Age-Related Differences in the Use of Phonology to Facilitate Implicit and Explicit Memory for New Associations

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Abstract

Two experiments tested young and older adults' retrieval of episodic memories under intentional (i.e., explicit) and incidental (i.e., implicit) retrieval conditions following either an implicit encoding task (Experiment 1) or an explicit encoding task (Experiment 2). In addition, the ability of young and older adults to use lexically identical and phonological primes/cues to retrieve newly-formed associations was assessed. New associations were formed via a paired word-stem completion paradigm where a homophone (e.g., sine) was paired with a two-letter stem (e.g., gl____), and participants produced an appropriate target word (e.g., glass). New associations were later retrieved either implicitly or explicitly via lexically identical (e.g., sine), phonologically identical (e.g., sign), or unrelated (e.g., sink) primes/cues. Overall results showed that with regards to retrieval via lexically identical cues/primes, the type of retrieval (implicit vs. explicit) was more significant than the type of encoding for older adults when compared to younger adults. In contrast, retrieval via phonological primes/cues depended on type of encoding: associations made when implicitly encoding by both young and older adults were too weak to facilitate phonological priming/cueing, whereas associations made when explicitly encoding showed phonological priming and cueing for young adults, but only phonological priming for older adults.

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Within cognitive aging research, age-related memory deficiencies are consistently shown across a variety of tasks (e.g., Craik and Jennings 1992; Light 1991). However, because memory does not uniformly decrease with age, researchers must tease apart which aspects of memory decline and which aspects remain stable. Various studies have shown that older adults have more difficulties than young adults when asked to remember new episodic information (i.e., memory for events), and especially when asked to recall newly associated information, such as an association between previously unrelated words (Howard 1991; Kausler 1994; MacKay and Burke 1990).

One explanation for these age-related deficits in episodic memory for new associations is that older adults have particular difficulty binding together complex memories (e.g., Naveh-Benjamin 2000; see also Chalfonte and Johnson (1996), for binding deficits in amnesics). In terms of new associations between two previously unrelated items or words, both the Associative Deficit hypothesis (ADH; Naveh-Benjamin 2000) and the Transmission Deficit hypothesis (TDH; MacKay and Burke 1990) maintain that older adults have difficulty forming new links or connections between item representations. For example, when asked to form a new association between the words *zebra* and *paper*, a new connection must be created between the stored representations in memory for *zebra* and *paper*. Because this connection is new, it is weaker than connections between words like *zebra* and *tiger* that have been repeatedly associated for many years. According to TDH, connections between all stored representations weaken with increasing age. Thus older adults are at a particular disadvantage in memory tasks that rely on newly-formed associations because their recently-formed connections will be weaker than younger adults'.

Although older adults are thought to have more difficulty in episodic memory tasks that rely on the formation of new associations, evidence suggests that an additional factor influences older adults' episodic memory that must not be overlooked: the manner in which the memories are formed and retrieved. In general, older adults perform worse on tasks that rely on explicit, or intentional, processes than on tasks that rely on implicit, or unintentional, processes (Howard, Fry, and Brune 1991). This evidence suggests that older adults are at a disadvantage only when memory is evoked, or when they are consciously aware of

their memory use. For example, Naveh-Benjamin (2000) assessed older and young adults' memory for new associations by asking them to learn and recall word-nonword pairs. Results showed that older adults had significantly more difficulty than young adults in recalling the new associations. In contrast to this explicit memory task, implicit memory for newly-learned nonwords does not appear to be affected by aging (Light, La Voie, and Kennison 1995). Light et al. (1995) measured the time it took for young and older adults to read aloud nonwords on their first and second presentations. Both young and older adults' reading times decreased from the first to the second presentation, suggesting that the new connection that was formed during the first presentation of a nonword was equally accessible on the second presentation, at least when tested indirectly (i.e., implicitly). Taken together, these results imply that older adults' episodic memory disadvantage may only occur when explicit memory strategies are used. However, because the Naveh-Benjamin (2000) study required explicit processes at both *encoding* (i.e., forming the new connection) and *retrieval* (i.e., accessing the new connection), whereas the Light et al. (1995) study encouraged reliance on implicit processes at both phases, we do not know whether older adults' deficit lies in explicit memory per se, or whether it lies in just one phase of the memory task, i.e., encoding *or* retrieval.

One aim of the present experiment was to investigate the source of the episodic memory deficit in older adults, i.e., whether the age-related deficit appears at *encoding*, at *retrieval*, or both. It is possible that there is not an age-related deficit in either encoding or retrieval; rather, the deficit might arise only when older adults use conscious (explicit) retrieval attempts and strategies to encode and/or retrieve. Though other studies have looked at explicit encoding and implicit retrieval (Howard, Heisey, and Shaw 1986) or implicit encoding and explicit retrieval (Light et al. 1995), no one experiment has incorporated all of these factors into one design.

A second aim of the present research was to determine whether certain cues or primes facilitate episodic memory. With new associations, the first word in the pair (e.g., *zebra*) often serves as a prompt to facilitate retrieval of the target (e.g., *paper*). When the task is explicit, the prompt is referred to as a *cue*, and when the task is implicit, the prompt is referred to as a *prime*. Much of the previous research in both explicit

and implicit memory uses the same cues/primes at encoding and retrieval, which is referred to as *repetition cueing/priming*. Although not yet considered in explicit memory experiments, recent implicit memory research has presented primes at retrieval that overlap with the primes at encoding in sound (i.e., phonology) in order to determine whether older adults can use phonological primes to facilitate implicit retrieval of newly-formed associations. Specifically, White and Abrams (2004) investigated phonological priming, where retrieval of a target word (e.g., *glove*) is facilitated when the prime at retrieval (*sign*) shares phonology but not spelling or meaning (i.e., is a homophone) with the encoding prime (*sine*). Results showed that both young and older adults demonstrated similar levels of phonological priming under implicit encoding and retrieval conditions. This study provides further support for the notion that with regard to episodic memory performance, older adults do not appear to experience difficulties when asked to rely on implicit or unintentional memory processes.

The present experiments further extended the research done by White and Abrams (2004) by investigating whether there are limits to when and how phonology can be utilized by young and older adults in the retrieval of newly formed associations. The existence of phonological priming demonstrates that the encoding and retrieval of new associations can be facilitated by the use of sound cues alone. Phonological priming has been demonstrated for implicit retrieval of new associations, suggesting that sound can be used to access a new association when retrieval is unintentional. However, it is unclear whether phonological priming is simply a function of retrieval type, as it has only been shown under implicit priming conditions. Other word retrieval tasks, such as retrieval of a target word following a tip-of-the-tongue state, are also facilitated by words that share phonology with the target, but these tasks also involve implicit priming (e.g., James and Burke 2000; White and Abrams 2002). It is unknown whether phonological priming will occur for explicit retrieval where intentional and strategic retrieval processes require people to recall the exact association that was studied, not a homophone of the originally studied word. Additionally, it is unknown whether phonological priming will occur as the time between encoding and retrieval increases to several minutes rather than a few seconds, as shown by White and Abrams

(2004).

Our current studies intended to further the current research on episodic memory for new associations by (1) investigating the specific encoding and retrieval conditions (implicit vs. explicit) that facilitate young and older adults' memory for new associations, and (2) determining any limits to the use of phonology to facilitate new association learning. In both Experiment 1 and Experiment 2, new learning was tested using a paired word-stem completion paradigm, a form of associative priming where a new connection in memory is formed between two previously unrelated words (e.g., Graf and Schacter 1985). With paired word-stem completion, a prime/cue word (e.g., *sine*) is paired with a two-letter word stem (e.g., *gl*____) that is intended to elicit retrieval of the target word. In Experiment 1, participants were subjected to an implicit encoding phase, followed by both an implicit and explicit retrieval phase. In Experiment 2, participants were subjected to an explicit encoding phase, followed by the same implicit and explicit retrieval phases that were used in Experiment 1. During the retrieval phases, participants were presented with (1) primes/cues (e.g., *sine*) that were identical to the primes/cues (e.g., *sine*) presented at encoding (repetition condition), (2) primes/cues (*sign*) that were related in sound to the primes/cues (*sine*) at encoding (phonological condition), or (3) words (*sink*) that were unrelated to the primes/cues (*sine*) at encoding (unrelated condition). Participants' memory for the newly learned associations was measured by the proportion of times they completed the two-letter word stem (e.g., *gl*____) with same word during both encoding and retrieval.

Experiment 1

Experiment 1 presented participants with an *implicit* encoding task in which they were instructed to simply complete the word stem with the first word that came to mind and were given no indication of a later memory test. This task was followed by an implicit retrieval task and then an explicit retrieval task; in both retrieval tasks, participant's memory for the associations formed during encoding was measured by the proportion of the time they completed the two-letter stem with the same word that they gave during the implicit encoding phase.

Method

Participants. A total of 90 adults (45 young adults, 45 older adults) participated in this experiment. The young adults included 34 females and 11 males, ranged in age from 18-29 (M = 19.86, SD = 2.29), who were obtained from psychology courses at the College of Charleston, and who completed this experiment for either partial course credit or extra credit. The older adults included 25 females and 19 males (with one individual's gender not reported), ranged in age from 61-90 (M = 73.59, SD = 7.02), and consisted of volunteers from the Charleston community who were paid $10 for their participation.

Design. The experimental design consisted of three independent variables, with age group (young, older adults) as a between-participants variable and retrieval type (implicit, explicit) and prime condition (repetition, phonological, unrelated) as within-participants variables. The primary dependent variable was the percent of time the word stems were completed with the same target word during encoding and retrieval.

Materials. During the encoding phase of the experiment, participants were presented with a word-stem completion task using 48 homophone pairs (96 total homophones) identical to those used in White and Abrams (2004). In order to ensure that new associations would be made, these homophones were paired with two-letter stems that did not elicit any preexisting semantically-related response (e.g., *sine-gl*_____) and each of the homophones within a pair were paired with the same two-letter stem (e.g., *sine-gl*____, *sign-gl*_____). Each of these word pairs had at least 10 different plausible completions and each was pilot tested to ensure the absence of any semantically related response. In order to disguise the presence of the homophones, 24 nonhomophone filler word-stem pairs were also presented between every two homophones.

In this experiment there were three prime conditions (repetition, phonological, and unrelated). One member of each homophone pair (e.g., *sine*) was always presented during encoding, and thus prime condition was defined by the type of prime presented during retrieval. In the repetition condition, participants saw the same homophone that they saw during encoding, paired with the same word stem (e.g., *sine-gl*____). In the phonological condition, participants saw the homophone that was not presented during encoding, paired with the same word

stem (e.g., *sign-gl*_____). In the unrelated condition participants saw a word unrelated in meaning to the encoding homophone, paired with the same word stem (e.g., *sink-gl*_____). These unrelated words were closely matched to each encoding homophone in spelling, word length, and word frequency.

Counterbalancing these 48 homophone word-stem pairs resulted in six files, with each file including 24 word-stem pairs that were seen during implicit retrieval and 24 word-stem pairs that were seen during explicit retrieval. Of the 24 word-stem pairs seen during each retrieval phase, 8 were repetition, 8 were phonological, and 8 were unrelated. Each participant saw each word-stem pair in only one retrieval phase (e.g., implicit) and in only one prime condition (e.g., phonological). Word-stem pairs were counterbalanced across both retrieval phase and prime condition so that each pair was represented equally in both implicit and explicit retrieval as well as in repetition, phonological, and unrelated prime conditions.

Apparatus. In order to control stimulus presentation, all stimuli were presented on Pentium III 350 MHz IBM-compatible computers using a program written in Visual Basic 5.0. Participants saw the stimuli on a 17-inch monitor, and the response rates of their verbal responses were recorded via a Plantronics DSP-500 Headset with microphone. The experimenter recorded any errors in response times (e.g., failure to register response) on a sheet of paper, and keyed each verbal response into the computer.

Procedure. Participants were first asked to read the instructions on the computer screen, which were then reiterated verbally, and participants were given a chance to ask questions. During the encoding phase, participants were told to read the word and complete the stem with the first word that came to mind and completed the stem. Because of the implicit nature of this encoding task, there was no indication of a later memory test. They were also given an example (e.g., *cookie-up*____) to help clarify the task. Participants then saw the 48 homophone word-stem pairs, as well as the 24 non-homophone filler word-stem pairs. The word-stem pairs appeared on the screen for a maximum of 4 seconds or until a response was made, and there was a 1 second pause in between word pairs.

At the end of the encoding phase, participants saw a new set of

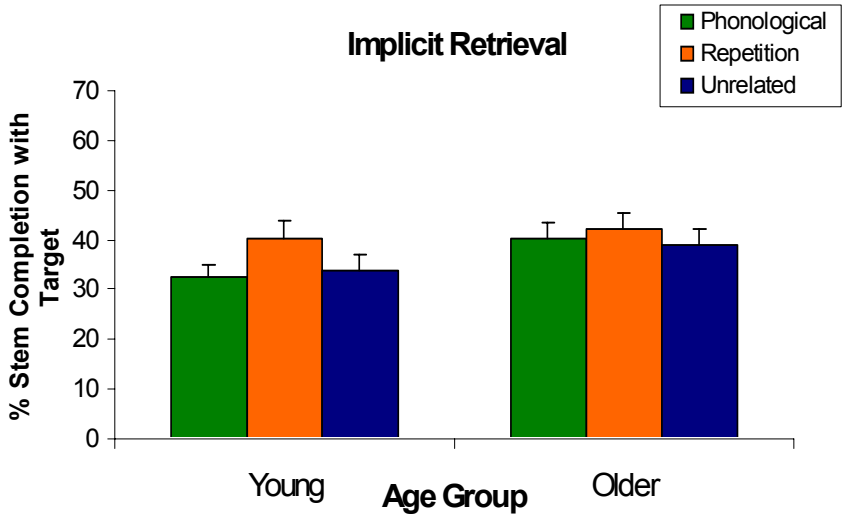
instructions on the screen that corresponded to the implicit retrieval task. In order to ensure that participants were unaware that their memory was being tested, they were told they would be completing a "pronunciation task." They were told that they would read aloud some words and generate other words and that they should speak clearly and to try to focus on their pronunciation. In order to further disguise the task, the primes preceded their corresponding word stems, resulting in primes and word stems appearing on separate screens. Of the words they read aloud, 24 were prime words (8 in each condition) and the other 36 were non-homophone filler words that ranged in length from 1-4 syllables and were included to further support the nature of the pronunciation task. Participants would see either one or two filler words, followed by a prime (repetition, phonological or unrelated), followed by its word-stem target. For the word-stem generation task, participants were asked to simply pronounce the first word that came to mind and began with the given letters. Each stimulus (filler, prime, word stem) remained on the screen until a response was made or four seconds elapsed. One second elapsed between the offset of one stimulus and the onset of the next stimulus.

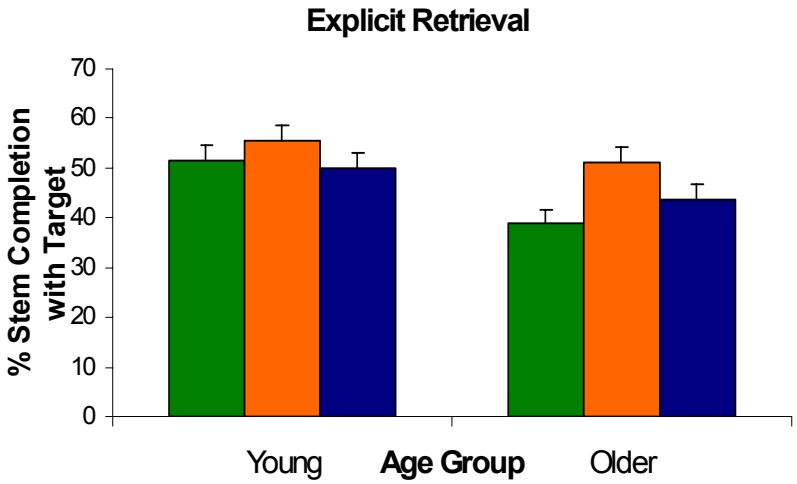
Once the implicit retrieval task was completed, all participants proceeded to the explicit retrieval task, where they were told that they were now going to be tested on their ability to recall their responses from the first task. They were asked to read aloud a cue word that may or may not have helped them to retrieve the earlier generated word, and then to try to give their earlier response to the word stem. If participants were unable to recall their previous response, they were told to make their best guess. Participants then saw the other 24 cues (8 in each condition) that were not presented in the implicit retrieval phase, and that corresponded to 24 of the word stems presented in the encoding phase. The cue was presented prior to the word stem, and remained on the screen until the participant read it aloud or four seconds elapsed. Then the word stem was presented for a maximum of four seconds or until a response was made. Because the purpose of the explicit retrieval task did not need to be disguised, there were no fillers.

Once the entire experiment was completed, all participants were given a written and verbal debriefing, as well as a chance to answer questions.

Results

A 3 (prime condition: repetition, phonological, unrelated) x 2 (retrieval type: implicit, explicit) repeated measures analysis of variance (ANOVA) was performed on the percent of time the word stems were completed with the same target word during encoding and retrieval, separately for young and older adults. As seen in the figure, for young adults, there was a significant main effect of prime condition, F (2, 88) = 3.34, MSE = .03, p < .040, showing more retrieval following repetition primes/cues than unrelated ones (p < .014) but similar retrieval for phonological and unrelated primes/cues (p > .936). There was also a main effect of retrieval type, F (1, 44) = 55.51, MSE = .03, p < .001, with more retrieval occurring when explicitly than when implicitly retrieving. There was no significant interaction between prime condition and retrieval type, F < 1.





For older adults, there was a significant main effect of prime condition, F (2, 88) = 4.04, MSE = .03, p < .021, and a marginally significant effect of retrieval type, F (1, 44) = 2.95, MSE = .04, p < .093, and this is also seen in the figure. These main effects were mediated by a marginally significant interaction between prime condition and retrieval type, F (2, 88) = 2.45, MSE = .02, p < .092. Further analysis of this interaction showed no prime condition effects for implicit retrieval (p > .589), although there was an effect of prime condition for explicit retrieval (p < .005). Specifically, older adults showed slightly more explicit retrieval following repetition cues than unrelated cues (p < .063), but did not show any retrieval differences between phonological and unrelated cues (p > .126).

Discussion

Experiment 1 showed that when young and older adults learn new associations incidentally, or implicitly, they later retrieve this new association only when provided with the exact context that they encoded: lexically identical (i.e., repeated) primes/cues. Neither age group showed any facilitation at retrieval from phonological primes/cues. With respect to type of retrieval, older adults appear to be more affected by retrieval

type than young adults. Young adults' retrieval using lexically identical primes/cues was independent of retrieval type, although their overall retrieval was slightly higher when the task was explicit than when it was implicit. In contrast, older adults only benefited from lexically identical cues when explicitly retrieving.

Results also show that, contrary to White and Abrams (2004), phonological priming/cueing was not seen during implicit or explicit retrieval tasks for either age group. It is possible that the inclusion of repetition primes/cues may be responsible for these findings. White and Abrams (2004) used phonological and semantic primes, while Experiment 1 used phonological and repetition primes/cues. The addition of a repetition condition may have forced participants to search for an "exact match" when retrieving and therefore diminished their reliance on phonological support. It is also likely that the time course between encoding and retrieval affects the degree to which one is able to benefit from phonology. Perhaps as the length of time between encoding and retrieval (an average of approximately 7 minutes in this experiment) increases then benefits from phonology decrease.

Experiment 2

Experiment 2 sought to further investigate the impact of encoding type on age-related differences seen during retrieval of new associations. Similar to Experiment 1, Experiment 2 assessed new association learning using a paired word-stem completion paradigm. However, in this experiment, participants underwent an explicit encoding condition, as was differentiated through the manipulation of instructions, contrary to the implicit encoding condition given in Experiment 1. This encoding phase was again followed by both implicit and explicit retrieval phases. Similar to Experiment 1, participants were presented with repetition, phonological, or unrelated cues during both implicit and explicit retrieval phases and their memory for the newly-learned associations was measured by the proportion of times they completed the word stems with same word they gave during the encoding phase.

Method

Participants. A total of 89 adults (44 young adults, 45 older adults)

participated in this experiment. The young adults included 30 females and 14 males, ranged in age from 18-25 (M = 19.31, SD = 1.52), who were obtained from psychology courses at the College of Charleston, and who completed this experiment for either partial course credit or extra credit. The older adults included 25 females and 20 males, ranged in age from 60-81 (M = 71.31, SD = 5.58) and consisted of volunteers from the Charleston community who were paid $10 for their participation.

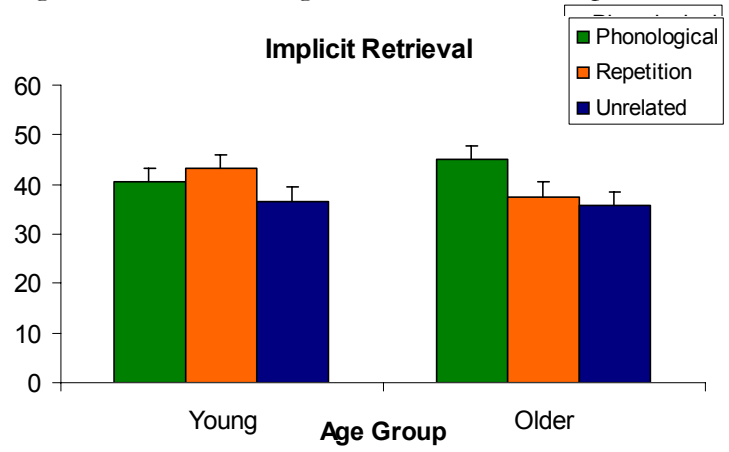
Design. The experimental design was identical to Experiment 1.

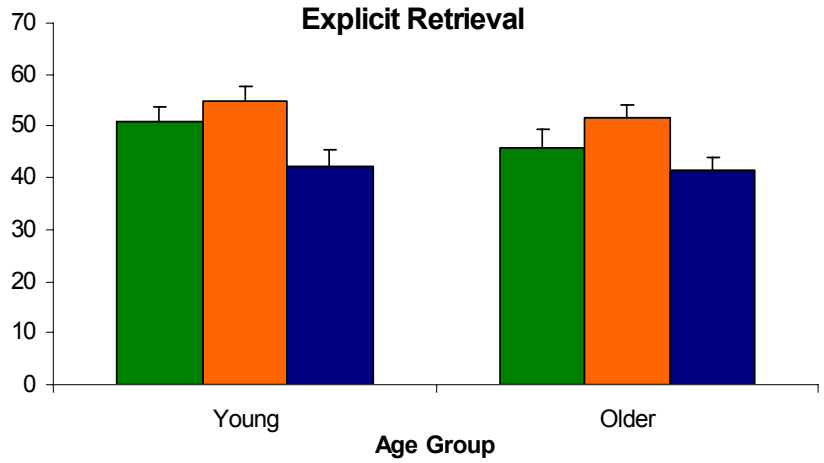
Materials and Apparatus. The materials and apparatus were identical to Experiment 1.

Procedure. The only procedural difference between Experiments 1 and 2 was in the encoding instructions. In addition to responding to the word-stem pairs with the first word that came to mind, participants were now told to try to remember the first word along with their generated response as a word pair, because they might later be asked to recall the pairs.

Results

As with Experiment 1, a 3 (prime condition: repetition, phonological, unrelated) x 2 (retrieval type: implicit, explicit) repeated measures analysis of variance (ANOVA) was performed on the percent of time the word stems were completed with the same target word during encoding and retrieval, separately for young and older adults. The figure shows that for young adults, there was a significant main effect of prime condition,





F (2, 86) = 6.95, MSE = .03, p < .002, showing more retrieval following repetition primes/cues than unrelated ones (p < .001) and more retrieval following phonological primes/cues than unrelated ones (p < .025). There was also a main effect of retrieval type, F (1, 43) = 11.72, MSE = .05, p < .001, with more retrieval occurring when explicitly than when implicitly retrieving. There was no significant interaction between prime condition and retrieval type, F < 1.

The figure also shows that for older adults, there was a significant main effect of prime condition, F (2, 88) = 3.59, MSE = .03, p < .032, and significant effect of retrieval type, F (1, 44) = 8.35, MSE = .04, p < .006. These main effects were mediated by a significant interaction between prime condition and retrieval type, F (2, 88) = 3.36, MSE = .03, p < .039. Further analysis of this interaction showed prime condition effects for implicit retrieval (p < .028) and for explicit retrieval (p < .043). When retrieving implicitly, there were no retrieval differences between repetition and unrelated primes (p > .693), but more retrieval occurred with phonological than unrelated primes (p < .016). When retrieving explicitly, repetition cues led to more retrieval than unrelated cues (p < .010), but there were no differences between phonological and unrelated cues (p > .302).

Discussion

Similar to Experiment 1, both young and older adults were able to retrieve their newly formed associations when the context at retrieval was an exact match with the context at encoding (i.e., when given a lexically identical cue). Young adults benefited from repeated information and this benefit was independent of retrieval type, whereas older adults were only able to use repeated cues under explicit retrieval conditions. However, unlike Experiment 1, phonological information was also helpful in retrieving new associations, under both implicit and explicit retrieval conditions for young adults, but only under implicit retrieval conditions for older adults. Thus older adults were unable to utilize phonological cues when explicitly retrieving. This again may be related to the presence of repetition cues. When explicitly retrieving older adults were again looking for the "exact match" and thus were unable to benefit from the phonological cues. However, when they were unaware that they were using their memory during implicit retrieval, they were able to benefit from the phonological primes.

General Discussion

The purpose of these experiments was to investigate (1) the influence of implicit and explicit encoding and retrieval on memory for new associations in young and older adults, and (2) whether implicit and explicit retrieval of new associations can be equally facilitated by the use of identical vs. phonological primes/cues. In retrieving the identical association (through repeated primes/cues), type of retrieval was more critical for older adults' memory of new associations than type of encoding. In both Experiments 1 and 2, older adults only retrieved the associations when consciously trying to recall them, whereas young adults retrieved the associations independent of the type of encoding or retrieval. Under explicit retrieval conditions, both young and older adults demonstrated new association learning when the prime was the same word that was given during encoding. However, when retrieval was implicit, regardless of whether or not encoding was implicit or explicit, repetition priming was not able to facilitate retrieval of new associations in older adults. Young adults were, however, able to use repetition priming in both Experiment 1 and 2, indicating that repetition priming/cueing was useful regardless of type of encoding as well as

retrieval.

Though repetition priming/cueing seemed to be more dependent on type of retrieval, at least in reference to older adults, the opposite appeared to be true for phonological priming/cueing. In Experiment 1, when participants implicitly encoded information, there was no phonological priming/cueing in either of the retrieval conditions for either age group. However, in Experiment 2, when participants explicitly encoded information, young adults showed phonological priming/cueing during both implicit and explicit retrieval conditions, and older adults demonstrated phonological priming under implicit retrieval conditions. These results suggest that the type of encoding determines whether or not one will be able to utilize phonology in the retrieval of new associations. It appears as though connections established during implicit encoding, demonstrated in Experiment 1, were too weak to be facilitated by a phonological prime/cue unless the delay between encoding and retrieval is very brief, as seen in White and Abrams (2004). However, those associations encoded under explicit conditions, as seen in Experiment 2, were perhaps encoded with a heightened awareness and thus phonology could be used to facilitate recall even after a relatively long time delay. Explanations as to why, with older adults, phonological priming/cueing was seen under implicit retrieval but not during explicit retrieval may again be explained by the presence of repetition primes/cues. It is possible that when strategic retrieval processes are used during explicit retrieval, new association learning may only be demonstrated when there is an exact match between material at encoding and material at retrieval. Thus with explicit retrieval, strategic retrieval processes are used to recall the exact association that was studied, not a homophone of the originally studied word, explaining why phonological cueing would not be seen.

These experiments have helped to shed some light on the conditions in which episodic memory is facilitated in older adults. According to the TDH, older adults have difficulties forming connections between newly associated item representations. These experiments provide support for this hypothesis and suggest that under implicit encoding conditions, the connections formed may be even weaker than those formed under explicit encoding situations. These studies also suggest that the type of retrieval (implicit vs. explicit) may determine the degree

to which older adults benefit from repetition or phonological priming/cueing. Under explicit retrieval conditions, older adults were able to use repetition cueing to facilitate recall. However, under implicit retrieval conditions, repetition priming did aid in recall. Future research may look to further investigate the differences seen in implicit vs. explicit encoding and retrieval as well as the benefits seen from phonological and repetition priming/cueing.

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