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Using orthographic neighborhood size manipulations to investigate memory deficits in aging memory

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Abstract: In three previous studies, manipulations of orthographic neighborhood size and orienting task were used to differentiate between item-specific and relational processing in young adults (aged 18–35) in standard recognition tasks. The current study attempts to investigate memory deficits in older adults (aged 65+) using similar manipulations. Experiment 1 manipulated orthographic neighborhood size within an item recognition task. Young adults demonstrated a standard mirror effect, showing more accurate performance for low-*N* words. No such effect was found in older adults, possibly indicating a deficit in item-specific processing. Experiment 2 included an orienting task during study to emphasize a specific type of processing. While younger adults' performance was influenced by orienting task, older adults showed consistently better performance for High-*N* words. These results suggest that older adults show a deficit in item-specific processing, relying more on relational processing regardless of task.

Subjects: Cognitive Psychology; Gerontology (Aging); Health Psychology; Memory; Mental Health

Keywords: recognition memory; relational processing; item-specific processing; orthographic neighborhood size; orienting task; aging memory; memory deficits

1. Introduction

Distinctiveness has been found to be an important concept in memory theory (e.g. Hunt & Mcdaniel, 1993; Reed Hunt, 2003; Schmidt, 1991). The early emphasis of semantic distinctiveness in memory (e.g. Jacoby, Craik, & Begg, 1979; Klein & Saltz, 1976) has gradually shifted to also include investigation of the effects of orthographic distinctiveness on memory processes (Cortese, Watson, Khanna, & McCallion, 2006; Cortese, Watson, Wang, & Fugett, 2004; Glanc & Greene, 2007, 2009; Hunt & Mitchell, 1982). While a universal definition of distinctiveness has not yet been adopted, it has been reasonably accepted as the encoding of ideas or words to memory using both item-specific memory cues of

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Glanc's research focuses primarily on visual word recognition and how different aspects of the visual experience inform the memory process. She is largely interested in a multidisciplinary approach to memory research, investigating how phenomena from linguistics, cognitive, and even social psychology influence information processing.

PUBLIC INTEREST STATEMENT

One comment I hear often about aging is that "the memory is the first to go." This study compares memory performance on a simple item recognition task between younger and older adults in order to better inform researchers what is, exactly, "going." The good news is that deficits in older individuals' memory performance can be improved with specific orientation techniques that encourage the correct type of information processing.

those words (i.e. information that is pertinent to the processing of the item in particular, in exclusion of context, such as font or distinctive spelling pattern) as well as relational cues (i.e. information that is pertinent to the processing of the particular item in relation to contextual items, such as shared spelling patterns, or shared associations; see Burns, 2006, for a review). Lexical distinction can arise when words have either a unique phonological or orthographic representation in memory.

One way to operationalize lexical distinction is through the concept of orthographic neighborhood size, which combines both aspects of lexical distinction in a single operational definition. Denoted as "*N*," orthographic neighborhood size is defined in the current study as the number of words that share the same orthographic and phonological rime (Cortese et al., 2004; Glanc & Greene, 2007, 2009, 2012; Ziegler & Perry, 1998). A word's rime is defined as the spelling body following the initial onset sequence of a word. As an example, the words *hat* and *cat* share the same rime (-*at*; Ziegler, Stone, & Jacobs, 1997). Research has shown that words with small orthographic neighborhood size, meaning they lack large numbers of other words sharing the same rhyming and spelling pattern (e.g. *Thyme, rhyme)*, are more distinctive than words with large orthographic neighborhoods (e.g. *mat, cat, hat, rat … etc*.; Cortese et al., 2004).

When subjects are asked to perform a standard item recognition task using words which vary in orthographic neighborhood size, words with small orthographic neighborhoods ("Low *N*" words) show a higher hit rate than those of words with large orthographic neighborhoods ("High *N*" words), while also showing a lower false alarm rate (i.e. greater accuracy). This occurrence is considered a "mirror" effect (Glanc & Greene, 2007, 2009, 2012). This mirror pattern, however, is reversed in tests of associative recognition and recall tasks, where the mirror effect pattern is now seen for High-*N*, rather than Low-*N* words. The proposed theory is that the *type of processing* emphasized in a memory task determines which word class will show a performance advantage in that particular task. For example, a test of item recognition emphasizes the processing of distinctiveness (or item-specific information), while associative recognition emphasizes the relational encoding between words.

Glanc and Greene (2007, 2009) have also demonstrated that the type of processing engaged in during a specific task *can be manipulated* by instituting a certain type of orienting task during the encoding phase. The orienting task is designed to draw the subject's attention to or away from specific characteristics of verbal information. In these studies, the use of an item-specific orienting task was used to draw participants' attention away from relational encoding, which reversed the High-*N* mirror effect in an associative recognition task. In addition, the use of a relational orienting task reversed the Low-*N* mirror effect found in an item recognition task. These studies support the idea that the processing demands of a specific orienting task can elicit specific encoding strategies that either help the retention of an item at a simple level of processing or aid in more complex forms of processing, which has been demonstrated in previous research (Torgesen, Murphy, & Ivey, 1979).

Evidence from this previous research would appear to suggest that memory performance, then, is a function of *both* relational and item-specific processing of information. Unfortunately, it is well established that, as people age, they begin to display deficits in memory performance. For example, Smith, Lozito, and Bayen (2005) demonstrated that older adults utilized item-specific processing less often than younger adults during memory recollection. As an example, the number of items recalled per category (IPC) during a recall task has been commonly used as an index of the accessibility of individual items in memory (Tulving & Pearlstone, 1966). Thus, item-specific processing should increase (IPC) by increasing item discriminability Hunt and Seta (1984). Smith et al. (2005) discovered that, while older adults recalled more items per category on oral free recall tasks, younger adults recalled more items per category on written free recall and cued-recall tasks. Written free recall and cued-recall tasks (where the individual is given a cue in order to recall an individual target or set of targets) may require an additional amount of item-specific processing because, by their nature, they draw attention to item-specific information, which oral free recall tasks do not. If older adults have a deficit in item-specific processing, they should be less able to use this item-specific information as a memory cue; therefore, it would be predicted that older adults would perform worse (as compared to younger adults) on these tasks. Thus, Smith et al.'s (2005) findings would appear to support the idea that memory is a combination of both item-specific and relational processing, and that older adults are better able to use memory cues that are more relational in nature, as opposed to more item-specific memory cues.

Similar to Glanc and Greene's (2007, 2009) use of orienting task to manipulate type of encoding processes, other researchers have theorized that simulating the difference in encoding processes used by older adults in younger age groups would eliminate the performance advantage seen in these younger adults on written free recall and cued recall tasks (see Smith, 2006; for a nice review of the memory aging literature). One way this was accomplished was by providing explicit relational information as context (in the form of a short narrative), thus encouraging young adults to utilize relational, rather than item-specific, memory cues (Rankin & Collins, 1986). Accompanying results indicated that letter-cued recall of unrelated words was equal across age groups, thus their manipulation was successful in eliminating the performance difference between younger and older adults. Rankin and Collins (1986) also included an additional condition in which participants were asked to supply their own narrative. When comparing performance across condition, it was found that, during recollection of target words, younger adults performed better when asked to generate their own narrative, while older adults performed better when given a previously scripted narrative. It was also noted that the narratives generated by older adults were less detailed than those provided by younger individuals. These results would seem to suggest that older adults are not processing enough item-specific information when attempting to create their own narrative.

The results from the studies mentioned previously would seem to support the idea that older adults have a deficit in item-specific processing in recall-based tasks. This same deficit has also been found in tests of associative recognition, as older adults have been shown to exhibit complications with making proper associations between specific items of information (Naveh-Benjamin, 2000). This issue extends to a variety of interitem relationships, including word-nonword pairs, word-font pairs, and learning of new face-name pairs (e.g. Logan & Balota, 2008; Naveh-Benjamin, Guez, Kilb, & Reedy, 2004; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003; Tse, Balota, & Roediger, 2010). Interestingly, when tested specifically on specific item information, not associations among items, older adults perform comparably to younger adults (Naveh-Benjamin, Hussain, et al., 2004; Naveh-Benjamin, Guez, et al., 2004; Overman & Becker, 2009). For example, when learning the pair CHAIR-TURTLE, older adults remember CHAIR and TURTLE individually as well as younger adults but are not as likely to remember the two items were paired together. These results may indicate that older adults are still able to process item-specific information, but not to the same extent as younger adults. Instead, older adults exhibited a reliance on more general associative cues, rather than cues specific to the target pairs themselves. This idea is supported by the fact that older adults made more false associations, resulting in false recall of incorrect pairings, than their younger counterparts.

Further evidence for this idea has been found in other studies, which demonstrate that encouraging participants to process information semantically leads to better performance for associated word pairs (e.g. Naveh-Benjamin, Brav, & Levy, 2007). Naveh-Benjamin et al. (2003) found better performance in older adults for related word pairs (like CHAIR-TABLE) than unrelated word pairs (CHAIR-TURTLE). The presence of semantic cues as external support also improved associative memory performance (Naveh-Benjamin et al., 2002; Bouazzaoui et al., 2010). The authors suggest that cues reduce the demand on the diminished resources of older adults, which may also explain why older adults perform better on *recognition* tasks than free recall tasks. Recognition tasks provide more substantial environmental support (in the form of additional memory cues) than free recall tasks. These cues are most beneficial for tasks that require associative processing, and produce optimal performance when presented both at encoding and retrieval (Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2002).

Other researchers have investigated the idea that simple repetition might aid older adults' performance in associative recognition tasks. Overman and Becker (2009) found that repetition of word pairs did not benefit retention of associations in older adults as it did in younger adults. Item memory, for each element of a pair, improved with repetition in both groups; however, repetition did not benefit memory for pairs in older adults. Contrastingly, in a study of name learning in older adults, Tse et al. (2010) found that older adults benefited from both repeated study and repeated testing with corrective feedback when learning face-name pairs. Thus, some question still exists of whether simple repetition can be used to improve associative memory in older adults.

As mentioned previously, when using relational processing, older adults exhibit a reliance on more general associative cues and sometimes make false associations, resulting in false recall and less accurate performance on associative recognition tasks. When external cues are provided to assist older adults to help them encode item-specific information, a more accurate performance is achieved (Glanc & Greene, 2007, 2009). Thomas and Sommers (2005), suggested that older adults' reliance on general associations may be evidence that they tend to over-engage in relational processing, resulting in a deficit of item-specific processing. Although relational processing tends to improve both recall and recognition in older adults, it also produces a residual effect of false recollection. Because older adults are relying most strongly on relational processing, they may falsely report the presence of items that are similar to the correct response, but were not originally presented in the study session. Consequently, Thomas and Sommers (2005) hypothesized that encouraging item-specific processing would not only increase recall and recognition, but decrease false recall and recognition as well. Their results demonstrated that older adults were then able to encode item-specific information and, through this distinctive processing, the older adults were able to remember specific aspects of the presented items. Results from these and other studies provide evidence of two things: (1) that older adults *can* process item-specific information and (2) that if older adults are to be encouraged to engage in more item-specific processing, external cues are required (Naveh-Benjamin & Craik, 1995).

The purpose of the current study was to further investigate the differences in memory processing between younger and older adults, focusing specifically on differences in item-specific and relational processing between groups, using a manipulation of orthographic neighborhood size and orienting task. As demonstrated in previous studies, the authors have demonstrated that High-*N* words may illicit relational processing and, therefore, have a performance advantage in associative recognition tasks. On the other hand, in item recognition tasks (which are supposed to elicit item-specific processing), low-*N* words illicit more item-specific processing (because they are more distinctive than high-*N* words), resulting in more accurate recognition for low-*N* words (Glanc, 2007, 2009). If the conclusions made in these studies using younger adults were extended to make predictions regarding performance of older adults, who are suspected to have a deficit in item-specific processing, it would be expected that the performance advantage for low-*N* words which is typically seen in studies of younger adults on a standard item recognition task should be diminished, or even extinguished, in older adults due to their inability to successfully process item-specific information without external memory cues. Experiment 1 investigated this hypothesis by comparing the performance of younger adults to that of older adults in a standard item recognition task.

The current authors have also previously demonstrated that orienting tasks can be used as an external cue to encourage participants to engage in specific types of processing. For instance, when relational encoding is used on an item recognition task, the advantage held by low-*N* words during item-specific processing was lost and, instead, high-*N* words were favored. Experiment 2 attempts to utilize two different orienting tasks, one item-specific and one relational, in an attempt to encourage older adults to engage in more item-specific processing, thus reducing the performance difference seen between age groups.

2. Experiment 1

The main purpose of Experiment 1 is twofold. First, the authors attempt to replicate results found previously in item recognition studies with young adults (Glanc & Greene, 2007). Secondly, young adult performance on an item recognition task is compared to that of older adults on the same task.

Research has shown that older adults perform differently than younger adults on item recognition tasks. It has been hypothesized that older adults have a deficit in item-specific processing, instead relying more on relational, "gist"-based information processing during the recognition process. Glanc and Greene (2007) were able to successfully differentiate between item-specific and relational processing using a manipulation of orthographic neighborhood size in an item recognition task. They argued that low-*N* words are distinctive because of their unique orthographic and phonological representation in memory. This distinctiveness can be used as an additional retrieval cue, thereby facilitating accurate recognition of low-*N* words over their less distinctive, high-*N* counterparts. This orthographic distinctiveness is thought to encourage item-specific processing. Therefore, when using an item recognition task as a measure of item-specific processing, an orthographic neighborhood size effect was found. That is, participants showed more accurate performance (i.e. higher hit rates and lower false alarm rates) for low-*N* words than high-*N* words.

If it is assumed that item-specific and relational processing are in opposition to each other, then factors that encourage item-specific processing may also lead to a reduction in relational processing (Hockley & Christi, 1996; Hunt & Mcdaniel, 1993). From this, it can also be assumed that an emphasis on relational processing may lead to reduced item-specific processing, which would eliminate the orthographic neighborhood size effect. In the current experiment, it is hypothesized that older adults, because of their heavy reliance on relational processing, will have difficulty encoding low-*N* words (which typically encourage item-specific processing). Therefore, older adults should not exhibit more accurate performance for low-*N* words when performing an item recognition task.

2.1. Method

All methods, including participants, design of study, materials, and procedures for the current study were approved by the Institutional Review Boards at both locations where data was gathered from participants (i.e. Texas A&M University Corpus Christi and Rice University).

2.1.1. Participants

57 young adults and 31 older adults were used in this study. Younger adults were classified as aged 18–35 (*M* = 20.3 years; SD = 4.83; Range = 18–25) and older adults were classified as aged 65 years of age or older (*M* = 68.2 years; SD = 3.97; Range = 65–77). Younger adults consisted of undergraduate students from Texas A&M University Corpus Christi, who received extra credit for participation. Older adults were recruited from the Greater Houston community, and consisted of normally functioning, healthy older adults who regularly volunteer to participate in research at Rice University. Older adult volunteers were compensated $10/hour for participation.

2.1.2. Design

A 2 × 2 × 2 repeated measures design was used, with factors including word status (old vs. new), orthographic neighborhood size (high-*N* vs. low-*N*), and mapping (consistent vs. Inconsistent). The dependent variables measured were number of "yes" responses made and reaction time (in ms). Mapping was considered here because, while it has been shown to facilitate lexical decision (Ziegler & Perry, 1998), the effects on memory have been less well studied and often contradictory (e.g. Cortese et al., 2004 vs. Hirshman & Jackson, 1997).

2.1.3. Materials

The stimuli consisted of 116 monosyllabic words which were equated for word length (*M* = 4.23 letters) and normative frequency (*M* = 71.01 words per million) according to Kucera and Francis (1967). Orthographic neighborhood size and mapping consistency were determined according to Ziegler, Stone, and Jacobs (1997). The high-*N* word group included only words with six or more orthographic neighbors, or words sharing the same orthographic and phonological rime (see intro; Mean *N* = 12.13), while the low-*N* word group included only words with three or fewer orthographic neighbors (Mean *N* = 1.25). Mapping Consistency was determined by the number of spellings onto which the target word's orthographic rime can be mapped. If a target word is consistent, its rime (spelling pattern) can only be mapped onto one pronunciation (e.g. *–yme in thyme)*, whereas, if a target word is inconsistent its rime can be mapped onto multiple pronunciations (e.g. *–int in pint {or mint};* See Ziegler et al.'s [1997] definition of "feedback consistency").

2.1.4. Procedure

The study list consisted of 68 words, divided into 48 target words and 20 primacy/recency buffers. The target study list consisted of 24 high-*N* words (half of which were consistently mapped and half inconsistently mapped) and 24 low-*N* words (half of which were consistently mapped and half inconsistently mapped). Buffer items were not used in the testing phase. Assignment of stimulus items to old/new status and order of presentation were randomized for each participant. Both study list and recognition test were presented on a computer using ePrime 2.0 computer software. Participants were presented with an instruction screen in which they were instructed that they were about to see a list of words presented one at a time and to pay equal attention to each word as it appeared on the screen. They were also informed that a memory test would follow the study phase.

The experiment began when the participant pressed the space bar. The study list was then presented one at a time in the middle of the computer screen at a rate of 2 s per study item. A blank screen with a "+" was presented for 250 ms between each word in order to direct the participant's attention toward the correct part of the screen. Immediately following the last word in the study list, participants viewed a screen informing them that a memory test would follow. They were given instructions to determine whether or not they had seen each word on the previous study list and answer either "yes" or "no" by pressing the corresponding keys on the keyboard.

The memory test began when the participant pressed the space bar to continue. The stimuli for the memory test included the 48 target items from the study list as well as 48 new items which hadn't appeared on the study list. The test was self-paced, with the offset of each word elicited by the participant's response. A blank screen with a "+" was presented for 250 ms before each word appeared to direct attention to the correct part of the screen. Both reaction time and number of "yes" responses was recorded for each participant.

Table 1. Recognition accuracy in Experiment 1: Mean proportion of positive responses

Mapping	Positive responses			
	Old items (hit rate)		New items (false alarm rate)	
	High-*N*	Low-*N*	High-*N*	Low-*N*
Younger adults				
Consistent	.67**	.72**	.29*	.21
Inconsistent	.66**	.74**	.25*	.24
Collapsed	.67	.73*	.27*	.23
Older adults				
Consistent	.65**	.62**	.31*	.24
Inconsistent	.62**	.70**	.29	.32*
Collapsed	.64	.66	.31	.28

*$p < .01$.
**$p < .001$.

2.2. Results

The mean proportions of positive responses are shown in Table 1.

2.2.1. Recognition accuracy

A mixed factors ANOVA was conducted on the number of "Yes" responses made, with Group (older adults vs. younger adults) used as a between subject variable and Item Status, Neighborhood Size, and Mapping Consistency as within subject variables. Results showed a main effect of Item Status [$F(1,85) = 372.93$, $MS_e = 9.81$, $p < .001$, $\eta^2 = .81$]. Interaction effects were found between Group and Item Status [$F(1,85) = 5.29$, $MS_e = 9.81$, $p = .03$, $\eta^2 = .06$], between Neighborhood Size and Mapping Consistency [$F(1,85) = 22.56$, $MS_e = 1.67$, $p < .001$, $\eta^2 = .21$], and between Neighborhood Size and Item Status [$F(1,85) = 12.94$, $MS_e = 2.57$, $p < .001$, $\eta^2 = .13$]. No other main effects or interactions were found. Additional repeated measures ANOVAs were performed on each individual age group, looking at Item Status, Neighborhood Size, and Mapping Consistency as factors of interest. The results of these individual ANOVAs are presented separately, in the following sections.

2.2.1.1. Young adults. An ANOVA was performed on the number of "Yes" responses, using Item Status, Neighborhood Size, and Mapping Consistency as within subjects variables. The data for the younger adult group replicate results found in a previous study using the same stimulus set (Glanc & Greene, 2007). A main effect of Item Status [$F(1,56) = 301.58$, $MS_e = 9.85$, $p < .001$, $\eta^2 = .84$] was found, in addition to an interaction between item status and neighborhood size [$F(1,56) = 26.66$, $MS_e = 1.85$, $p < .001$, $\eta^2 = .32$]. No other main effects or interactions were found. The data show an effect of Neighborhood Size on recognition accuracy, with low-*N* words showing both greater hit rates (*M* = 73%) and lower false alarm rates (*M* = 23%) than high-*N* words (*M* = 67% and *M* = 27%, respectively). This effect was significant for both hit rates [$F(1,56) = 15.05$, $MS_e = 1.82$, $p < .001$, $\eta^2 = .21$] and false alarm rates [$F(1,56) = 9.16$, $MS_e = 2.41$, $p = .004$, $\eta^2 = .14$], when these were analyzed separately. In addition, there was a marginally significant interaction between Neighborhood Size and Mapping Consistency for false alarm rates only [$F(1,56) = 3.94$, $MS_e = 2.46$, $p = .052$, $\eta^2 = .07$].

2.2.1.2. Older adults. A separate ANOVA on the number of "Yes" responses was also performed for the older adult group, again using Item Status, Neighborhood Size, and Mapping Consistency as within subjects variables. The results showed that the older adult group demonstrated a different pattern of performance than the younger adult group. In addition to a main effect of Item Status [$F(1,29) = 93.31$, $MS_e = 1092.27$, $p < .001$, $\eta^2 = .76$], there was also a main effect of Mapping Consistency [$F(1,29) = 4.56$, $MS_e = 1.18$, $p = .04$, $\eta^2 = 14$]. There was also an interaction between Mapping Consistency and Neighborhood Size [$F(1,29) = 21.37$, $MS_e = 1.19$, $p < .001$, $\eta^2 = .59$]; however, the interaction between item status and neighborhood size was not significant [$F(1,29) = 1.21$, $MS_e = 3.76$, $p = .27$], as it was in the younger adult group. The Mapping Consistency x Neighborhood Size interaction was significant for both hit rates [$F(1,29) = 7.95$, $MS_e = 1.68$, $p = .009$, $\eta^2 = .22$] and false alarm rates [$F(1,29) = 8.62$, $MS_e = 1.40$, $p = .006$, $\eta^2 = .23$] . The older adult group did not show the same Neighborhood Size effect as the younger adults. That is, the older adult group did not show overall higher hit rates and lower false alarm rates for low-*N* items, as the younger adults did. Instead, older adults tended to have higher hit rates for consistent high-*N* items (*M* = 65%) and inconsistent low-*N* items (*M* = 70%), while at the same time having lower false alarm rates for inconsistent high-*N* items (*M* = 29%) and consistent low-*N* items (*M* = 24%). This consistency mirror effect could mean that older adults, having a deficiency in item-specific processing, are relying more heavily on the consistency of word mapping. This may be considered evidence of a higher degree of dependency on relational processing in older adults, which corresponds with the idea that older adults tend to rely more heavily on "gist" processing rather than item-specific processing of information.

2.2.2. Response time

To further investigate the difference in performance between age groups, an additional set of analyses was performed using individual reaction time (as seen in Table 2) as the dependent variable. A mixed factors ANOVA was conducted, with Group (older adults vs. younger adults) used as a between subject variable and Item Status, Neighborhood Size, and Mapping Consistency as within

Table 2. Response times (in ms) in Experiment 1

Mapping	Positive responses			
	Old items (hit rate)		New items (false alarm rate)	
	High-*N*	Low-*N*	High-*N*	Low-*N*
Younger adults				
Consistent	871.43*	881.60*	976.11**	949.53**
Inconsistent	843.96	855.23	917.14**	869.00**
Collapsed	857.69	868.41*	946.62*	909.26
Older adults				
Consistent	1066.24	1176.32*	1176.45*	1281.69*
Inconsistent	1209.16*	858.00	1419.01*	1258.37*
Collapsed	1137.7*	1017.16	1297.73*	1270.03

*$p < .05$.
**$p < .01$.

subject variables. Main effects of Group [$F(1,61) = 10.77$, $MS_e = 9896736.57$, $p = .002$, $\eta^2 = .15$], and Neighborhood [$F(1,61) = 4.13$, $MS_e = 90568.43$, $p = .047$, $\eta^2 = .06$] were found. A main effect of Item Status was marginally significant [$F(1,61) = 3.35$, $MS_e = 374856.97$, $p = .07$, $\eta^2 = .05$]. In addition, a marginally significant interaction was found between Group and Mapping Consistency [$F(1,61) = 3.63$, $MS_e = 980553.61$, $p = .06$, $\eta^2 = .06$]. When hit rates and false alarm rates were compared separately, results showed a main effect of Group for both hit rates [$F(1,85) = 17.29$, $MS_e = 943394.64$, $p < .001$, $\eta^2 = .17$], and false alarm rates [$F(1,85) = 4.08$, $MS_e = 863442.55$, $p = .048$, $\eta^2 = .06$]. The interaction between Group x Mapping Consistency was marginally significant in hit rates [$F(1,85) = 3.96$, $MS_e = 302314.95$, $p = .05$, $\eta^2 = .04$], but not for false alarm rates [$F(1,61) = 1.18$, $MS_e = 255806.32$, $p = .28$]. No other main effects or interactions were found to be significant.

2.2.2.1. Young adults. As previously, separate repeated measures ANOVAs were performed on reaction time for each age group, using Item Status, Neighborhood Size, and Mapping Consistency as within subject variables. Young adults showed a main effect of Item Status [$F(1,39) = 9.55$, $MS_e = 206164.03$, $p = .004$, $\eta^2 = .20$]. Individual comparisons of hit rates and false alarm rates showed a main effect of Item Consistency [$F(1,56) = 4.20$, $MS_e = 26577.52$, $p = .045$, $\eta^2 = .07$], but this effect was present for hit rates only. Young adults were significantly slower in responding to low-*N*, consistent words when they had been previously studied. No other main effects or interactions were found.

2.2.2.2. Older adults. A repeated measures ANOVA performed on the older adult group, again using Item Status, Neighborhood Size, and Mapping Consistency as within subject variables, also showed a main effect of Item Status [$F(1,22) = 4.36$, $MS_e = 187853.86$, $p = .049$, $\eta^2 = .17$]. Unlike the younger adult group, older adults also showed a Neighborhood Size x Item Status interaction [$F(1,22) = 6.30$, $MS_e = 73677.23$, $p = .02$, $\eta^2 = .22$]. Older adults were significantly faster in responding to high-*N*, old items. Individual comparisons of hit rates and false alarm rates showed no additional main effects or interactions.

2.3. Discussion

The Young Adult group showed a typical Orthographic Neighborhood Size Effect in item recognition. Results showed significantly more accurate performance for Low-*N* words. Hit rates were higher and false alarm rates were lower for low-*N* words as compared to their high-*N* word counterparts. This replicates results seen previously for young adults (Glanc & Greene, 2007, Exp. (1). As expected, this pattern was not seen in the older adult group.

Interestingly, older adults' performance appears to be affected by Mapping Consistency, where the younger adults' performance was not. The highest hit rates were seen for inconsistent, low-*N* words, which are especially distinct. This may be expected in an item recognition task, which promotes item-specific processing. The second highest hit rates, however, were seen for consistent, high-*N* words. An explanation for this might be that relational processing is interfering with item-specific processing during the task, and older adults are using information about Mapping Consistency as an attempt to alleviate this interference. Consistent items are more familiar, especially high-*N*, consistent items, because of their many associative connections with their orthographic neighbors. Gist-based, relational processing is known to be influenced by familiarity, with higher recollection rates for familiar items (Naveh-Benjamin et al., 2007). This may be seen as evidence that older adults are attempting to rely on relational processing during a task that would normally encourage item-specific processing. An examination of Reaction Time results appears to support the explanation that older adults are being influenced by familiarity, as older adults had the fastest response times for high-*N*, old, words, which are going to be the most familiar.

Young adults also seem to be influenced by mapping consistency (and therefore familiarity), although to a much smaller degree. Although there were no significant main effects or interactions of mapping consistency, young adults exhibited significantly slower response times for consistent, old, low-*N* items. This may be seen as further evidence supporting the theory that item-specific and relational processing operate in opposition to each other, and that both the memory task, and the items used in the memory task, can influence the type of processing used during encoding.

3. Experiment 2

Experiment 2 attempted to manipulate the type of processing occurring during encoding using an orienting task during word presentation. The orienting task was designed to draw attention either to, or away from, information about orthographic distinctiveness, therefore, either encouraging, or discouraging, item-specific processing. In previous item recognition studies, using young adults as subjects, introduction of a relational-processing task during encoding reduces the effect of orthographic distinctiveness, thereby eliminating (or reducing) the performance advantage for low-*N* words (Criss & Shiffrin, 2004; Glanc & Greene, 2007; Hilford, Glanzer, & Kim, 1997; Hirshman & Arndt, 1997). The main purpose of the current experiment was to compare performance of young adults to that of older adults when adding an additional orienting task manipulation to the original orthographic neighborhood size manipulation used in the previous experiment.

If the explanation made for the difference in older adults' performance in the previous experiment is correct, that is, if older adults are relying more on relational processing, whereas younger adults are relying more on item-specific processing, then it can be hypothesized that young adult performance will look more similar to older adult performance if they are encouraged to engage in relational processing. From this, it was expected that the orthographic neighborhood size effect seen in young adults in the previous experiment would be eliminated in the current experiment, where a relational orienting task is used during word presentation to encourage relational processing over the spontaneous item-specific processing that would normally be elicited by an item recognition task.

It may also be possible to overcome a lack of spontaneous item-specific processing in older adults by using an item-specific orienting task to encourage the processing of item-specific information. In this case, it would be expected that the orthographic neighborhood size effect, which was missing from older adults' performance in the previous experiment, may appear in the current study with the addition of an item-specific orienting task. Therefore, it would be expected that older adults' performance in the current experiment would be more similar to that of younger adults in the previous experiment.

3.1. Method

3.1.1. Participants

Twentyseven older adults and 38 younger adults participated in this experiment. As in the previous experiment, younger adults consisted of undergraduate students from Texas A&M University Corpus Christi, who received extra credit for participation. Older adults were recruited from the Greater Houston community, and were paid a small incentive for participation. Younger adults were classified as aged 18–35 (*M* = 21.1 years; SD = 5.32; Range = 18–27) and older adults were classified as aged 65 years of age or older (*M* = 70.1 years; SD = 3.54; Range = 65–77).

3.1.2. Design

This was a 2 × 2 × 2 × 2 × 2 mixed factorial design, with word status (old vs. new), orthographic neighborhood size (high*N* vs. low*N*), mapping (inconsistent vs. consistent), and list task (vowel counting vs relatedness rating) as within subjects factors and age group (younger vs older) as a between subjects factor. The participants were randomly assigned to one of two counterbalances of the experiment, switching the order of the tasks they had to complete.

3.1.3. Materials and procedure

The materials and procedure used in the current experiment were similar to Experiment 1 (20 buffer words, 48 target words, 48 new words), with the following exceptions: For the study phase, participants encoded 48 words but the words were divided into two task blocks of 24 words each, yielding 6 observations of each word type in each task (high*N* consistent, high*N* inconsistent, low*N* consistent, low*N* inconsistent). Task was blocked, but words were presently randomly within each task. The recognition test consisted of a list of 48 new words and a list of 48 old words from the learning phase (24 from the Relatedness Task, 24 from the Vowel Counting task). Buffers were not used in the testing phase. Assignment of stimulus items to new/old status, task, and order of presentation were randomized for each subject.

In the study phase, words were presented in the same manner as Experiment 1. Before each list of 24 words, instructions for each task were given. For the Relatedness task, participants were asked to rate each word by how closely it was related to the previous word, on a scale from 1 = *very little* to 5 = *a lot*. For the Vowel Counting task, participants were asked to enter the correct number of vowels in each word using the number keys at the top of the keyboard. After the study phase, participants were given a recognition test with the same parameters as in Experiment 1.

3.2. Results

Individual mean proportions of positive responses are shown in Table 3, while accuracy (measures as *d*′) and order effects are shown in Table 4. As in Experiment 1, a mixed factors ANOVA was conducted on the number of "Yes" responses made, with Group (older adults vs. younger adults) used as a between subject variable and Item Status, Neighborhood Size, and Mapping Consistency as within subject variables. In addition, Task Order was added as a second between subjects factor in order to identify any carryover effects from the orienting tasks. Separate analyses were done for each of the two orienting tasks (see Table 3).

3.2.1. Recognition accuracy

For the Relatedness Task, results showed a main effect of Item Status [$F(1,61) = 548.69$, $MS_e = 811.51$, $p < .001$, $\eta^2 = .75$]. Interaction effects were found between Task Order and Item Status [$F(1,61) = 4.11$, $MS_e = 811.51$, $p = .03$, $\eta^2 = .07$] and between Mapping Consistency, Group, Task Order and Item Status [$F(1,61) = 9.05$, $MS_e = 157.36$, $p = .02$, $\eta^2 = .08$]. No other main effects or interactions were found. For the Vowels Task, results showed a main effect of Item Status [$F(1,61) = 318.94$, $MS_e = 660.21$, $p < .001$, $\eta^2 = .71$] and Consistency [$F(1,61) = 6.41$, $MS_e = 222.01$, $p = .005$, $\eta^2 = .12$]. Interaction effects were found between Task Order and Item Status [$F(1,61) = 4.62$, $MS_e = 660.21$, $p = .03$, $\eta^2 = .07$], between Mapping Consistency and Item Status [$F(1,61) = 7.99$, $MS_e = 217.78$, $p = .04$, $\eta^2 = .20$], between Neighborhood Size and Mapping Consistency [$F(1,61) = 6.38$, $MS_e = 177.42$, $p = .03$, $\eta^2 = .07$], and

Table 3. Recognition accuracy in Experiment 2: Mean proportion of positive responses by type of orienting task

Mapping	Positive responses			
	Old items (hit rate)		New items (false alarm rate)	
	High-*N*	Low-*N*	High-*N*	Low-*N*
Relatedness task				
Younger adults				
Consistent	.77**	.78**	.16	.17
Inconsistent	.82**	.84**	.25*	.24*
Collapsed	.8	.81	.21	.21
Older adults				
Consistent	.68**	.64**	.18	.28*
Inconsistent	.7**	.77**	.19	.2
Collapsed	.69	.71	.19	.24*
Vowel counting task				
Younger adults				
Consistent	.75**	.69**	.4*	.34
Inconsistent	.69**	.75**	.26	.42*
Collapsed	.72	.72	.33	38*
Older adults				
Consistent	.51**	.57**	.19	.25*
Inconsistent	.64**	.64**	.25	.27
Collapsed	.58	.61	.22	.26

Note: The proportions indicated are when task was encountered in block 1.
*p > .05.
**p < .001.

between Neighborhood Size, Mapping Consistency, Group, and Task Order [$F(1,61) = 5.82$, $MS_e = 177.42$, $p = .02$, $\eta^2 = .08$]. No other main effects or interactions were found.

3.2.1.1. Younger adults. In order to be consistent with Experiment 1, each age group was again analyzed separately. A mixed factor ANOVA was conducted for each age group and orienting task, using Task Order as a between subjects variable and Item Status, Neighborhood Size, and Mapping Consistency as within subject variables.

For the Relatedness Task, results showed a main effect of Item Status [$F(1,36) = 396.04$, $MS_e = 732.62$, $p < .001$, $\eta^2 = .80$]. Interaction effects were found between Item Status, Mapping Consistency, and Task Order [$F(1,36) = 4.75$, $MS_e = 145.44$, $p = .04$, $\eta^2 = .07$]. No other main effects or interactions were found. The data show an effect of Item Status, Consistency and Task Order on recognition accuracy (measured as d'), such that items in the Relatedness task had higher accuracy, [$F(1,36) = 4.65$, $MS_e = 190.06$, $p = .04$, $\eta^2 = .06$], for Inconsistent items (69%) than Consistent items (59%) when the Relatedness task was preceded by the Vowels task. However, there was no effect of Consistency when the Relatedness task was first: Consistent items had only slightly higher hit rates than Inconsistent items (58% vs. 60%).

For the Vowels task, results showed a main effect of Item Status [$F(1,36) = 209.72$, $MS_e = 660.99$, $p < .001$, $\eta^2 = .76$]. Interaction effects were found between Task Order and Item Status [$F(1,36) = 4.73$, $MS_e = 660.99$, $p = .04$, $\eta^2 = .06$] and between Neighborhood Size and Mapping Consistency [$F(1,36) = 5.05$, $MS_e = 179.55$, $p = .04$, $\eta^2 = .05$]. No other main effects or interactions were found.

Table 4. Effect of task order in Experiment 2: measures of *d* prime as a function of task order

Mapping	*d* prime			
	Relatedness task		Vowel counting	
	High-*N*	Low-*N*	High-*N*	Low-*N*
Relatedness task presented first				
Younger adults				
Consistent	.61	.61	.46	.51*
Inconsistent	.58	.6	.48	.52
Collapsed	.6	.61	.47	.52**
Older adults				
Consistent	.36	.49	.34	.34
Inconsistent	.57*	.52*	.36	.56*
Collapsed	.47	.51	.35	.45*
Vowel counting task presented first				
Younger adults				
Consistent	.56	.62	.35	.35
Inconsistent	.68*	.69*	.33	.43*
Collapsed	.62	.66	.34	.39
Older adults				
Consistent	.69	.65	.31	.33
Inconsistent	.64	.63	.38*	.4*
Collapsed	.67	.64	.35	.36

Note: *d* prime is measured as hits minus false alarms.
*$p < .05$.
**$p < .01$.

Recognition accuracy was higher for Inconsistent low-*N* items (52%), which are the most distinctive items, as compared to other items (high-*N* inconsistent items 48%, low-*N* consistent 51%, and high-*N* consistent 46%). Accuracy was much higher for items in the Vowels task when the task was preceded by the Relatedness task compared to when the Vowels task came first (50 vs. 37%, respectively). This effect suggests that young adults were able to successfully switch from the relational processing task to the vowel counting task, but had more trouble when doing the reverse.

3.2.1.2. Older adults. As with the younger age group, a mixed factor ANOVA was conducted for each orienting task, using Task Order as a between subjects variable and Item Status, Neighborhood Size, and Mapping Consistency as within subject variables. For the Relatedness Task, results showed a main effect of Item Status [$F(1,25) = 189.54$, $MS_e = 925.10$, $p < .001$, $\eta^2 = .68$]. Significant interaction effects were found between Item Status and Task Order [$F(1,25) = 4.08$, $MS_e = 925.10$, $p = .04$, $\eta^2 = .09$] and between Item Status, Mapping Consistency, and Task Order [$F(1,25) = 4.24$, $MS_e = 174.54$, $p = .04$, $\eta^2 = .07$]. No other main effects or interactions were found.

As in the younger adults, the data from older adults show an effect of Item Status, Consistency and Task Order on recognition accuracy, *but in the opposite pattern*. Items in the Relatedness task had greater accuracy for Inconsistent items (55%) than Consistent items (43%) when the Relatedness task came first. However, there was no effect of Consistency when the Vowels task preceded the Relatedness task: Consistent items had only slightly greater accuracy than Inconsistent items (67 vs. 65%).

For the Vowels task, results showed a main effect of Item Status [$F(1,25) = 124.41$, $MS_e = 659.08$, $p < .001$, $\eta^2 = .64$] and Consistency [$F(1,25) = 7.71$, $MS_e = 234.26$, $p = .02$, $\eta^2 = .15$]. Interaction effects were found between Mapping Consistency and Item Status [$F(1,25) = 7.32$, $MS_e = 280.08$, $p = .03$, $\eta^2 = .20$] and between Neighborhood Size, Mapping Consistency and Task Order [$F(1,25) = 6.15$, $MS_e = 174.35$, $p = .03$, $\eta^2 = .17$]. No other main effects or interactions were found.

When the vowels task came first, recognition accuracy was greater for Inconsistent items than Consistent items (39 vs. 32%, respectively). More pointedly, when the Vowels task was first, recognition accuracy was higher for Inconsistent items than Consistent items of *both* High (38 vs. 31%, respectively) and Low (40 vs. 33%, respectively) Neighborhood Sizes. When the Vowels task came after the Relatedness task, however, Low-*N* Inconsistent items were better recognized than Low-*N* Consistent items (56 vs. 34%, respectively) but there was no such effect of Consistency in High-*N* items. These results would appear to indicate that older adults persisted with the relational task even when the task was switched to vowel counting.

3.3. Discussion

Younger adults seemed to persist in the original task only when it was congruent with the type of processing encouraged by the orienting task (i.e. only when presented with the vowel counting task first. This effect suggests that young adults were able to successfully switch from the relational processing task to the vowel counting task, but had more trouble when doing the reverse. This could possibly be because the relational task was interfering with their ability to process item-specific information. The standard mirror effect pattern was seen with recognition accuracy significantly greater for low-*N* than for high-*N* items for both tasks. This may indicate that younger adults tend to spontaneously utilize item-specific processing over relational processing in item recognition. Older adults, however, continued to show a bias toward relational processing, even when performing an item-specific memory task. This is evidenced by greater accuracy for High-*N* words for the relatedness task no matter whether they encountered it in the first or second block. Unlike in Experiment 1, however, older adults did show greater accuracy for low-*N* words for the vowel task. This may be a result of the item-specific orienting task, which encouraged them to overcome a lack of spontaneous item-specific processing.

4. General discussion

While neither word rimes nor mapping consistency are commonly used in recognition studies (primarily being linguistic concepts), the results from the current study support the assumption that older adults tend to spontaneously engage in more relational processing during memory tasks than do younger adults, and that the addition of an external orienting task can be used to encourage the use of item-specific processing in older adults. Experiment 1 demonstrated that older adults' over-reliance on relational processing led to a deficit in performance on an item recognition task, which requires the processing of item-specific information. In addition, the data show that older adults make more use of item consistency, possibly in an attempt to make up for the deficit in item-specific processing. Experiment 2 demonstrated that the addition of an external orienting task designed to encourage the attention to, and therefore processing of, item-specific information increased performance accuracy in older adults on an item recognition task. Following the results from the current study, it is reasonable to assume that orienting tasks, or perhaps other external cues that draw attention to specific types of information, may also aid older adults' performance in other types of memory tasks as well.

The current study adds to the body of evidence in concordance with Thomas and Sommers (2005), various studies which attempt to explain the mechanisms that contribute to older adults' tendency to spontaneously engage in relational processing over item-specific processing (García-Bajos, Migueles, & Aizpurua, 2012; Kensinger & Schacter, 1999; Murphy, West, Armilio, Craik, & Stuss, 2007; Thomas & Sommers, 2005). From a neurological standpoint, a depletion of resources due to declining inhibitory control and executive functions may cause older adults to retrieve overgeneral memories (García-Bajos et al., 2012; Holland, Ridout, Walford, & Geraghty, 2012). Information retrieved, therefore, becomes primarily based on preexisting connections, not specific connections present in the task itself. In the absence of inhibitory mechanisms, knowledge of general events overrides the retrieval of specific events. Therefore, as aging occurs, processing becomes more automatic, utilizing less attentional resources and controlled processing. As a result, older adults commit more memory performance errors and false memories because it is simply easier for them to engage in relational processing rather than item-specific processing (García-Bajos et al., 2012; Kensinger & Schacter, 1999; Murphy et al., 2007; Thomas & Sommers, 2005).

Additional research has also supported the hypothesis that memory deficits occur due to the increased difficulty for older adults to engage in item-specific processing in order to make new connections between specific target items, which is essential to establishing associations between those items. It has been suggested that processing speed and efficiency may be the underlying factor resulting in this item-specific deficiency (Burke & Mackay, 1997; Salthouse, 1997). With increasing age, the speed of cognitive operations declines. Salthouse (1997) suggested a limited time mechanism and a simultaneity mechanism as explanation for said decline. This study suggests that, in older adults, cognitive operations are executed too slowly to be completed in the allotted trial time (*limited time mechanism)*. Slower processing results in less processing, which leads to decreased performance. Slower processing may also inhibit multiple sources of information from being simultaneously available. Therefore, the products of early processing may be lost by the time the later processing has been completed (s*imultaneity mechanism)*. This is deleterious to cognitive functioning because it inhibits the updating of new information which is essential to forming new memories (Holland et al., 2012; Salthouse, 1997).

This becomes especially salient for older adults because these same memory processes are also associated with declines in episodic memory (in daily life) for specifically new or recent events. Burke and Mackay (1997), distinguish between explicit and implicit episodic memory, explaining that explicit episodic memory involves the deliberate and conscious recall of recently learned information or experiences. Implicit episodic memory, on the other hand, reflects the strengthening of pre-existing connections. When it comes to decline in episodic memory, it is the explicit memory that suffers with age. Slow processing speed and deficient connection-making impede the ability to sufficiently encode the newly presented items. Thus, this presents a challenge for older adults in tasks in which they are required to remember new people, places, and events.

Because this type of processing is related to memories of events that actually occurred, deficiencies in item-specific processing may predict that an individual may not be able to appropriately determine which events did (or did not) occur. These types of memories, one which an individual did not actually experience, are known as false recall (Smith et al., 2005). According to research on the relationship between false recall and aging, this phenomenon is explained as a result of the deficiency in source memory. Similarly to the use of orienting tasks in the current study, tests utilizing source recognition as a cue for recollection have resulted in fewer memory errors (Schacter, Koutstaal, & Norman, 1997).

Alternatively, Thomas and Sommers (2005) concluded that false memories are the result of a failure by older adults to encode contextualized information. When semantically related lists were used in order to eliminate gist-based processing, false recall and recognition was reduced in adults of both younger and older age groups. In cases where repetition was used to induce distinctive processing, older adults did not utilize item-specific information in order to reduce false memories. Recontextualizing information did not benefit older adults, however, indicating a deficiency in the ability to process context cues. Even when older adults are able to encode these cues, they are somehow limited in their ability to use them effectively (Thomas & Sommers, 2005). One explanation for this, based on the results of the current study, as well as other studies conducted by the current authors, could be that recontextualization does not encourage item-specific processing as strongly as a direct orienting task or as the manipulation of distinctive orthographic information.

At least one additional study by Justi & Jaeger (in Press) supports the findings of Glanc and Greene (2007) that orthographic neighborhood size manipulations may impact false recollection. In addition, manipulations of material supporting specific types of processing have been used to improve adult modes of encoding and recollection, such as the organization of material (Smith, 2006). Based on this seemingly converging evidence, further research is warranted to investigate the usefulness of orienting tasks in other types of memory tasks.

In conclusion, the results of the current study would appear to support the idea that older adults show a deficit in memory performance due to a deficiency in item-specific processing. This memory deficit is found both in laboratory memory tasks as well as the creation of false memories in real-life situations when new information has to be assimilated into previously existing memory. The current study also provides additional evidence that presenting older adults with appropriate external (environmental) cues can help to reduce this memory deficit. It is hoped that this research will encourage future researchers to investigate the use of appropriate environmental cues in improving older adults' memory performance, in addition to the continuation of research into aging memory.

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