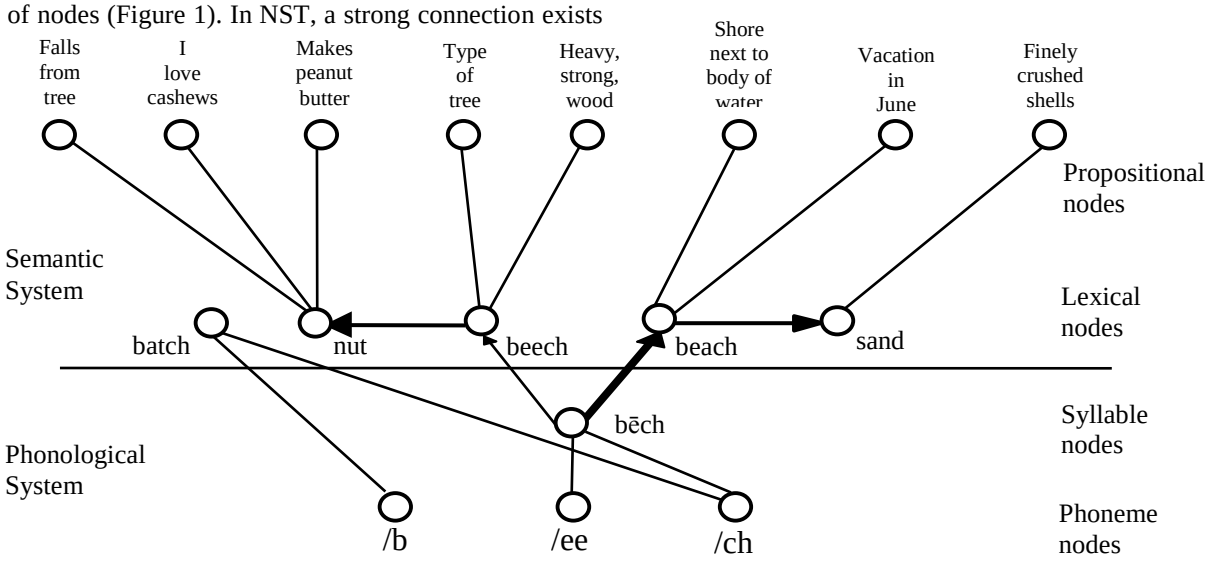

Figure 1. Node Structure Theory's hierarchical network. An example of Node Structure Theory's hierarchical network for the homophones *beach* and *beech*. This figure shows how node priming should spread for preexisting associations discussed in Experiment 1. More node priming of semantic associates occurs for subordinate homophones than for dominant homophones because node priming must travel to the phonology and then across the connection to the dominant homophone, which is a stronger connection than that from the phonology to the subordinate homophone. However, strong connections exist between each homophone and their semantic associates.

and priming between these representations (i.e., nodes) is transmitted rapidly. Node priming is similar to the concept of activation as specified in many connectionist theories (e.g., Dell, 1986), although node priming prepares a node for activation, which is necessary for retrieval. NST also asserts that the connections between new associations are weaker because they have not been accessed and strengthened over time. Hence, priming between two newly associated words is slower and will only occur if the connection has been adequately formed (see Graf & Schacter, 1985, 1989; Micco & Masson, 1991, for similar theories of new association formation).

With respect to aging and phonologically mediated priming, hypotheses can be derived from two known theories of cognitive aging, the Transmission Deficit hypothesis (TDH; MacKay & Burke, 1990) and the Inhibition Deficit hypothesis (IDH; Hasher & Zacks, 1988). TDH maintains that the connections between nodes weaken with increasing age, leading to a reduction in the transmission of node priming. However, age-related declines in node priming can be offset when multiple connections converge on a single node, such as the many connections from the semantic system that converge on a lexical node (see Figure 1). Strong connections between semantic associates exist for all ages because of the repeated and frequent activation of these associations, thus helping to offset any age-related deficits in node priming of semantic associates. However, new connection formation and the retrieval of new associations are more affected in older adults than the retrieval of preexisting connections. In contrast, the Inhibition Deficit Hypothesis maintains that the occurrence of age declines is due to difficulty inhibiting irrelevant information. Two specific consequences of inefficient inhibitory mechanisms are the activation of irrelevant information (such as multiple meanings of homophones) and the sustained activation of previously relevant and/or irrelevant information. NST, TDH, and IDH provide testable hypotheses that are discussed below for each experiment.

Experiment 1:

Phonologically Mediated Priming of Preexisting Associations

Experiment 1 assessed the existence of phonologically mediated priming across preexisting associations using an associative word-stem completion test, which paired a homophone prime word with the first letter of the opposite homophone's semantic associate (e.g., *beech*-*s*____). The association is preexisting because one homophone (*beach*) is semantically related to the target (*sand*). If *sand* is retrieved more often relative to an unrelated prime (e.g., *batch*-*s*_____), retrieval is presumed to have been mediated through the shared phonological representation between the homophones.

Experiment 1 was designed to test the following hypotheses. First, we predicted that phonologically mediated priming of preexisting associations would occur because activating the phonology for *beech* spreads node priming to the phonologically identical word *beach*, which in turn sends node

priming to its semantic associates (e.g., *sand*), which are strongly connected. Furthermore, as suggested by TDH, we did not expect to find age differences in phonologically mediated priming of preexisting associations if older adults have strong preexisting connections between semantic associates as well as phonological associates (MacKay & Burke, 1990). However, an alternative prediction comes from the IDH, where older adults would be expected to show more phonologically mediated priming of preexisting associations than young adults because of older adults' reduced ability to inhibit semantic associates related to both members of a homophone pair. This prediction is consistent with descriptions by Hasher and Zacks (1988) that older adults are more likely to activate both meanings of an ambiguous homonym (*bank*).

Because most homophones have a dominant and a subordinate member of the pair, we were interested in whether phonologically mediated priming would differ across homophone dominance when semantic associations were to be retrieved. Similar to findings with homophone frequency reported in the word recognition literature (Lukatela & Turvey, 1994), we predicted greater phonologically mediated priming for subordinate than for dominant homophones (see Figure 1). For example, when the subordinate homophone is presented (e.g., *beech-s*____), activation of the dominant homophone (*beach*) is likely to occur because the phonological node /bēch/ is more strongly connected to the dominant homophone, due to greater frequency of use. This activation will enable retrieval of a semantically related word *(sand)* because of the strong semantic connection between *beach* and *sand* and the restricted number of word choices that begin with the given letter, "*s*." In contrast, when the dominant homophone is presented (e.g., *beach-n*____), activation of the subordinate homophone (*beech*) is less likely (but still possible) because the phonological nodes are more strongly connected to the dominant homophone, which also happens to be the presented word. Therefore, if the subordinate homophone is not activated, then its semantic associate, *nut*, is not likely to be retrieved.

Method

Participants

Young adults (ages 17-26; *M* = 18.73, *SE* = .18) included 60 students from the University of Florida who were enrolled in General Psychology or Cognitive Psychology courses and received partial course credit or extra credit for one-half hour of participation. Sixty older adults (ages 60-86; *M* = 72.87, *SE* = .90) were recruited from the University of Florida Cognition and Aging Lab Participant Pool. All participants completed the following background information forms/tests: (1) a participant questionnaire asking for age, education, ethnicity, native language, health status, and current medications, (2) a 25-item vocabulary test, and (3) forward and backward digit span tests to assess working memory. In addition, older adults were also given the Mini Mental State Examination (MMSE) to assess any cognitive impairment and/or dementia. Mean scores on these tests can be found in Table 1. Scores are based on the 55 young and 55 older adults who were included in analyses (ten participants were excluded from analyses for not following directions on the word-stem completion task). The remaining participants included 40 young females, 15 young males, 24 older females, and 31 older males. Independent samples t-tests indicated that young adults from Experiment 1 had fewer years of education, $t(108) = -12.35$, $p < .001$, and worse vocabularies, $t(108) = -12.09$, $p < .001$ than older adults, but larger forward, $t(107) = 2.21$, $p < .029$, and backward, $t(107) = 3.27$, $p < .001$, digit spans. Young and older adults did not differ on self-reported health, $p > .46$.

Design

The experimental design consisted of three factors, with Age Group (young, older adults) as the only between-participants factor, and Dominance of the prime (dominant, subordinate) and Prime-Target Relationship (phonological, semantic, unrelated) as within-participants factors. The primary dependent variable was the proportion of word stems completed with the target word.

Apparatus

The experiment was performed on Pentium II 350 MHz IBM-compatible computers using a program written in Visual Basic 5.0.

Materials

This experiment utilized association norms that were collected in prior pilot studies.[1] There were three types of relationships between the prime and target: (1) a phonological condition where a word was paired with the stem of a semantic associate of the word's homophone (e.g., *beech-s*____), (2) a semantic condition where a homophone word was paired with

Table 1
Background characteristics for young and older adults in Experiment 1

	Group					
	Young Adults			Older Adults		
Variable	*N*	*Mean*	*SE*	*N*	*Mean*	*SE*
Age*	55	18.72	0.19	55	73.09	0.94
Education (years)*	55	12.52	0.13	55	17.03	0.34
Vocabulary* (max = 25)	55	14.73	0.37	55	20.89	0.35
Forward digit*	55	7.84	0.16	54	7.35	0.15
Backward digit*	55	5.76	0.18	54	4.94	0.17
Health (max = 10)	55	8.17	0.17	54	7.98	0.20
MMSE (max = 30)				55	27.91	0.27

Note. Asterisks indicate significant differences between the age groups, $p < .05$. Participants who were missing data from particular characteristics were excluded from that analysis. Data from one older participant on the digit span tests is missing because he refused to participate in the test.

the one-letter stem of a semantic associate (e.g., *beach-s____*), and (3) an unrelated condition where a word that was orthographically similar to the homophones was paired with the same stem used in the other two conditions (e.g., *batch-s-_____*). The homophone, or prime word, was manipulated in order to measure its effect on retrieval of the associate, or target (e.g., *sand*), which remained constant in all the word pairs. The semantic condition was included to compare the effect size of phonologically mediated priming to the more established semantic priming effect. The unrelated condition served as a baseline for target completion independent of a homophonic prime.

The target words were counterbalanced across the three main prime-target relationships and the two dominance conditions for a total of six versions. For example, the target word *sand* fell in one of three versions: (1) phonological-subordinate, *beech-sand*; (2) semantic-dominant, *beach-sand*; and (3) unrelated, *batch-sand*. Similarly, the target word *nut* fell in one of three versions: (1) phonological-dominant, *beach-nut*; (2) semantic-subordinate, *beech-nut*; and (3) unrelated, *batch-nut*. The dominant and subordinate word stems were counterbalanced across participants so that half of the stems consisted of the dominant homophone for any given pair (e.g., *beach-sand*) and the other half consisted of the subordinate homophone (e.g., *byte-giga*). In addition to the 48 homophone pairs, 10 "foil" homophones were included for pilot testing for a future experiment. Five foils were included in each version but did not receive any further analysis.

Each homophone pair was assigned one unrelated, orthographically-similar control word to serve in the "prime" position (e.g., *batch* for *beach/beech*). Control words were chosen so that one-half were similar in spelling and length (and frequency where possible) to the dominant homophone, and the other half were similar to the subordinate homophone. The unrelated words always started with the same letter as the homophones they were paired with; attempts were also made to have multiple letters overlap and to have word length similar. The average word length for the homophones that were matched with orthographic control words and for the orthographic control words can be found in Table 2. Finally, the homophones and their orthographic control words were matched as much as possible on overall word frequency without sacrificing spelling similarity. Overall, the 48 subordinate homophones had a mean Francis and Kucera (1982) frequency of 20.44, whereas the 48 dominant homophones had a mean frequency of 200.00 (excluding one homophone outlier, *in*, which has a frequency of over 20,000).

A total of 90 word-stems were presented to each participant: 5 practice trials with unrelated (nonhomophone) paired word-stems, and 85 experimental trials including: 8 word stems from each of the six versions, 5 foils, and 32 unrelated (nonhomophone) word stems (i.e., fillers) intended to disguise the use of homophones in the study. Six versions of the word-stem list were developed with a different random ordering of experimental trials (but the same ordering of filler trials intermixed among the experimental trials) per version.

Table 2

Characteristics of the twenty-nine homophones and their matched orthographic control words

	Homophone		Matched Orthographic Control Word	
Characteristic	Dom (*bite*)	Sub (*beech*)	Dom (*bike*)	Sub (*batch*)
Average Word Length	4.50	4.27	4.59	4.31
Overall	4.38		4.44	
Average Frequency	261.10	29.12	325.23	26.89
Overall	132.32		163.63	

Note. Two different examples (*bite, beech*) are used to illustrate that each homophone pair had one orthographic control word matched to either the dominant or subordinate homophone. The "Overall" row refers to the overall mean of both dominant and subordinate words.

Upon completion of the experiment, participants were verbally administered a post-experimental questionnaire intended to assess any knowledge they had of the relationship between prime and target words.

Procedure

Participants completed the background information paperwork and tests at the beginning of the testing session, which took approximately 10-15 minutes.

At the onset of each trial, participants saw a warning signal (+) presented for 500 ms, followed by the prime paired with a one-letter word stem. Participants were instructed to read the word and stem to themselves (silently) and to immediately complete the stem aloud with the first word that came to mind and started with the given letter. Participants then pressed the "Enter" key to bring on the next trial. The paired word-stem remained visible until a verbal response was made or 4000 ms had elapsed. A timed verbal response was intended to encourage participants to give the first word that came to mind. If participants did not respond in the time allotted, the word stem disappeared, and a new screen appeared that instructed participants to press the "Enter" key to begin the next trial. The experimenter wrote down each response given by the participant. The experiment took approximately 10-15 minutes. After completion of the experiment, participants were given the post-experiment questionnaire and were then debriefed.

Results

Five young and five older adults were excluded because of failure to follow directions (e.g., admitted to not reading the prime word). Table 3 displays the means and standard

deviations for the percent of time a word stem was completed with the target word and the amount of priming in each condition for young and older adults. The post-experiment questionnaire revealed that no participants were able to figure

Table 3

Percent of time stem was completed with the target word in Experiment 1 (participant analysis)

	Prime-target relationship				
	Phonological		Semantic		
Age group	Dom	Sub	Dom	Sub	Unrelated
Young					
M	5.7	13.2	40.0	31.4	2.3
(*SE*)	(1.2)	(2.0)	(3.4)	(3.2)	(0.5)
% Priming	3.4	10.9	37.7	29.1	
Older					
M	5.1	10.0	47.1	50.3	2.4
(*SE*)	(1.0)	(2.2)	(3.5)	(3.5)	(0.6)
% Priming	2.7	7.6	44.7	47.9	

out the purpose of the experiment (i.e., the phonological relationship between the primes and targets), suggesting that the priming manipulation was well disguised.

Because the unrelated condition cannot be broken into dominant and subordinate, the analyses were performed on the means after subtracting the baseline (unrelated) condition from each of the other four conditions. This method provides a measure of priming, or the percent of time the target word was given in each of the experimental conditions minus the percent of time the target word was given in the unrelated condition (i.e., given by "chance"). An independent samples t-test revealed no age difference in the unrelated condition, $t1(108) = -.163$, $p > .871$, $t2(96) = .00$, $p > .99$, suggesting young and older adults had similar completion with the target word in the unrelated condition. To compare priming effect sizes, one-sample t-tests showed that each difference score was significantly greater than 0, ps $< .020$, indicating significant priming in all four conditions.

A 2 (age group: young, older) x 2 (prime-target relationship: phonological, semantic) x 2 (dominance: dominant, subordinate) analysis of variance (ANOVA) revealed main effects for Age Group, $F1$ (1, 108) = 4.45, MSE = .07, $p < .037$, $F2$ (1, 94) = 17.55, MSE = .02, $p < .001$, and Prime-Target Relationship, $F1$ (1, 108) = 245.92, MSE = .05, $p < .001$, $F2$ (1, 94) = 182.21, MSE = .06, $p < .001$, but not for Dominance, $F1$ (1, 108) = 1.46, MSE = .02, $p > .23$, $F2 < 1$. Two-way interactions were found for Age Group x Prime-Target Relationship, $F1$ (1, 108) = 12.12, MSE = .05, $p < .001$, $F2$ (1, 94) = 41.60, MSE = .01, $p < .001$, and for Prime-Target Relationship x Dominance in the participant analysis, $F1$ (1, 108) = 9.68, MSE = .02, $p < .002$, but not in the item analysis, $F2$ (1, 94) = 2.27, MSE = .06, $p > .135$. No Age Group x Dominance interaction was found in either analysis, $F1$ (1, 108) = 2.47, MSE = .02, $p > .119$, $F2$ (1, 94) = 2.14, MSE = .02, $p > .147$. These main effects and two-way interactions were mediated by a significant interaction between Age Group, Prime-Target Relationship, and Dominance, $F1$ (1, 108) = 6.44, MSE = .02, $p < .013$, $F2$ (1, 94) = 10.03, MSE = .01, $p < .002$.

Following up the three-way interaction revealed a significant Prime-Target Relationship x Dominance interaction for young adults, $F1$ (1, 108) = 15.95, MSE = .02, $p < .001$, $F2$ (1, 94) = 7.72, MSE = .04, $p < .007$. Post-hoc analyses revealed that young participants had greater priming for subordinate than for dominant homophones in the phonological condition ($p1 < .001$, $p2 < .02$), but greater priming for dominant than for subordinate homophones in the semantic condition ($p1 < .014$, marginal in the item analysis, $p2 > .098$). Unlike young adults, there was no significant Prime-Target Relationship x Dominance interaction for older adults, $F1 < 1$, $F2 < 1$, indicating similar dominance effects for both phonologically mediated and semantic priming. However, older adults had a significant simple main effect of Prime-Target Relationship similar to young adults ($F1$ (1, 108) = 183.61, MSE = .05, $p < .001$; $F2$ (1, 94) = 222.41, MSE = .04, $p < .001$), such that older adults had greater semantic than phonologically mediated priming. The simple main effect of Dominance was significant in the participant analysis only, $F1$ (1, 108) = 3.86, MSE = .02, $p < .05$; $F2$ (1, 94) = 1.03, MSE = .04, $p > .313$, suggesting that older adults had more priming for subordinate homophones than for dominant homophones.

Further analyses of the semantic and phonological conditions indicated an Age Group x Dominance interaction for the semantic condition, $F1$ (1, 108) = 5.92, MSE = .03, $p < .017$, $F2$ (1, 94) = 6.94, MSE = .02, $p < .010$, such that older adults had greater semantic priming for subordinate homophones than young adults ($p1 < .001$, $p2 < .001$). Furthermore, older adults had greater semantic priming than young adults for dominant homophones in the item analysis ($p2 < .016$), with a similar but insignificant trend in the participant analysis ($p1 > .149$). In contrast, there was no Age Group x Dominance interaction for the phonological condition ($F1 < 1$, $F2$ (1, 94) = 2.22, MSE = .01, $p > .140$), suggesting that young and older adults had similar phonologically mediated priming for dominant and subordinate homophones.

Analyses were performed that collapsed across dominance in order to see if there were any overall age differences in semantic and phonologically mediated priming. Although older adults had greater semantic priming than young adults ($p1 < .002$, $p2 < .001$), there were no significant age differences in phonologically mediated priming ($p1 > .291$, $p2 > .080$).

Discussion

Experiment 1 demonstrated phonologically mediated priming of preexisting semantic associations in a retrieval paradigm, supporting similar findings from the word

recognition literature (Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994) and extending this phenomenon to longer-term (up to four seconds) retrieval paradigms. Furthermore, consistent with TDH's predictions but contrary to IDH's predictions, young and older adults showed equivalent amounts of phonologically mediated priming for both dominant and subordinate homophones. This finding suggests that, similar to other forms of priming that show age-equivalence (e.g., repetition priming), phonologically mediated priming in word retrieval is less susceptible to age declines because it utilizes preexisting connections, ones that adults of any age have stored and used over a lifetime. Although older adults report more TOTs than young adults, a phenomenon that is caused by weakened connections to phonological nodes, increased TOTs most often occur for infrequently or nonrecently used words. In contrast, homophones are more commonly used words in everyday speech and writing and therefore older adults are less likely to have weakened connections to them than to infrequently or nonrecently-used words. With respect to IDH, it appears that in this paradigm, either older adults did not have differentially more trouble inhibiting semantic alternatives to homophones than young adults, or older adults did not activate the other alternatives in the first place.

Although phonologically mediated priming was found between homophones and their semantic associates, the amount of priming depended on the homophone's dominance for both young and older adults, with more priming occurring for subordinate than for dominant homophones. Finding more phonologically mediated priming for subordinate homophones is also consistent with Lukatela and Turvey's (1994) finding of more phonologically mediated priming in word recognition when the lower-frequency homophone was the prime and the time course was longer (250 ms compared to 50 ms). Assuming that the low-frequency homophones are also generally subordinate homophones (see Method), these findings are also consistent with the predictions of NST.

It is worth noting that the size of this phonologically mediated priming effect was very small relative to the semantic priming effect, which is likely due to the number of connections that priming must travel across (i.e., one connection for semantic priming and three connections for phonologically mediated priming). Furthermore, whereas there were no age-related differences in phonologically mediated priming, older adults demonstrated greater semantic priming than young adults. This result is consistent with previous semantic priming studies and supports the explanation that older adults' more intricate semantic architecture allows them to offset any one weakened connection and to benefit more from semantic priming accumulating from many associations onto a target node (Laver & Burke, 1993).

Experiment 2:
Phonologically Mediated Priming of New Associations

Experiment 2 expanded on the findings of Experiment 1 by investigating the effects of aging on phonologically mediated priming of new associations in a word-stem completion paradigm. A homophone was paired with a semantically unrelated first letter (e.g., *beech-l*_____) and later the opposite homophone was paired with the same unrelated first letter (e.g., *beach-l*_____). If the association that is formed on the first encounter of the homophone (e.g., *beech-laugh*) is retrieved during the second encounter of the homophone (e.g., *beach-laugh*), retrieval was mediated through the homophones' phonology. Phonologically mediated priming in this paradigm indicates that a new association was formed between *beech* and *laugh* and that this new association then facilitated retrieval of *laugh* when later paired with the homophone *beach*. Note that in this experiment, the participant determined the "target" word with their first completion; whatever word was retrieved on the first completion was the intended target for the second completion.

Similar to Experiment 1, we predicted that phonologically mediated priming would occur because an identical phonological representation (/bēch/) is activated upon presentation of either *beach* or *beech*. Suppose a direct connection has been formed between *beech* and *laugh* when *beech-l*____ is encountered (see Figure 2). When *beach-l*____ is later presented, node priming travels from the lexical node for *beach* to its phonology (/bēch/) and then to the other instance of the homophone, *beech*. If the newly formed connection between *beech* and *laugh* is strong enough, then *laugh* will get activated and result in retrieval of the same word twice.

Experiment 2 used the same preexisting phonological representations that were found to be unimpaired in older adults in Experiment 1; however, Experiment 2 required new semantic associations to be formed (and retrieved via the phonological connections). If older adults have more difficulty retrieving new associations than young adults as suggested by TDH, we would expect older adults to show less phonologically mediated priming of new associations than young adults. In contrast to TDH, IDH predicts that older adults should show more priming of new associations than young adults because of sustained activation from the first completion to the second completion.

Similar to Experiment 1, dominance was expected to influence the activation of the phonological representations: More phonologically mediated priming was expected when the subordinate homophone (*beech*) was presented first, followed by the dominant homophone (*beach*) than when the dominant homophone was presented first and followed by the subordinate homophone (see Experiment 1 predictions for a similar dominance argument).

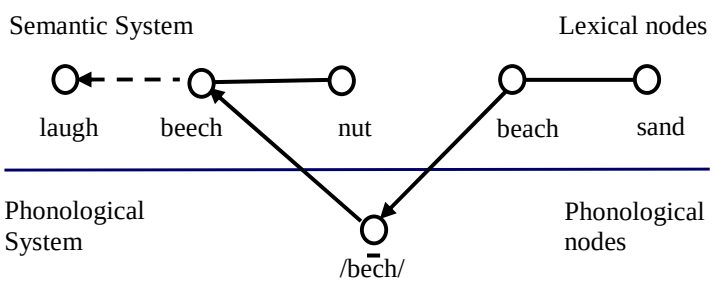

Figure 2. Phonologically mediated priming of new associations. An example of how node priming should spread between *beach* and *laugh* if *laugh* has been newly connected to *beech*.

Participants

Sixty young adults (ages 18-24; *M* = 19.21, *SE* = .17) and 60 older adults (ages 61-86; *M* = 72.68, *SE* = .84) were recruited in the same manner as discussed in Experiment 1, although none participated in Experiment 1. The same background information was collected for this experiment as indicated in Experiment 1 (see Table 4). Scores are based on 57 young and 50 older adults because these were the participants included in analyses (the remaining participants were excluded for not following directions or for having difficulties with the task). Young adults included 39 females and 18 males, and older adults included 25 females and 25 males. Independent samples t-tests indicated that young adults had less years of education, $t(105) = -9.85$, $p < .001$, and worse vocabularies, $t(105) = -9.27$, $p < .001$ than older adults, but larger forward digit spans, $t(105) = 2.56$, $p < .012$. Although young adults tended to have larger backward digit spans, the difference was only marginally significant, $t(105) = 1.62$, $p < .11$. Young and older adults did not differ on self-reported health, $p > .45$.

Design

The experimental design was similar to Experiment 1, with Age (young, older) as a between-participants factor, and Prime Condition (phonological, semantic, unrelated) and Dominance Order (dominant homophone presented first, subordinate homophone presented first) as within-participants factors. The one difference in design between Experiments 1 and 2 was that Experiment 1 presented only one homophone and had dominance inherent in that homophone (either dominant or subordinate), whereas Experiment 2 presented both homophones in the phonological condition, although not consecutively, and manipulated the order in which the homophones were presented (either dominant or subordinate presented first in the list). The dependent variable was the percent of time word stems were completed with the same target word.

Table 4
Background characteristics for young and older adults in Experiment 2

	Group					
	Young Adults			Older Adults		
Variable	*N*	*Mean*	*SE*	*N*	*Mean*	*SE*
Age*	57	19.26	0.18	55	72.32	0.90
Education (years)*	57	13.25	0.17	55	17.16	0.37
Vocabulary* (max = 25)	57	14.81	0.41	55	20.22	0.41
Forward digit*	57	7.72	0.15	54	7.16	0.16
Backward digit*	57	5.79	0.17	54	5.38	0.19
Health (max = 10)	57	7.95	0.19	54	7.70	0.27
MMSE (max = 30)				57	28.30	0.22

Note. Asterisks indicate significant differences between the age groups, $p < .05$.

Apparatus

The apparatus was identical to Experiment 1.

Materials

Participants were presented with the word-stem completion test, which consisted of the same 48 homophone pairs (96 total homophones) that were included in Experiment 1 (excluding foils). These homophones were paired with a different word stem than they were paired with in Experiment 1: To encourage new associations and not preexisting ones, each homophone was paired with a letter that did not elicit any obvious semantic responses (e.g., *l*___ for *beach*), and members of a homophone pair were paired with the same word stem (e.g., *beach-l*____, *beech-l*____).[2] In addition to the experimental pairs, 49 non-homophone filler stems intended to disguise the presence of homophones were included. Five non-homophone practice trials began the experiment.

Similar to Experiment 1, Experiment 2 had three conditions (phonological, semantic, and unrelated) and 2 dominance categorizations (dominant, subordinate). However, unlike Experiment 1, the present experiment required that one of the words in the homophone pair (e.g., *beach-l*_____) be presented prior to either a semantic associate (semantic condition; e.g., *sand-l*____)[3], the other word in the homophone pair (phonological condition; e.g., *beech-l*_____), or a word that was orthographically related to one of the homophones in a pair (unrelated condition, e.g., *batch-l*____). Thus, dominance referred to which member of the homophone was presented first in the list, the dominant or subordinate one (hereafter referred to as "dominance order" for clarity). Members of each experimental word-stem pair (phonological, semantic, or unrelated) were separated by eight other word stems (e.g., the homophones *beech* and *beach* might have fallen in positions 1 and 10 in the word stem list). Furthermore, a non-homophone filler word stem was presented after every two experimental word stems.

Twenty-four of the 26 letters of the alphabet were used as word-stems (*x* and *z* were excluded because very few common words begin with those letters). The 24 stems were each paired with an experimental pair twice (for a total of four presentations of each letter) and with a filler word stem twice. Thus, each of the 24 letters was presented six times in the experiment (with

the exception of five letters (r, f, l, w, g) that were also used in the practice trials). The 24 letters were randomized and then the experimental pairs and fillers were assigned to the letters. The entire list of 24 randomized letters was completed before the letter cycle was repeated. Thus, no word-stem pairs that shared the same word stem as the experimental pair were presented in between an experimental pair (e.g., the word-stem *l____* was not presented in between the experimental stems *beech-l____* and *beach-l____*). These precautions were taken in order to minimize the likelihood of responses being given repeatedly (i.e., repetition priming). Once a word stem (e.g., *l____*) had been presented with an experimental homophone pair, it was then paired with a filler word (e.g., *actor-l____*) and was not again paired with another experimental pair until at least 43 word stems later.

Both the dominant and subordinate members of a homophone pair were counterbalanced across participants so that one word from the pair occurred first for half of the participants and the other word of the pair occurred first for the other half of the participants.

Similar to Experiment 1, participants in Experiment 2 received a verbal questionnaire after completion of the experiment in order to assess whether participants were able to figure out the purpose of the experiment.

Procedure

The procedure for Experiment 2 was identical to that of Experiment 1 with the exception that Experiment 2 contained 150 total word stems instead of 90.

Results

As assessed by the post-experiment questionnaire, two young adults and one older adult guessed as to the purpose of the experiment, although none of these participants were sure of their guesses, and none reported trying to respond any differently to the homophones than they did to any other word-stem pairs. Therefore, these participants were included in the following analyses.

Three young adults and 10 older adults were excluded from analyses for not following directions (e.g., did not read the prime word) or reporting they (repeatedly) intentionally inhibited responses or tried not to use the same word twice). Means and standard deviations for each prime condition and dominance order and the amount of priming in each condition can be found in Table 5. In contrast to Experiment 1, Experiment 2's unrelated condition could be included in the ANOVA because it was crossed with dominance (i.e., an unrelated, orthographic control word-stem pair followed either a dominant homophone or a subordinate homophone). A 2 (age group) x 3 (prime condition) x 2 (dominance order) ANOVA on the percent of time the same target word was given for an experimental pair only revealed a main effect of Prime Condition, $F1$ (2, 210) = 9.38, MSE = 03, $p < .001$, $F2$ (2, 186) = 9.04, MSE = 03, $p < .001$. All other main effects and interactions were not significant, Fs < 1 (except the Age Group main effect in the item analysis, which was marginally significant favoring young adults, $F2$ (1, 93) = 3.61, MSE = 03, $p > .061$). The percent of time the same target word was given for both members of a homophone pair (phonological condition) was greater than the percent of time the same target word was given for a homophone and its unrelated, orthographic control word (unrelated condition), $p1 < .001$, $p2 < .001$, indicating phonologically mediated priming. Similarly, the percent of time the same target word was given for a homophone and its semantic associate (semantic condition) was greater than the percent of time the same target word was given in the unrelated condition, $p1 < .001$, $p2 < .001$, indicating semantically mediated priming. There were no differences in the percent of time the same target word was given in the semantic and phonological conditions, $p1 > .933$, $p2 > .929$, suggesting that the size of the priming effects was equal, and given the lack of an interaction, was similar for young and older adults.

Table 5

Percent of time stem was completed with the target word in Experiment 2 (participant analysis)

	Prime Condition					
	Phonological		Semantic		Unrelated	
Age Group	Dom	Sub	Dom	Sub	Dom	Sub
Young						
M	30.4	31.6	30.4	30.2	23.0	25.3
(*SE*)	(3.4)	(3.2)	(3.1)	(3.2)	(2.6)	(3.1)
% Priming	7.4	6.3	7.4	4.9		
Older						
M	26.6	28.8	28.4	30.3	24.4	20.5
(*SE*)	(3.3)	(3.7)	(2.7)	(3.0)	(3.3)	(2.6)
% Priming	2.2	8.3	4.0	9.8		

Note. Dominant and Subordinate in Table 5 refer to which type of homophone (dominant or subordinate) came first in the list. For the unrelated condition, either the dominant or subordinate homophone was presented prior to an orthographic (unrelated) control word.

Analyses Eliminating Repeated Previous Responses. In contrast to Experiment 1 where very little target completion occurred in the unrelated condition, Experiment 2's participants used the same target word in the unrelated condition over 20% of the time. The high target use in the unrelated condition suggests a repetition priming effect, where participants are more likely to repeat a word they just said than to think of a different word beginning with the same letter. In addition, Experiment 2 differed from Experiment 1 in that the word stems in Experiment 2 did not have a completion that was obviously semantic (whereas in Experiment 1, one-third of the experimental word stems fell into the semantic condition, e.g., *beach-s____*). Hence, because there were no overridingly strong

semantic completions in Experiment 2, people tended to repeat responses that began with the same letter (something that experimenters observed while running the experiment and participants asked about during the debriefing session). Because this repetition priming was so noticeable, analyses were conducted to ensure that the phonologically and semantically mediated priming were not due to repetition priming.

The main analysis, a 2 (age group) x 3 (prime condition) x 2 (dominance order) ANOVA, was conducted after excluding all cases (16.4% for young adults and 17.6% for older) where a response was given prior to the first encounter of an experimental pair. This analysis revealed the same effect as the analysis that included previous responses: a Prime Condition main effect, $F1$ (2, 208) = 9.62, MSE = 04, $p < .001$, $F2$ (2, 184) = 13.12, MSE = .03, $p < .002$, but no other main effects or interactions. The phonological condition (M = 28.2, SE = 3.5) had greater completion with the same target word than the unrelated condition (M = 20.7, SE = 3.0), $p1 < .001$, $p2 < .001$. Similarly, the semantic condition (M = 27.8, SE = 3.1) had greater completion with the same word than the unrelated condition, $p1 < .001$, $p2 < .001$, but the semantic and phonological conditions did not differ, $p1 > .933$, $p2 > .929$. Furthermore, the lack of an interaction with age suggests similar patterns of results for young and older adults in all conditions.

Discussion

The main finding of Experiment 2 was that the retrieval of new associations was mediated through a shared phonological representation for both young and older adults. Interestingly, this finding was not due to repetition priming (i.e., repeating one response multiple times when encountering a given one-letter stem) because the priming effects remained after excluding all cases where a response was given prior to the first encounter of an experimental pair. These results suggest that participants formed new associations after one presentation and exhibited priming across these new associations through phonology. This finding is consistent with previous research that has demonstrated priming of new associations without elaborative processing at study (Goshen-Gottstein & Moscovitch, 1995; McKone & Tyrnes, 1999; Micco & Masson, 1991; Poldrack & Cohen, 1997). However, the surprising result is that priming can spread beyond this association through a homophone's phonology. Indeed, NST predicted that the new connection formation that accompanies associative priming would decrease the amount of priming seen in this experiment compared to Experiment 1. However, the difference between the phonological condition and the unrelated condition in both experiments, averaged across dominance, was 5-7%, suggesting similar amounts of phonologically mediated priming in both experiments.

One explanation for finding new association priming that is similar to preexisting association priming is that the time frame in this experiment was brief: Participants only had to "maintain" the new connection for up to 30 seconds (or 8 intervening word-stem pairs). Therefore, participants most likely benefited from the recency of connection formation. The recency explanation can also describe why older adults did not have a deficit with new association priming, contrary to the predictions of TDH. The brief time period required to maintain the new connection was advantageous to older adults by preventing significant decay in the connection's strength. However, these results are unable to tell us how long the new connection will remain sufficiently strong to enable reactivation or whether the recently formed connection could differentially weaken over time for young and older adults. Nonetheless, the age-related stability of phonologically mediated priming in Experiment 2 is inconsistent with the predictions of IDH. If older adults had more difficulty than young adults suppressing activation of the new association, they would have demonstrated more priming than young adults.

Recency of activation can also be used to explain why there was no difference in the amount of priming found when the dominant or subordinate homophone was presented first in the list. Recent exposure to one member of a homophone pair (e.g., *beach-l___*) prior to presentation of the other member (e.g., *beech-l___*) strengthened the phonological connections to both homophones. Instead of a weak link between a subordinate homophone and its phonology resulting in dominance effects (as in Experiment 1), recent exposure to the lexical and phonological nodes strengthened the connection between those nodes, for both homophones, and allowed for node priming to transmit more effectively across the recently-strengthened connection.

Unlike Experiment 1, there was no difference between the phonological and semantic conditions in Experiment 2, but this is likely due to the semantic condition being mediated in Experiment 2. Furthermore, young and older adults did not differ in the amount of semantically mediated priming, suggesting that older adults' semantic priming advantage is reduced when node priming must travel across multiple connections.

General Discussion

The experiments reported here demonstrated the existence of a new phenomenon: phonologically mediated priming of word retrieval. Phonologically mediated priming occurred across retrieval of preexisting semantic associations (e.g., participants completed *beech-s____* with *sand*, a semantic associate of *beach*) and across retrieval of new semantic associations (e.g., participants completed *beech-l____* and *beach-l____* with the same word, such as *laugh*). In addition, homophone dominance influenced phonologically mediated priming of preexisting associations but not of new associations. Finally, there were no age differences in the amount of phonologically mediated priming across preexisting or new associations. Together, these experiments demonstrate that the nature and activation of phonological representations is stable across the lifespan, as is the ability to form new associations and

use shared phonological representations to retrieve these new associations, at least within approximately 30 seconds of formation.

Theoretically, the predictions of NST were supported by the demonstration of phonologically mediated priming of preexisting and new associations. Because homophones share a common phonological representation, encountering one member of a homophone pair automatically primes the other member of the homophone pair. Thus, activating associates related to the other member, and activating new associations formed with the other member, is possible through the shared phonological representation. The finding that homophone dominance influences phonologically mediated priming of preexisting associations but not of new associations has interesting implications for the roles of word frequency and recency of use on the retrieval of preexisting and new associations. The idea that the recency of activation of one homophone member could be strong enough to override word frequency (or homophone dominance in this case) suggests that recency is a stronger factor than frequency (dominance) in word activation. One future direction for research is to tease apart whether recency or frequency is more powerful in language production and comprehension tasks.

The equivalence of young and older adults on phonologically mediated priming of preexisting associations can be explained within TDH and NST, which maintains that transmission deficits along phonological connections are greater when the task involves top-down node priming (from the semantic system to the phonological system) because priming must diverge and travel along single connections from a semantic node to its phonological nodes. In contrast, bottom-up priming from phonological nodes to a semantic node is convergent: node priming transmits from many phonological nodes onto a single semantic node. In this word-stem paradigm, priming begins with the homophone (prime word), allowing for activation of the phonology which in turn sends bottom-up priming to the semantic system (target word). This argument is consistent with Taylor and Burke (2002) who found age differences in top-down phonological priming but no age differences in bottom-up phonological priming of pictures. Furthermore, the finding that priming of older adults' phonological representations was intact–complements recent research with phonological priming of tip-of-the-tongue (TOT) states (e.g., James & Burke, 2000; White & Abrams, 2002). These studies showed greater resolution of TOTs following presentation of the missing word's phonology (see also Abrams, White, & Eitel, in press), and this increase in resolution was similar for young and older adults (but see White & Abrams, 2002, for declines in old-old adults). Finding preserved priming along phonological connections also mimics research on repetition priming, which commonly does not differ across age groups (see Light et al., 2000 for a review).

In contrast to preexisting associations, TDH predicted that older adults should have more difficulty than young adults on tasks that require the formation of new associations, and this result did not occur. Forming new associations requires that a connection be made between two previously unrelated words. Because connections weaken with old age, older adults should have weaker new connections than young adults. Perhaps young and older adults are equally able to form new connections, but older adults suffer in maintaining the connections. Indeed, research on implicit new learning of nonwords through repetition priming supports the view that connection formation is stable in old age: Both young and older adults' time to pronounce nonwords made of compound words or syllables of words gets faster after only one presentation of the nonword (Light et al., 1995, 1996). However, the notion that older adults might have difficulty maintaining the connection over time remains an issue for future investigation.

Another explanation for age equivalence in the formation of new associations emphasizes the implicit nature of the task. Perhaps implicit (vs. explicit) learning conditions facilitate new learning in older adults (see also Light et al., 1995, 1996). Tasks that require participants to name or pronounce new associations (or nonwords) are less likely to be influenced by explicit processes than tasks that require the participants to explicitly form new associations (or explicitly learn nonwords) and then test new learning through word-stem completion (e.g., Howard, Heisey, & Shaw, 1986). Indeed, implicit learning situations appear to help young adults as well: The amount of phonologically mediated priming in the present experiments was similar for preexisting and new associations (5-7%), suggesting that priming across new associations is similar to priming across preexisting associations under implicit conditions.

Conclusion

The demonstration of phonologically mediated priming in word retrieval has important theoretical and practical implications. Theoretically, the existence of phonologically mediated priming is consistent with the predictions of NST, but also demonstrates the need for greater specification of the duration of new connections as well as the impact of implicit versus explicit encoding of these new connections. Practically, the experiments reported here paint a positive picture for aging adults. First, older adults' retrieval of preexisting information is equivalent to young adults for phonological information and better than young adults for semantic information. However, these findings must only be interpreted for retrieval of common words; older adults are still known to have difficulty retrieving infrequently- and nonrecently-used information, which result in an increased number of TOTs in old age. These results suggest that older adults need continual exposure to language in order to maintain strong existing connections and to offset potential retrieval deficits.

Second, older adults are able to form new connections and retrieve new associations under implicit conditions. Although their explicit formation and retrieval may place them at a disadvantage, the experiments reported here suggest that the formation of the connections is not affected by age per se,

unless encoding conditions are made more difficult (e.g., time pressure, working memory load, divided attention, etc). Rather, older adults' difficulties could be due to the maintenance and strengthening of new connections over time, which may require more exposure to the new information or more elaborative techniques to stabilize the connections between the new information. Another possibility is that older adults have difficulty accessing the newly-learned information under explicit conditions. Whether they can retrieve new associations across longer time periods (e.g., 10 minutes, 1 hour) has yet to be determined, as well as the amount of exposure required to allow for retrieval at longer intervals. Future research should investigate the conditions under which older adults have difficulty sustaining new connections and accessing the information at long time intervals.

References

Abrams, L., White, K. K., & Eitel, S. L. (in press). Isolating Phonological Components that Increase Tip-of-the-Tongue Resolution. *Memory and Cognition*.

Burke, D. M. (1997). Language, aging, and inhibitory deficits: Evaluation of a theory. *Journal of Gerontology: Psychological Sciences, 52B,* 254-264.

Burke, D. M., MacKay, D. G., Worthley, J., & 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.

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

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

Goshen-Gottstein, Y., & Moscovitch, M. (1995). Repetition priming effects for newly formed associations are perceptually based: Evidence from shallow encoding and format specificity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 1249-1262.

Graf, P., & Schacter, D. L. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 501-518.

Graf, P., & Schacter, D. L. (1989). Unitization and grouping mediate dissociations in memory for new associations. *Journal of Experimental Psychology: Learning, Memory, & Cognition,15,* 930-940.

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: Academic Press.

Howard, D. V., Heisey, J. G., & Shaw, R. J. (1986). Aging and the priming of newly learned associations. *Developmental Psychology, 22,* 78-85.

James, L. E., & Burke, D. M. (2000). Phonological priming effects on word retrieval and tip-of-the-tongue experiences in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26,* 1378-1391.

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.

Lesch, M. F., & Pollatsek, A. (1993). Automatic access of semantic information by phonological codes in visual word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 285-294

Light, L. L., Kennison, R., Prull, M. W., LaVoie, D., & Zuellig, A. (1996). One-trail associative priming of nonwords in young and older adults. *Psychology and Aging, 11,* 417-430.

Light, L. L., LaVoie, D., & Kennison, R. (1995). Repetition priming of nonwords in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 327-346.

Light, L. L., Prull, M. W., LaVoie, D. J., & Healy, M. R. (2000). Dual-process theories of memory in old age. In T. J. Perfect & E. A. Maylor (Eds.), *Models of cognitive aging.* Oxford: Oxford University Press.

Lukatela, G., & Turvey, M. T. (1994). Visual lexical access is initially phonological: I. Evidence from associative priming by words, homophones, and pseudohomophones. *Journal of Experimental Psychology: General, 123,* 107-128.

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., & Burke, D. M. (1990). Cognition and aging: A theory of new learning and the use of connections. In T. Hess (Ed.), *Aging and cognition: Knowledge organization and utilization* (pp. 13–263). Amsterdam: North Holland.

McKone, E., & Tyrnes, K. (1999). Acquisition of novel traces in short-term implicitly memory: Priming for nonwords and new associations. *Memory & Cognition, 27,* 619-632.

Micco, A., & Masson, M. E. (1991). Implicit memory for new associations: An interactive process approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 1105-1123.

Poldrack, R. A., & Cohen, N. J. (1997). Priming of new associations in reading time: What is learned? *Psychonomic Bulletin & Review, 4,* 398-402.

Taylor, J. K., & Burke, D. M. (2002). Asymmetric aging effects on semantic and phonological processes: Naming in the picture-word interference task. *Psychology and Aging,* 17, 662-676.

White, K. K., & Abrams, L. (2002). Does priming specific syllables during tip-of-the-tongue states facilitate word retrieval in older adults? *Psychology and Aging, 17,* 226-235.

End Notes

1. To summarize those pilot studies briefly, young and older adults performed free association to a list of 197 homophones, and then chose which word of a homophone pair they believed to be more dominant. These norms were used (1) to choose an associate (e.g., *sand* for *beach*) that was provided by both young and older adults, and (2) to assess dominance within each homophone pair. Attempts were made to choose homophone pairs that produced equivalent associations and dominance ratings for young and older adults. Forty-eight homophone pairs were chosen to use in the experiment (these pairs had the most equivalent free associations and dominance ratings for young and older adults). Each of these 48 homophone pairs had two target words (associates) assigned to it: One target word was chosen for the dominant homophone (e.g., *sand* for *beach*) and one target was chosen for the subordinate homophone (e.g., *nut* for *beech*). More information regarding the pilot studies can be obtained from the authors.

2. Pilot testing of experimental word stems prior to the actual experiment eliminated potential stems that could obviously be completed with a word that was semantically related to the homophone. For example, the word-stem pair *urn-b___* was changed to *urn-k____* because *burn* was a potential semantic (and rhyming) response to the word stem *b____*.

3. The semantic condition used many of the semantic associates that were used as targets in Experiment 1. However, unlike Experiment 1 where semantic priming was direct (e.g., *beech-nut*), in Experiment 2 semantic priming was mediated through a semantic associate (e.g., *nut-beech-laugh).* Therefore, in order to increase the likelihood of priming in the semantic condition, we changed some of the semantic associates that were used in Experiment 1. In Experiment 1, pilot testing showed that some homophones could not be paired with the strongest semantic associate due to stimuli issues (e.g., *smell* was not paired with *scent* because both words start with "s" and we wanted to avoid eliciting homophones, e.g., *sent*, as responses). Experiment 2 did not have this problem because the semantic associate was presented after its homophone (e.g., *scent-h____* preceded *smell-h____*) and not along-side its homophone as the word stem (e.g., *scent-o___* in Experiment 1). Thus, in order to increase the strength of association between a homophone and its semantic associate (and therefore increase the chance of semantically mediated priming, 34 of the 96 semantic associates (35%) were changed between Experiments 1 and 2.