­

Contextual similarity negatively affects associative memory performance in both younger and older adults

\*Carpenter, C.M.1, \*Webb, C. E.1,2, Overman, A. A.3, & Dennis, N. A.1

1Department of Psychology,The Pennsylvania State University

2Center for Vital Longevity, School of Behavioral and Brain Sciences, The University of Texas at Dallas

3Psychology Department & Neuroscience Program, Elon University

Keywords: associative memory, aging, context, gist, interference

Corresponding author information:

Nancy A. Dennis

450 Moore Building, University Park, PA 16802

nad12@psu.edu

tel: 814-865-1712

**Abstract**

Associative memory involves the ability to encode and remember the relationship between individual items. This ability can become diminished when there is a high degree of similarity between stimuli that are being learned. Associative memory errors often stem from the fact that lures include a high degree of item familiarity as well as mnemonic similarity with the original associative episode. The current set of experiments examined how this overlap, in the form of contextual similarity, affects veridical and false retrieval in both younger and older adults. Across three experiments, results suggest that mnemonic overlap between targets and lures is detrimental to the ability to discriminate between highly similar information. Specifically, shared contextual information between targets and lures led to increased false associative memories across age groups. These results have implications for scenarios where there is a high degree of overlap between target and lure events and indicate that these types of associative memory distinctions are difficult irrespective of age.

**Introduction**

Associative memory involves the ability to learn and remember the relationship between individual items and is essential for everyday functions. For example, it is important to remember the location of where you parked your car at any given parking lot or remember both an acquaintance’s face and their name. Misremembering these associative details, such as calling someone by the wrong name, can feel like a relatively minor memory error, but even these minor errors can cause embarrassment and frustration. Associative memory success is more critical in cases where the consequences of errors are more serious, such as remembering medications and their accompanying dosages. False memory errors are shown to be especially prevalent when information at test shares overlapping features with, or is similar in some capacity to, studied information (Brainerd & Reyna, 2002; Coane et al., 2015; D. A. Gallo & Roediger, 2003; Koutstaal & Schacter, 1997). This overlap in similarity, such as contextual similarity in the case of encountering similar parking lots, can lead to failed separation of mnemonic representations and over-reliance on a non-specific memory trace. However, it remains to be determined to what degree similarity across features influences false memories for associative information, and whether older adults, who experience both age deficits in associative memory and age-related increases in false memories (Cohn et al., 2008; D. A. Gallo & Roediger, 2003; Jones & Jacoby, 2001; Naveh-Benjamin et al., 2003; Naveh-Benjamin & Mayr, 2018; Old & Naveh-Benjamin, 2008), may be more adversely affected by contextual similarity when trying to remember associative information compared to younger adults.

Noted throughout the aging literature, associative, compared to item, memory has been shown to be a relatively difficult memory task for both younger and older adults (Bender et al., 2010; Castel & Craik, 2003; Kilb & Naveh-Benjamin, 2011; Overman & Becker, 2009). Not only does it require the simultaneous encoding of two or more discrete pieces of information, but also the encoding of the relational link between these pieces. One everyday example of associative memory use is the need to create and retrieve memories for an item and the context in which it was encountered. For example, accurately remembering that you met Lily at a school fundraiser and met Ainsley at a work conference, requires you to separately encode and store this information as two discrete relational pairs (i.e., Lily-school, Ainsley-conference). If these two events are sufficiently distinct from one another this may be a relatively easy task. However, as the degree of mnemonic similarity in the context increases (such as two similar school events or two similar work conferences), the associative memory task may become increasingly difficult as one attempts to retrieve a specific item-context link, absent of interference from the other. Moreover, while associative memory tasks in the lab are inherently difficult due to the fact that lure pairs are made up of recombinations of previously encountered (i.e., familiar) items, the additional aspect of contextual similarity between scenes that are then recombined may compound this difficulty. That is, an already difficult memory task may become harder due to shared gist induced by overlapping context categories (i.e., contextual similarity). Consequently, associative errors may be more prevalent when there is a high degree of contextual similarity between target and lure information (Dennis et al., 2014; Giovanello et al., 2009; Kelley & Wixted, 2001).

Contextual similarity may further exacerbate associative memory difficulties already experienced by older adults. While age-related deficits in associative memory have been observed across a wide array of stimuli and experimental paradigms (Chalfonte & Johnson, 1996; Naveh-Benjamin et al., 2003; Old & Naveh-Benjamin, 2008; Overman et al., 2018; Overman & Becker, 2009), it is largely assumed that older adults’ associative deficit arises from an inability to encode or bind relational information as evidenced by reduced associative hits. However, data suggests that age-related deficits in associative memory tasks are largely due to an age-related increase in the endorsement of recombined lures during retrieval resulting in older adults producing a greater amount of associative false alarms compared to that seen for younger adults (Cohn et al., 2008; D. A. Gallo & Roediger, 2003; Jones & Jacoby, 2001; Naveh-Benjamin & Mayr, 2018; Old & Naveh-Benjamin, 2008). This is thought to occur, at least in part, from older adults’ tendency to rely on familiarity as compensation for reduced recollection (Jacoby, 1991; Jennings & Jacoby, 1997). However, age-related increases in the endorsement of associative lures may stem not only from the robust familiarity of individual items comprising the lure pairs, but also from an over-reliance on remembering the general concept, or gist, of item and source information in the task (Johnson et al., 1993; Ly et al., 2013; Rahhal et al., 2016).

Additionally, memory errors tend to be positively related to the number of associations that are available to the person during encoding (Radvansky, 1999) and older adults have more prior life experiences that create a greater number of associations (Buchler & Reder, 2007). These fan effect errors are more of a detriment to older adult’s memory, compared to younger adults, which has often been attributed to inhibitory deficits (Gerard et al., 1991; Hasher & Zacks, 1988)and to changes in the structure of the semantic network (Wulff et al., 2022). Thus, increased numbers of associations may be the reason that older adults typically show more errors than younger adults.

Related to the influence of familiarity in memory retrieval, gist-based processing is thought to contribute to the creation of false memories, and especially age-related increases in such memories (Brainerd et al., 1995; Reyna & Brainerd, 1995). Specifically, the Fuzzy Trace Theory posits that both item-specific and gist traces are encoded and stored as part of an episodic memory. While item-specific traces include detailed memory representations of episodes, gist traces comprise more global, surface-level features of the event. False memories occur when there is shared gist, whether it be conceptual, semantic, or perceptual, between studied and lure information, relative to when there is little gist-related overlap (Brainerd et al., 2008; Brainerd & Reyna, 2002; Coane et al., 2015; D. Gallo, 2006; D. A. Gallo & Roediger, 2003; Koutstaal & Schacter, 1997). Within item memory tasks, such similarity, or shared gist of mnemonic information across targets and lures, has been shown to contribute to an age-related increase in false memories to related lures (Dennis et al., 2015; Koutstaal & Schacter, 1997; Stark & Stark, 2017; Tun et al., 1998). While the effect of gist-based processing has been examined with respect to item memory in older adults, the effect of this gist reliance on older adults’ associative memory is less clear. Greene & Naveh-Benjamin (2020) demonstrated an age-related reliance on gist-based representations of face-scene associations and an age deficit in accurately identifying intact versus similar face-scene associations. However, in this study the gist of both face (e.g., old male, young male) and context (e.g., scene category) were manipulated, limiting the ability to isolate contextual similarity effects on associative memory fidelity. Thus, an open question is: does an age-related reliance on gist processing make older adults more susceptible to interference from highly similar contextual information, compared to situations in which information across events is more distinct?

The current set of three studies sought to investigate the role of familiarity and gist in associative false memories across age by manipulating contextual similarity alone, rather than manipulating multiple components of the association as was done in previous work by Greene and Naveh-Benjamin (2020). Specifically, in Experiment 1 of Greene and Naveh-Benjamin, they attempted to enhance schematic support by presenting 84 categories of scenes at encoding with the same age and gender assigned to each scene category (e.g., young male always was the age and gender that appeared with the “restaurant” scene category). In Experiment 2 of the foregoing work, the scenes were paired with different ages and genders across all categories of scenes and did not attempt to rely on schematic support. While the current set of studies used a similar face-scene encoding task to Greene and Naveh-Benjamin, we manipulated the categorical similarity of the scene context when presenting associative lures at test and controlled for familiarity of lure pairs. That is, while all lures included faces and scenes presented at encoding, contextual similarity across lures was manipulated by either assembling a recombined lure using scenes from within the same scene category that had previously been used to form the face-scene pair (i.e., high contextual similarity) or assembling a recombined lure from a scene from a different scene category than what had previously been used to form the face-scene pair (i.e., low contextual similarity). Additionally, while Greene and Naveh-Benjamin utilized a side-by-side presentation, the current set of studies examined associative memory and contextual interference using superimposed stimuli and gave no schematic support in order to foster the creation of a cohesive pair that was depending on individuals’ binding together the particular face with its corresponding scene.

We posit that high contextual similarity across associative pairs should negatively influence associative recognition compared to when there is low contextual similarity across associative pairs. Specifically, we posited that a greater degree of contextual similarity between studied and lure information should induce contextual interference thereby contributing to higher rates of false memories to recombined pairs. In addition, we hypothesized that due to older adults’ increased reliance on familiarity and gist as memory support strategies (Anderson et al., 2008; Castel, 2005; Castel et al., 2007; Koutstaal & Schacter, 1997; Tun et al., 1998), they would show greater susceptibility to contextual interference at retrieval compared to younger adults. This would be reflected in an age-related increase in false alarms to recombined pairs in the high relative to low similarity conditions. In the first study, the effect of contextual similarity on associative recognition was tested using a between-subjects design that included categorically similar scenes in the high similarity condition and scenes from different context categories in the low similarity condition. The second study aimed to replicate the effect of contextual similarity found in Study 1 using a within-participants design, while also exploring whether contextual interference effects exist when there are differences in homogeneity between the high and low similarity conditions (e.g., both feature the same set of scene categories). Finally, the third study sought to test whether target reinstatement provides retrieval support necessary to reduce contextual interference effects. In doing so this study utilized a two-alternative forced choice task, rather than “intact”, “related” or “unrelated” response options as in Greene and Naveh-Benjamin. This design was used to examine if participants would be able to overcome interference brought on by the contextual similarity inherent in schematic lure from the same category when the target pairing was a response option.

**Study 1**

**Introduction**

The goal of Study 1 was to test 1) whether contextual similarity between study and test phases influences associative recognition relative to a condition where similarity is reduced, and 2) whether there are age-related differences in this effect. We tested these questions using a between subjects’ design. In the high contextual similarity condition, younger and older adults studied face-scene pairings in which the background scenes were drawn from one of four context categories (kitchens, restaurants, offices, or living rooms). In the low contextual similarity condition a separate group of participants studied face-scene pairings in which the background scenes were random with respect to their context category labels (i.e., all from unique context categories). Following the study phase participants were given an associative recognition test where they saw both intact pairings, as well as recombined lure pairings. Associative lures in the high contextual similarity condition were recombined at random within the same studied contextual category and lures in the low contextual similarity condition were recombined at random from unique studied categories. By comparing false alarms between both lure conditions, we aimed to identify the effect of contextual similarity on associative recognition both within and between age groups. We hypothesized that greater contextual similarity in recombined lures would have a negative effect on associative memory in both older and younger adults (i.e., higher false alarm rates in the high vs. low similarity conditions). Moreover, we hypothesized that older adults would show a greater difference in associative memory across the conditions as a result of an age-related increase in reliance on general gist traces to support memory recognition.

**Methods**

*Participants*

Sixty-two younger adults and sixty older adults participated in Study 1. Younger adults were recruited from both Elon University and Penn State University and participated for research credit as part of introductory psychology courses, and older adults were recruited from the local community surrounding both Universities. On the day of study, participants provided written informed consent for a protocol approved by the Pennsylvania State University and the Elon University Institutional Review Board. Older adults completed the Mini-Mental Status Exam (*M*=29.30; *SD*=1.31) to screen for neurological illness. Of these participants, 30 younger adults (mean age = 20; SD = 1.39) and 30 older adults (mean age = 73.33; SD = 4.74) saw face-scene pairs where no two scenes were drawn from the same category label (low contextual similarity condition), and 32 younger adults (mean age = 19.86; SD = 0.93) and 30 older adults (mean age = 71; SD = 4.90) saw face-scene pairs where scenes were drawn from one of four categories (high contextual similarity condition). One older adult in the low similarity condition was excluded from all analyses for not responding on at least 25% of trials and a second for not following task instructions. One older adult in the high similarity condition was also excluded due to a computer error, leaving a final total of 28 older adults in the low similarity condition and 29 older adults in the high similarity condition. Broken down by condition, the study 1 high similarity group of older adults had an average age of 71 (SD = 4.90) and an average of 16.08 (SD = 2.67) years of education. The low similarity older adults had an average age of 73.33 (SD = 4.74) and an average of 16.08 (SD=2.81) years of education. A direct comparison between the high and low older adults in terms of age and education were not significant (all *p’s*>.07). The high similarity group of young adults had an average age of 19.86 (SD = 0.93) and an average of 12.71 (SD = 1.08) years of education. The low similarity younger adults had an average age of 20 (SD = 1.39) and an average of 12.8 (SD=1.06) years of education. A direct comparison between the high and low younger adults in terms of age and education were not significant (all *p’s*>.65). A post-hoc sensitivity analysis conducted in G\*Power 3.1 (Faul et al., 2007) confirmed that power was sufficient to detect a small effect size (*f*=0.31) for within-between interaction (age x contextual similarity condition x stimulus type) given that α=.05, and the correlation between repeated measures is equal to .05.

*Stimuli*

Associative stimuli for Study 1 included pairings of faces and scenes. Face stimuli consisted of both male and females faces, each exhibiting a neutral expression, taken from the following online databases: the Color FERET database (Phillips et al., 1998), adult face database from Dr. Denise Park’s lab (Minear & Park, 2004), the AR face database (Martinez & Benavente, 1998) and the FRI CVL Face Database (Solina et al., 2003). Scene stimuli consisted of outdoor and indoor scenes collected from an Internet image search of scenes that excluded any faces or words. Using Adobe Photoshop CS2 version 9.0.2 and Irfanview 4.0 (http://www.irfanview.com/), we edited face stimuli to a uniform size (320 x 240 pixels) and background (black), and scene stimuli were standardized to 576 x 432 pixels. For both study conditions, individual images were used to construct face-scene pairs that were constructed such that the face was presented on top of the scene or with the face and scene presented next to each other. However, as the goal of the current question was unrelated to this manipulation all following analyses are collapsed across spatial layouts. Critical to the goal of this study was the manipulation of contextual similarity. In the low contextual similarity condition participants studied a total of 136 face-scene pairings that included scenes from all unique, non-conceptually overlapping contexts (e.g., bridge, library, factory, farm, desert, etc.). In contrast, in the high similarity condition participants studied a total of 136 face-scene pairings that included scenes from four sets of contexts (kitchens, restaurants, offices, living rooms). Retrieval in each condition featured 136 recombined face-scene pairings from encoding (see Procedure).

*Procedure*

The following procedures were identical across both the low and high contextual similarity study conditions. Participants completed four runs of the associative memory task, alternating between encoding and retrieval phases. Within each encoding run, 34 face-scene pairs were each presented on the screen for 4 seconds at a time. Stimuli were randomized within each run of the task. At the start of the study, participants were informed of the subsequent memory task and asked to encode the face-scene pairs by rating ‘How welcoming are the scene and face?”, to which they responded using a key press on a scale from ‘1-not at all welcoming’ to ‘4-very welcoming’. Immediately after the encoding phase, participants completed a recognition memory task in which they were asked to respond either ‘Yes’ or ‘No’ to the retrieval question, “Did this face and scene appear together previously?” Each retrieval run included 34 face-scene pairings, with 18 intact pairs (exactly the same face-scene pair from encoding) and 16 recombined lure pairs (a new face-scene pairing created by re-combining previously studied faces and scenes). Participants had 4 seconds to respond to each trial. Importantly, recombined lure pairs in the low contextual similarity condition consisted of a studied face re-paired with a studied scene different from that with which it was originally seen (e.g., encoding: Face A – Bridge >> retrieval: Face A – Library), whereas recombined lure pairs in the high contextual similarity condition consisted of a studied face re-paired with a studied scene from the same contextual category as that with which it was originally presented (e.g., encoding: Face A – Kitchen A >> retrieval: Face A – Kitchen B; see Figure 1A). For both encoding and retrieval, participants were given written instructions and were asked to repeat the instructions of the task to the experimenter to demonstrate their understanding of the task.

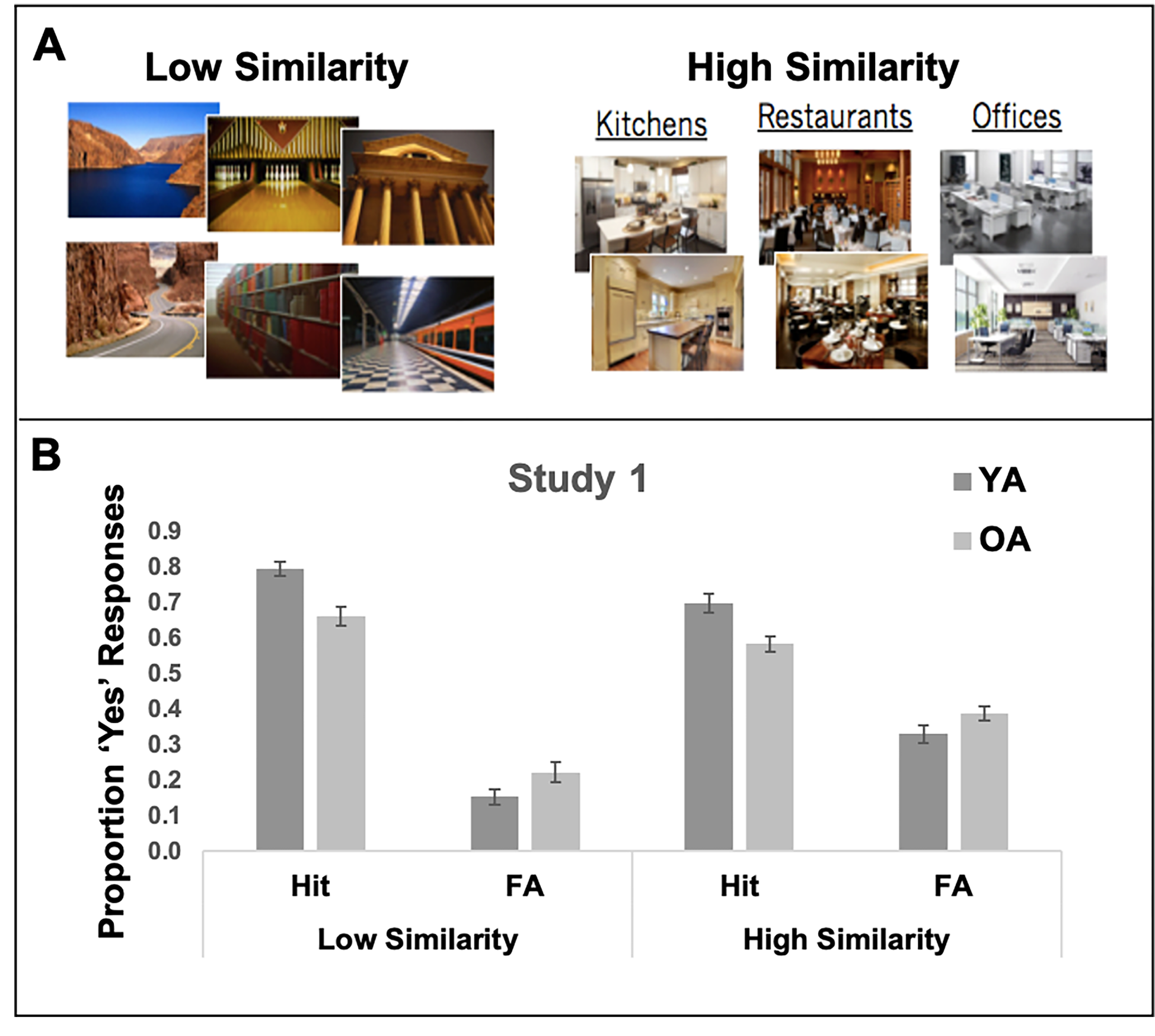


Figure 1. Study 1 paradigm and recognition results. A) Depicted are the two conditions included in the associative memory task, one in which the scene contexts were all random (low contextual similarity) and another in which scene contexts were categorically similar (high contextual similarity). B) hit and false alarm (FA) rates across the two conditions in both age groups (YA: Younger adults, OA: Older adults).

**Results**

Statistics for all studies were computed using SPSS Version 25 and all tests of significance were performed with an alpha value of .05 unless otherwise noted. Figure 1B depicts hit and false alarm rates across age and contextual similarity condition (see also Table 1). In order to examine contextual effects on associative recognition across age in Study 1, we conducted a mixed model ANOVA including between-subjects factors of contextual similarity condition (low, high similarity) and age group (younger, older) and a within-subject factor of stimulus type (target, lure) on proportion of “Yes” responses. This analysis revealed a main effect of stimulus type [*F*(1,115) = 562.09, *p <* .001, η*p*2 = 0.83], with participants generally showing higher hit than false alarm rates across age and context condition, and a main effect of contextual similarity [*F*(1, 115) = 6.67, *p =* .01, η*p*2 = 0.06], with greater “Yes” response rates in the low compared to the high similarity context condition across age and stimulus type. Importantly, there was a significant two-way interaction between stimulus type and contextual similarity [*F*(1, 115) = 55.13, *p <* .001, η*p*2 = 0.32]. Follow-up comparisons showed that across age, in the high similarity condition hit rates were lower and false alarm rates were higher compared to the low similarity condition [hit rate: *t*(117) = 3.26, *p* = .002; false alarm rate: [*t*(117) = 7.03, *p* < .001], indicating that both age groups showed poorer associative memory when the context was similar across studied and lure pairs compared to when there was less similarity in scene context. There was also a significant two-way interaction between stimulus type and age [*F*(1, 115) = 29.20, η*p*2 = 0.20], such that older adults showed lower hit rates and higher false alarm rates across context conditions [hit rate: *t*(117) = 4.93, *p* < .001; false alarm rate: [*t*(117) = 2.17, *p* = .03], which is consistent with typically observed age-related memory differences. The three-way interaction between contextual similarity, stimulus type, and age was not significant [*F*(1,115) = 0.20, *p* = .65, η*p*2 = 0.002], suggesting that contextual similarity had no differential impact on memory responses to targets and lures across age groups.

|  |  |  |  |
| --- | --- | --- | --- |
|  | | |  |
| Study 1 |  |  |  |
|  | YA | OA |  |
| Hit |  |  |  |
| High Similarity | 0.70 (0.15) | 0.59 (0.12) |  |
| Low Similarity | 0.80 (0.11) | 0.66 (0.14) |  |
| FA |  |  |  |
| High Similarity | 0.33 (0.14) | 0.39 (0.11) |  |
| Low Similarity | 0.15 (0.12) | 0.22 (0.15) |  |
|  |  |  |  |
| Study 2 |  |  |  |
|  | YA |  |  |
| Hit | 0.69 (0.13) |  |  |
| FA |  |  |  |
| High Similarity | 0.51 (0.17) |  |  |
| Low Similarity | 0.27 (0.11) |  |  |
| Novel | 0.03 (0.09) |  |  |
|  |  |  |  |
| Study 3 |  |  |  |
|  | YA | OA |  |
| Correct |  |  |  |
| High Similarity | 0.67 (0.11) | 0.59 (0.12) |  |
| Low Similarity | 0.74 (0.11) | 0.65 (0.13) |  |
| Incorrect |  |  |  |
| High Similarity | 0.33 (0.11) | 0.41 (0.12) |  |
| Low Similarity | 0.26 (0.11) | 0.35 (0.13) |  |
| Table 1. Memory performance across studies. Note: Mean and standard error reported for hit and false alarm (FA) rates across all three studies in younger adults (YA) and older adults (OA). | | |  |
|  |

**Discussion**

Regarding manipulations of contextual similarity, the high contextual similarity condition (i.e., scenes from the same context category) resulted in reduced hit rates to targets and higher false alarm rates to recombined lures compared to the low similarity condition (i.e., unique contexts). That is, overall, associative memory was poorer under conditions where there was similarity across studied contexts and high contextual interference within lures. Similar to results seen in studies of item memory, the present results suggest that memory for associative information is influenced by the gist associated with the context in which item information is studied (Dennis et al., 2014; D. Gallo, 2006; Giovanello et al., 2009; Kelley & Wixted, 2001). Specifically, though each face and scene used in the high contextual similarity condition was unique, the scenes were all drawn from 4 categories, creating overlapping gist traces with respect to the general source category (e.g., kitchen, office) across the scenes. When a face was re-paired with a scene from the same context category with which it was originally studied, participants had a difficult time correctly rejecting the novel face-scene pairing as new. Thus, in the high similarity condition, we posit that interference from this contextual gist influenced associative recognition by contributing to higher rates of false alarms to recombined lure pairs, lower accurate recognition of target pairs, and consequently, overall poorer discrimination between target and lure pairs that shared a similar context. Alternatively, when the face was re-paired with a scene that was unrelated to the original source, there was likely less overlap in memory representations and no interference from category gist to impair memory. This reduced interference across contexts, resulted in overall greater associative memory, as evidenced by lower false alarm rates and higher hit rates in the low similarity condition.

In line with a wealth of previous aging research, we identified an overall reduction in associative memory in older compared to younger adults, with older adults evidencing lower hit rates and higher false alarm rates relative to younger adults. Despite a general age deficit in discriminability between targets and lures, we did not find evidence that contextual similarity had a disproportionate effect in older adults. That is, contrary to our hypotheses, the negative effect of contextual similarity on associative recognition was proportional across both age groups. The absence of an age interaction with respect to either hit rates or false alarm rates suggests that interference induced by similarity in context information is not differentially detrimental to older adults’ associative memory, at least in the present study. Moreover, results from Study 1 indicate that contextual relatedness influences both younger and older adults’ associative memory to a similar degree, highlighting the pervasiveness of context effects across age.

The lack of age differences when there is contextual similarity may be due to the greater demands of associative relative to item memory. That is, in the face of these additional demands, and especially under conditions where similarity in context is high, younger adults may rely to a greater extent on gist to support associative encoding and retrieval processes, than they would if no contextual overlap was present across associative pairs. Thus, the comparable associative discrimination for context observed within each age group may be a result of the demand on associative memory that requires reliance on gist processing and leads to false memories (Brainerd & Reyna, 2002; Dennis & Turney, 2018; D. Gallo, 2006; Giovanello et al., 2009; Webb & Dennis, 2018). This also may be demonstrated in the overall lower hit rate and higher false alarm rates in the high-similarity condition, such that both age groups may have relied on more gist-based processes rather than recollection-based processes, thus decreasing recognition of targets and overall memory performance (Tun et al., 1998). While this difference may have been due to the difficulty of the two different similarity conditions, we did ensure that both age groups were matched across the similarity conditions to eliminate potential effects of different groups taking part in the study.

Overall, these results highlight the negative influence that interference from contextual similarity has on associative memory across age and demonstrate that both younger and older adults’ memory performance can benefit from reduced mnemonic overlap in associative information.

**Study 2**

**Introduction**

Study 1 showed that associative memory performance is reduced when there is gist-based interference from high contextual similarity between encoding and retrieval. Additionally, results showed that older adults are not more susceptible to contextual interference in associative recognition than younger adults. While Study 1 utilized a between-subjects design, it also featured a difference in number of scene categories between the high and low similarity conditions, making it unclear as to whether differences across conditions were due to the within category similarity at retrieval or also partly to the fact that there were a smaller number of contextual categories in the high similarity condition. That is, the constraint of fewer categories may have contributed additional similarity effects in the high similarity condition because in addition to featural similarity, there are also fewer distinct categories from which to draw features. Thus, the aim of Study 2 was to explore the influence of contextual interference using the same set of scene context categories for both the high and low similarity conditions using a within-subject design. To accomplish this goal, Study 2 tested the effect of contextual similarity utilizing the design of only the high-similarity condition from Study 1 (i.e., 4 scene context categories) with the following exceptions. At retrieval, half of the recombined lure pairs featured a studied face recombined with a scene from the same contextual category as its original scene associate (high contextual similarity condition); the other half of the recombined lure pairs featured a studied face recombined with a scene from one of the other three contextual categories (low contextual similarity condition). Additionally, novel lure pairs were included in Study 2 in order to ensure effects of contextual similarity were independent of familiarity. The features of Study 2 importantly allowed us to hold both item and context familiarity equal (i.e., all faces and scenes were previously seen), as well as measure the effect of interference from contextual similarity within individuals. We predicted that, in line with Study 1, participants would show greater false alarms to recombined lure pairings that featured a high degree of contextual similarity compared to when contextual similarity was reduced. Moreover, false alarms to recombined pairings in both high and low similarity conditions should be higher than false alarms to novel lure pairs as familiarity with recombined pairings should be greater and unrelated lure pairs feature both novel face-scene items and a novel association. Because no age differences were observed between the high and low similar contexts in Study 1, Study 2 included only younger adults.

**Methods**

*Participants*

Thirty younger adults completed Study 2. Participants were recruited from introductory psychology classes at Penn State University. Two participants were excluded for not responding on at least 25% of trials and a third participant was removed for failing to follow task instructions, leaving a final sample of 27 participants (mean age = 19.78; SD = 0.93; 23 Female). On the day of study, participants provided written informed consent for a protocol approved by the Pennsylvania State University institutional review board. A post-hoc sensitivity analysis conducted in G\*Power 3.1(Faul et al., 2007) confirmed that power was sufficient to detect a small effect size (*f*=0.32) for a within factor of interference conditions, given that α=.05, and the correlation between repeated measures is equal to .05.

*Materials*

Face images consisted of male and female faces obtained from the same online databases as Study 1. Scene images from 4 different categories (backyard, kitchen, restaurant, street) were obtained from an Internet image search. These face and scene images were used to construct face-scene pairs, with the face always presented superimposed on the scene. Face-scene pairs in each condition were counterbalanced across both male/female faces and indoor/outdoor scenes.

*Procedure*

The task procedure included two encoding-retrieval blocks and is depicted in Figure 2A. Two versions were created to counterbalance order of encoding and retrieval lists. No effects of version were identified on any metric, thus all results are collapsed across version. Each encoding phase consisted of 40 face-scene pairs presented centrally on the screen for 4 seconds each. For each pairing, participants were asked to rate how well the face/person fit with the scene/location on a scale of 1 (poor fit) to 4 (good fit). They were also informed that they would have a subsequent memory test following the study phase. They were instructed to base their rating on how likely the person might be to live, work, vacation, or do some other activity in the pictured location. Each retrieval block followed immediately after encoding and consisted of 37 face-scene pairs randomly presented centrally on the screen for 4 seconds each. Sixteen of the pairs consisted of exact face-scene pairings from encoding (i.e., targets), 16 of the pairs were recombinations of a face and scene from encoding (i.e., recombined lures), and 5 of the pairs were entirely new face-scene images (i.e., unrelated pairs). To investigate effects of contextual similarity, we manipulated the degree to which the recombined lure pairs induced context interference. Critically, in half of the lure pairs the recombination consisted of a scene taken from the same category as that seen in the original encoded pairing (high contextual similarity; 8 per retrieval block) and in the other half of the lure pairs the recombination consisted of a scene taken from a different category as that seen in the original encoded pairing (low contextual similarity; 8 per retrieval block). The unrelated lure pairs consisted of a novel face and a novel scene from a category that was not one of the four studied (e.g., bedroom; grocery store) and were therefore expected to induce no familiarity or contextual interference as both face and scene were entirely novel at the retrieval phase. For each image at retrieval, participants were asked to make an ‘Old’/‘New’ judgment. They were instructed to press a key indicating ‘Old’ if they remembered seeing that exact pairing at encoding and to press ‘New’ if they thought it was either a new combination of face-scene or an entirely novel pairing.

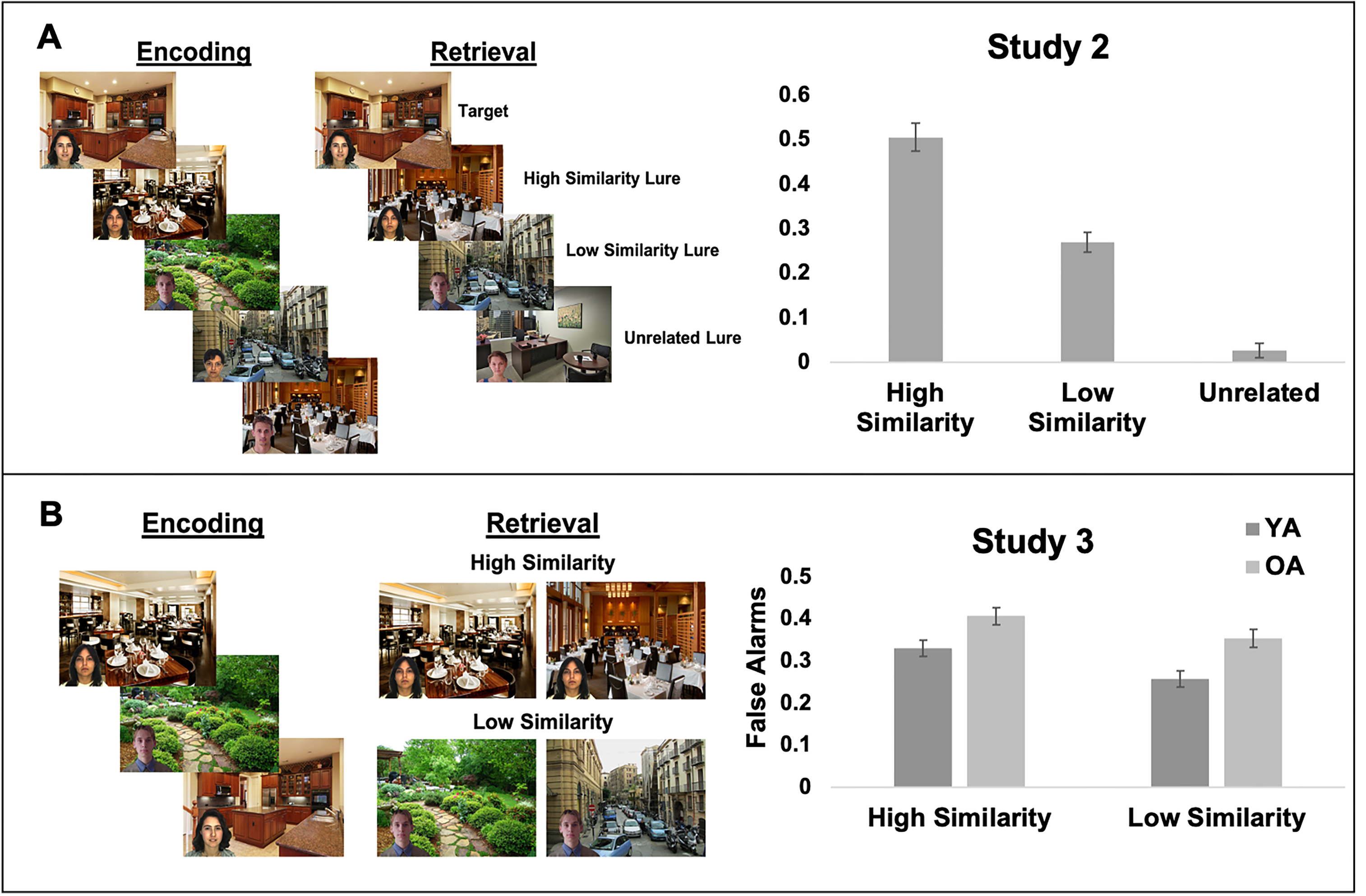
****

Figure 2. Paradigm and associative memory results from Study 2 (A) and Study 3 (B). In Study 2 younger adults encoded face-scene pairs and at retrieval made associative recognition decisions for intact (target) pairs, pair recombinations of studied scenes from the same category (high contextual similarity lures), pair recombinations comprised of studied scenes from different categories (low contextual similarity lures), and entirely new, unstudied pairs (unrelated lures). In Study 3, younger adults (YA) and older adults (OA) encoded face-scene pairs and at retrieval completed a two-alternative forced choice recognition task, where an intact target was presented next to either a high or low similarity lure.

**Results**

Table 1 reports average hit and false alarm rates for Study 2 across contextual similarity condition; see also Figure 2A for false alarm rates across conditions. A one-way repeated measures ANOVA was conducted to compare false alarm rates across the interference conditions (high, low, or no contextual similarity). This analysis indicated a significant decrease in false alarm rates across the 3 levels of similarity [*F*(1.49, 38.96) = 107.20, *p* < .001, η*p*2 = 0.81; Greenhouse-Geisser corrected]. False alarms to novel lure pairs were significantly lower than to that of both types of recombined lure pairs [high similarity: *t*(26) = 12.40, *p* < .001; low similarity: *t*(26) = 11.24, *p* < .001], indicating that participants made more false alarms to recombinations of studied lure information compared to novel lures. Important to our manipulation, false alarms were significantly greater when the lure context was from the same category as that from encoding compared to when the context was different from that which was originally studied [high vs. low contextual similarity; *t*(26) = 6.68, *p* < .001].

**Discussion**

Results from Study 2 replicate and extend findings from Study 1 to an independent set of participants, using a new paradigm that compared high and low similarity within the same set of source contexts. The results further emphasize the negative effects of contextual interference on associative recognition within individuals. Consistent with the previous study, participants showed poorer associative memory, as evidenced by higher rates of false alarms, when the face was re-paired with a unique scene drawn from the same versus a different context category as that with which it was originally paired. In fact, the difference between the high and low contextual similarity conditions in Study 1 and Study 2 were comparable (0.17 and 0.24, respectively), providing evidence for replication of findings across studies despite design differences. We conclude that, like Study 1, the high degree of similarity, or gist, in sources creates contextual interference in associative memory traces, contributing to greater false endorsement of recombined lures in the high contextual similarity condition. Study 2 removed the potential confound of heterogeneity across contextual similarity conditions. Importantly, we have, to this point, observed converging results both in the context of a between-subjects and within-subjects design, and across age groups, further highlighting the pervasive influence of contextual similarity on memory for associative information.

**Study 3**

**Introduction**

The previous two studies showed that interference induced by contextual similarity negatively affects associative memory performance, and it does so in a comparable manner across age. However, in the traditional recognition paradigms featured in Study 1 and 2 the lure pair was presented in isolation, which could potentially exacerbate the influence of gist-based retrieval processes. Studies suggest that under forced choice conditions (i.e., where the target and corresponding lure are presented simultaneously), memory judgments can be based on relative familiarity of the target, resulting in reductions in false recognition (Dennis et al., 2012; Migo et al., 2009). On the other hand, traditional Old/New recognition tasks can involve recollection of details to successfully endorse a target as old and avoid false memories (Bowman & Dennis, 2015; Cohn et al., 2008; Rotello & Heit, 2000). The necessity to engage this type of strategy should be reduced in a forced choice relative to standard memory paradigm as the target information is proximate at the time of retrieval. Evidence from (Guerin et al., 2012) indicates that, in younger adults, false alarm rates were reduced when using a two-alternative forced choice (2AFC) retrieval task compared to a traditional Old/New recognition task. In older adults, the use of a 2AFC test can reduce age differences in associative memory relative to standard recognition tests (Ahmad et al., 2014; Delhaye & Bastin, 2016). Simultaneous presentation of the original target pair along with the lure pair thus appears to provide retrieval support, facilitating accurate retrieval in both younger and older adults. Given this, Study 3 aimed to assess whether presentation of original target details, concurrently with the similar lure, contributes to a reduction in contextual interference effects in younger adults. Additionally, this study aimed to determine whether target presentation at associative retrieval influences memory across contextual similarity conditions differentially across age.

To achieve this, the present study utilized a 2AFC design whereby, at retrieval, younger and older participants saw both the target and recombined lure simultaneously on the screen and were instructed to decide which of the face-scene pairs was originally studied during the encoding phase. In line with the previous two studies, we created recombined lures that featured a scene from the same studied category or a scene from one of the other studied categories. However, at retrieval in the present study the high contextual similarity condition entailed presentation of the original, intact face-scene pair alongside a same category lure and the low contextual similarity condition included the intact face-scene pair presented alongside a different category lure. Because presentation of the intact pair should induce higher familiarity for the original pair than the recombined pair, contextual interference effects should be reduced relative to what was observed in Study 2 (i.e., the associative memory difference between the high and low similarity conditions should be lessened), or even eliminated. Furthermore, we hypothesized that both older and younger adults should be able to capitalize on intact familiarity-based processing for retrieval support. This, therefore, should reduce the influence of contextual gist and result in little difference in associative recognition under conditions of high relative to low contextual similarity across both age groups. Alternatively, for older adults, gist influences induced by high contextual similarity may still override any benefit of target familiarity and the simultaneous presentation of target details, resulting in age differences in the interference condition effect.

**Methods**

*Participants*

Thirty-four younger adults (mean age = 18.58; SD = 1.00) and 34 older adults (mean age = 71.56; SD = 6.86) completed Study 3. Younger adult participants were recruited from introductory psychology classes at Penn State University and older adults were recruited from the local community surrounding Penn State University. On the day of study, participants provided written informed consent for a protocol approved by the Pennsylvania State University institutional review board. Older adults completed the Mini-Mental Status Exam (*M*=29.73, *SD*=0.72) to screen for neurological illness. The younger adults included in the study had an average of 12.47 years of education (*SD*=0.92), and the older adults included had an average of 18.24 years (*SD*=2.85). A post-hoc sensitivity analysis conducted in G\*Power 3.1 (Faul et al., 2007) confirmed that power was sufficient to detect a small effect size (*f*=0.32) for within-between interaction (age x contextual similarity condition) given that α=.05, and the correlation between repeated measures is equal to 0.5.

*Materials*

All stimuli were the same as in Study 2.

*Procedure*

The task procedure included three encoding-retrieval blocks and is depicted in Figure 2B. Each encoding block consisted of 32 face-scene pairs presented centrally on the screen for 4 seconds each. Stimuli were randomized within each run of the task. For each pairing, participants were asked to rate how well the face/person fit with the scene/location on a scale of 1 (poor fit) to 4 (good fit). Each retrieval block followed immediately after encoding and consisted of a typical 2AFC recognition task, during which 16 sets of face-scene pairs were presented. For each trial two face-scene pairs were presented next to each other on the screen, with one always consisting of the target pair and the other depicting a recombined lure or a novel lure. As in Study 2, we manipulated the degree to which the recombined lure pairs induced contextual interference. Critically, in half (8) of the trials, the target was presented next to a within-category recombined pair, inducing high contextual interference, and in the other half of trials the target was presented next to a between-category recombined pair, inducing less contextual interference. In each case, the face always remained the same across both target and lure and it was the scene that changed (either within- or between-category). The presentation of the target and lure was counterbalanced across the left and right side of the screen. For each retrieval trial, participants were asked to indicate whether the left or right pair was ‘Old’, meaning it was the exact pairing they saw at encoding. Each trial was self-paced to allow for greater time to examine both pairs and make a recognition decision (mean RT: younger adults = 2.52s; older adults = 3.58s).

**Results**

Table 1 reports average correct and incorrect responses for Study 3 (see also Figure 2B). A mixed model ANOVA with a between-subjects factor of age (young, old) and a within-subject factor of contextual similarity (high, low) predicting proportion of incorrect responses (akin to false alarms in old/new recognition paradigms) showed a main effect of age group [*F*(1, 66) = 15.61, *p* < .001, η*p*2 = 0.19], with older adults showing greater inaccurate recognition than younger adults across context type, and a main effect of contextual similarity [*F*(1, 66) = 11.83, *p* = .001, η*p*2 = 0.15], such that across age accuracy was poorer when the presented lure scene context was drawn from the same category as the target context compared to when the lure context was from a different category than the target context. There was no interaction between age and contextual similarity [*F*(1, 66) = 0.30, *p* = .59, η*p*2 = 0.004], suggesting that as in Study 1 contextual interference effects were similar across age.

To assess whether presentation of the originally studied target pair facilitated associative retrieval, false alarm rates and incorrect response rates across study version and high and low similarity conditions were compared in younger adults using a repeated measures ANOVA with a between-subjects factor of study (Study 2, Study 3) and a within-subject factor of contextual similarity (high, low ) predicting memory. This analysis revealed both a main effect of study [*F*(1, 59) = 12.59, *p* < .001, η*p*2 = 0.18], and a main effect of contextual similarity [*F*(1, 59) = 68.52, *p* < .001, η*p*2 = 0.54], whereby incorrect responses across context conditions were higher under Old/New recognition compared to 2AFC conditions and a higher proportion of inaccurate responses were made in the high versus low contextual similarity conditions. There was also a study by context type interaction on inaccurate responses (either false alarm rate in Study 2 or incorrect response rate in Study 3) [*F*(1, 59) = 18.89, *p* < .001, η*p*2 = 0.24], suggesting that the difference in associative memory in the high and low contextual similarity conditions under the Old/New recognition task (Study 2) was significantly greater than the difference in conditions in the 2AFC task (Study 3). This was driven by a higher false alarm rate between Study 2 and 3 under conditions of high contextual similarity, with a similar rate across studies under low contextual similarity, highlighting the beneficial influence that re-presentation of intact target pairs has on opposing gist interference induced by contextual similarity.

As Study 2 did not include older adults, we were consequently unable to conduct a similar comparison in aging; however, comparing the mean difference in high and low similarity conditions across Study 1 and Study 3 suggests that older adults were also able to benefit from presentation of the intact pair simultaneously with the high similarity lure to reduce contextual interference effects on associative memory (Study 1 difference in false alarms between similarity condition = 0.17; Study 3 difference in incorrect responses = 0.06).

**Discussion**

Similar to results in Studies 1 and 2, individuals across age groups in Study 3 produced more associative memory errors when there was a high degree of contextual similarity between the lure and the target relative to a condition in which contextual similarity between lure and target was absent). This was true despite the fact that the originally studied target pair was presented simultaneously with the lure during the retrieval task, allowing for reinstatement of the encoded association. However, a comparison of younger adults’ associative memory performance across Old/New and 2AFC study designs (Study 2 and Study 3, respectively) indicated that the contextual interference effect was reduced in the forced choice task relative to the traditional recognition test. Specifically, the difference in high and low contextual similarity conditions was reduced when target information was presented concurrently with the associative lure. While this comparison was done cross-experimentally and should be interpreted with caution, the influence of gist induced by high contextual similarity may be diminished by presentation of original target information. Target presentation at the time of retrieval may prompt a familiarity signal (Jones & Jacoby, 2001; Migo et al., 2009) that is, in part, able to override the gist induced by high contextual similarity in associative lures, thereby reducing the difference in contextual interference conditions. While older adults again demonstrated typical associative memory deficits relative to younger adults, we saw evidence for a reduction in contextual interference effects under 2AFC conditions in both younger and older adults. This suggests that individuals across the lifespan may benefit from this type of retrieval support; however, future research should include within-subject comparisons across age and task design in order to better understand the magnitude of this effect. The fact that the contextual interference effect was not eliminated in either age group (i.e., still significantly greater associative errors under high vs. low similarity conditions) demonstrates that contextual interference exhibits a strong and pervasive influence on memory for associative information that is not easily overcome. Yet, the present study suggests that this effect may be reduced by reinstating details of the original episode.

**General Discussion**

Across three studies, each incorporating different associative memory paradigms, results clearly point to a role of contextual similarity in evoking false memories. Specifically, we saw an increase in associative false memories of recombined lures when the lure scene shared the same categorical label as the original scene from encoding. We posit that such contextual similarity induces interference that contributes to reduced fidelity of associative memories. Importantly, results from these studies suggest that this context similarity effect is age invariant, with both older and younger adults experiencing similar susceptibility to contextual interference with high similarity contexts in associative memory tasks. Lastly, we found that while presentation of original target information at retrieval may reduce this effect, it does not eliminate it in either age group. Taken together, results underscore the pervasiveness of contextual similarity and gist influences on associative memory across age.

*Effects of Contextual Similarity on Associative Memory*

A wealth of prior research indicates that mnemonic similarity between target and lure information, whether it be of a semantic, conceptual, or perceptual nature contributes to greater false memory errors (Brainerd & Reyna, 2002; Coane et al., 2015; D. A. Gallo & Roediger, 2003; Koutstaal & Schacter, 1997; Stark et al., 2013). In these cases, overlapping features create less distinct mnemonic representations of the original encoded target, leading to later ambiguity between targets and related lures. The present set of studies extends this concept to associative memory, demonstrating that similarity in context information impairs successful associative memory for face-scene pairings. Across all three studies, associative false memories for item-context pair information occurred more often when the lure context was of the same category as that which was studied (e.g., two different kitchen scenes) compared to when it was more distinct (e.g., a kitchen context versus an office scene). When contextual similarity between a studied pair and a recombined lure is high, retrieval of specific item and pair information is required to correctly reject the lure. We posit that it is the familiarity with the scene category and gist induced by similarity between categorical exemplars that creates interference in memory traces (Brainerd et al., 1995; Jones & Jacoby, 2001; Reyna & Brainerd, 1995). This mnemonic overlap, in turn, contributes to false recognition of the recombined lure. Conversely, when there is little or no similarity in target-lure information, interference is reduced, leading to higher mnemonic discriminability within associative memory retrieval.

Notably, these contextual similarity effects were replicated across several paradigms, including separate between- and within-subject paradigms, as well as under standard recognition and alternative forced-choice memory conditions. Specifically, Study 1 demonstrated that participants who were presented with associative lures comprised of scenes from the same studied categories showed higher rates of associative false alarms than participants who were presented with lures involving more distinct scene contexts. The rate of successful associative recognition (hit rate) was also reduced in the high versus low contextual similarity condition, indicating that contextual interference negatively affected not only erroneous endorsement of lures, but overall memory discriminability. Study 2 expanded on these findings by using the same set of contexts in a within-participants design, with the only difference between the high and low similarity conditions being whether the lure recombinations occurred within or across a homogeneous set of categories. As in Study 1, we found higher rates of associative false alarms under conditions of high, relative to low, contextual interference. Results from Study 3 furthered our understanding of contextual interference by showing that, even with target information present, greater contextual lure similarity continued to induce higher rates of associative false alarms compared to when there was reduced or no similarity across target-lure contexts. Interference from contextual similarity across studied and lure associative pairs thus appears to represent a general memory phenomenon, occurring under various conditions, and even when studied target information is available concurrent with lure information at retrieval. While the present set of studies utilized similar face-scene stimuli to avoid confounding stimulus material with similarity effects, it will be important to determine whether these effects remain when different stimuli are used (e.g., conceptually similar word pairs, different visual stimuli, real-world events). Future research could also investigate whether similarity in items (versus contexts) or congruency between items and contexts induces analogous similarity interference effects to that observed in the current set of studies.

*Effects of Retrieval Support on Associative Memory*

Prior work has demonstrated that presenting target information at the time of recognition decisions (e.g., under 2AFC conditions) can provide retrieval support by reducing the erroneous endorsement of lure information compared to that seen in traditional recognition paradigms (Ahmad et al., 2014; Delhaye & Bastin, 2016; Guerin et al., 2012; Naveh-Benjamin & Craik, 1995). The current set of results suggest that, in cases of high similarity, such informational support may not be enough to overcome the mnemonic overlap across memory representations. While the individual items in the lure pairs likely evoked a strong feeling of familiarity (as they were both presented at encoding), target pairings uniquely included additional and specific associative information amongst individual items. We hypothesized that re-presentation of the target pairing (and this added information) alongside the lure pair would evoke an increased level of familiarity of both the individual items *and* associative-specific information (Huffman & Stark, 2017; Migo et al., 2009). We posited that this would consequently reduce the occurrence of false endorsement of lure pairs containing highly similar contexts. While we continued to see a significant difference across contextual similarity conditions in Study 3, we also observed evidence supporting this hypothesis when comparing performance in younger adults between Study 2 and Study 3. Specifically, we found a significant reduction in contextual similarity effects under 2AFC task conditions compared to the recognition task in Study 2 (and additionally saw an observational reduction in false alarms when comparing older adult performance across Study 1 and 3). That is, participants may have been better able to reject a lure pair that included a high degree of overlap in context under circumstances where the original studied pair was concurrently presented compared to when the lure pair was presented alone. We posit that, with simultaneous presentation of targets and lures, external target information may be more readily utilized to better support successful associative memory.

Previous studies comparing alternative forced choice with single item recognition have shown similar findings. For example, in a study by (Guerin et al., 2012) lure endorsement was greatly decreased when target information was made accessible at the time of retrieval decision. Research on source memory additionally suggests that reinstating context information acts as a cue for accurate retrieval (Dodson & Shimamura, 2000; Smith & Vela, 2001). Aging studies have also shown benefits of environmental support to successful associative memory in older adults (Ahmad et al., 2014; Delhaye & Bastin, 2016; Schacter et al., 1999). For example,(Naveh-Benjamin & Craik, 1995) showed that both younger and older adults’ memory can similarly benefit from reinstating original context information. When item specific information (i.e., the exact studied information) is available at the time of memory retrieval, the gist induced by overlap in contextual similarity is reduced, and this benefits both younger and older adults’ associative memory. Importantly, while the present evidence indicates that contextual interference may be reduced, the effect is not eliminated. This lends further evidence highlighting the pervasive influence of gist interference across age.

*Contextual Similarity Effects Between Age Groups*

In addition to being present across different study conditions, comparable contextual similarity effects were also evident within both younger and older adults. Specifically, evidence from Study 1 and Study 3 indicated that despite typical associative memory deficits (Kilb & Naveh-Benjamin, 2011; Naveh-Benjamin et al., 2003; Old & Naveh-Benjamin, 2008; Overman & Becker, 2009), older adults showed comparable sensitivity to interference from contextual similarity as younger adults. The absence of age differences in false memories stands in contrast to analogous studies of item memory where older adults typically show similar target recognition, but overall higher false alarm rates to related lures, compared to younger adults. This pattern of behavior has been attributed to a greater reliance on the gist inherent in related information, as well as a greater dependence on general familiarity when making recognition decisions (Anderson et al., 2008; Brainerd et al., 2008; Brainerd & Reyna, 2002; Jones & Jacoby, 2001; Koutstaal & Schacter, 1997). Based on this past work, we anticipated that older adults’ associative memory would be disproportionately negatively affected by high contextual similarity (Greene & Naveh-Benjamin, 2020; Overman & Stephens, 2013), compared to younger adults who more readily retrieve item-specific information (Cohn et al., 2008; Jennings & Jacoby, 1997; Yonelinas, 1997). In line with this prediction, recent work by (Greene & Naveh-Benjamin, 2020) showed that age-related associative memory deficits were influenced by categorical similarity across both faces and scenes in an associative memory task similar to that used in the current set of studies. However, in contrast to their findings, the present results suggest that when faced with contextual similarity alone (absent of additional item (face) similarity), both younger and older adults are unable to distinguish between highly similar information and rely on gist-based processing, which leads to the erroneous endorsement of a lure as a target.

Despite the common age-related increases in false memories observed across the literature, there is support for age invariant findings in item memory studies that manipulate the degree of gist inherent in lure information. When target-lure similarity is high, over-reliance on the gist trace is shown to contribute to false memories for related information in a similar manner across both younger and older adults (Dennis & Turney, 2018; Giovanello et al., 2009; Webb & Dennis, 2019). The present results extend these findings to an associative memory context, demonstrating that associative recognition is negatively influenced by shared context information, and that this overlap in contextual similarity across target and lure pairs influences associative memory in a similar manner across aging. At the same time, both age groups show proportionate benefits to associative memory recognition when lure information is more distinct from studied information, as was the case when there was no contextual similarity across target and lure scenes. This adds additional evidence to previous research which suggests that making information more distinct benefits recognition at any age (Brainerd et al., 1995; Dodson & Schacter, 2001; Schacter et al., 1999). We extend this to an associative memory context and show that this distinctiveness benefit occurs similarly across age groups. The present results further tie into the broader memory literature which suggests that unique mnemonic representations are poorly maintained and/or preserved in memory as a result of overlapping, competing information. Here, we demonstrate that contextual similarity across categories contributes to reduced mnemonic discrimination (i.e., poorer separation of similar contextual memory traces), resulting in a greater tendency toward generalization of memory traces as evidenced by higher rates of associative false memories.

*Conclusions*

The present set of experiments demonstrated that mnemonic overlap between targets and lures in an associative memory task can be detrimental to the ability to discriminate between highly similar target and lure information. Specifically, we found that shared contextual information between targets and lures led to increased false associative memories. This effect occurred regardless of age, indicating that despite typical age-related associative memory deficits and false memory increases, younger and older adults are equally susceptible to interference from contextual similarity. Our results also suggest that contextual interference effects may be reduced through retrieval support, such as providing target information alongside lure information, but this should be investigated further as we are limited in interpreting cross-experiment comparisons. These results have important implications for real-world situations where interference between pieces of information is high, such as remembering the relationship between critical medications and their dosages, or distinguishing where you parked your car in a given parking lot. The present set of findings suggests that these types of associative memory distinctions are difficult for both younger and older adults, and that being able to prompt retrieval of target information can reduce, but not remove, the influence of contextual interference on memory success.

**Disclosure**

The authors report no conflict of interest.

**Acknowledgements**

We thank Jordan Goodman, Haley Iriondo, Holly Richardson, Harini Babu, Jackie DeRosa, Kayla McGraw, Andrew Rowley, and Joanna Salerno for help with data collection and analyses. This work was supported by the National Institutes of Health under grant R15AG052903 awarded to A.A.O. and N.A.D. In addition, N.A.D. was also supported in part by National Science Foundation grants BCS1025709 and BCS2000047. Portions of the research in this article used the Color FERET (Facial Recognition Technology) database of facial images collected under the FERET program, sponsored by the Department of Defense Counterdrug Technology Development Program Office.

**References**

Ahmad, F. N., Fernandes, M., & Hockley, W. E. (2014). Improving associative memory in older adults with unitization. *Https://Doi.Org/10.1080/13825585.2014.980216*, *22*(4), 452–472. https://doi.org/10.1080/13825585.2014.980216

Anderson, N. D., Ebert, P. L., Jennings, J. M., Grady, C. L., Cabeza, R., & Graham, S. J. (2008). Recollection- and Familiarity-Based Memory in Healthy Aging and Amnestic Mild Cognitive Impairment. *Neuropsychology*, *22*(2), 177–187. https://doi.org/10.1037/0894-4105.22.2.177

Bender, A. R., Naveh-Benjamin, M., & Raz, N. (2010). Associative Deficit in Recognition Memory in a Lifespan Sample of Healthy Adults. *Psychology and Aging*, *25*(4), 940–948. https://doi.org/10.1037/A0020595

Bowman, C. R., & Dennis, N. A. (2015). Age differences in the neural correlates of novelty processing: The effects of item-relatedness. *Brain Research*, *1612*, 2–15. https://doi.org/10.1016/J.BRAINRES.2014.08.006

Brainerd, C. J., & Reyna, V. F. (2002). Fuzzy-trace theory and false memory. *Current Directions in Psychological Science*. https://doi.org/10.1111/1467-8721.00192

Brainerd, C. J., Reyna, V. F., & Kneer, R. (1995). False-Recognition Reversal: When Similarity is Distinctive. *Journal of Memory and Language*, *34*(2), 157–185. https://doi.org/10.1006/jmla.1995.1008

Brainerd, C. J., Yang, Y., Reyna, V. F., Howe, M. L., & Mills, B. A. (2008). Semantic processing in “associative” false memory. *Psychonomic Bulletin & Review 2008 15:6*, *15*(6), 1035–1053. https://doi.org/10.3758/PBR.15.6.1035

Buchler, N. E. G., & Reder, L. M. (2007). Modeling age-related memory deficits: A two-parameter solution. *Psychology and Aging*, *22*(1), 104–121. https://doi.org/10.1037/0882-7974.22.1.104

Castel, A. D. (2005). Memory for grocery prices in younger and older adults: The role of schematic support. *Psychology and Aging*, *20*(4), 718–721. https://doi.org/10.1037/0882-7974.20.4.718

Castel, A. D., & Craik, F. I. M. (2003). The Effects of Aging and Divided Attention on Memory for Item and Associative Information. *Psychology and Aging*, *18*(4), 873–885. https://doi.org/10.1037/0882-7974.18.4.873

Castel, A. D., Farb, N. A. S., & Craik, F. I. M. (2007). Memory for general and specific value information in younger and older adults: Measuring the limits of strategic control. *Memory & Cognition 2007 35:4*, *35*(4), 689–700. https://doi.org/10.3758/BF03193307

Chalfonte, B. l., & Johnson, M. K. (1996). Feature memory and binding in young and older adults. *Memory & Cognition 1996 24:4*, *24*(4), 403–416. https://doi.org/10.3758/BF03200930

Coane, J. H., McBride, D. M., Termonen, M.-L., & Cutting, J. C. (2015). Categorical and associative relations increase false memory relative to purely associative relations. *Memory & Cognition 2015 44:1*, *44*(1), 37–49. https://doi.org/10.3758/S13421-015-0543-1

Cohn, M., Emrich, S. M., & Moscovitch, M. (2008). Age-Related Deficits in Associative Memory: The Influence of Impaired Strategic Retrieval. *Psychology and Aging*, *23*(1), 93–103. https://doi.org/10.1037/0882-7974.23.1.93

Delhaye, E., & Bastin, C. (2016). The impact of aging on associative memory for preexisting unitized associations. *Https://Doi.Org/10.1080/13825585.2016.1263725*, *25*(1), 70–98. https://doi.org/10.1080/13825585.2016.1263725

Dennis, N. A., Bowman, C. R., & Turney, I. C. (2015). Functional neuroimaging of false memories. In *The Wiley Handbook on The Cognitive Neuroscience of Memory* (p. 150).

Dennis, N. A., Bowman, C. R., & Vandekar, S. N. (2012). True and phantom recollection: An fMRI investigation of similar and distinct neural correlates and connectivity. *NeuroImage*. https://doi.org/10.1016/j.neuroimage.2011.09.079

Dennis, N. A., Johnson, C. E., & Peterson, K. M. (2014). Neural correlates underlying true and false associative memories. *Brain and Cognition*, *88*(1), 65–72. https://doi.org/10.1016/J.BANDC.2014.04.009

Dennis, N. A., & Turney, I. C. (2018). The influence of perceptual similarity and individual differences on false memories in aging. *Neurobiology of Aging*, *62*, 221–230. https://doi.org/10.1016/J.NEUROBIOLAGING.2017.10.020

Dodson, C. S., & Schacter, D. L. (2001). “If I had said it I would have remembered it: Reducing false memories with a distinctiveness heuristic. *Psychonomic Bulletin & Review 2001 8:1*, *8*(1), 155–161. https://doi.org/10.3758/BF03196152

Dodson, C. S., & Shimamura, A. P. (2000). Differential Effects of Cue Dependency on Item and Source Memory. *Journal of Experimental Psychology: Learning Memory and Cognition*, *26*(4), 1023–1044. https://doi.org/10.1037/0278-7393.26.4.1023

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G\*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Gallo, D. (2006). *Associative Illusions of Memory: False Memory Research in DRM and Related Tasks*. Psychology Press. https://doi.org/10.4324/9780203782934

Gallo, D. A. (2013). *Associative Illusions of Memory: False Memory Research in DRM and Related Tasks*. Psychology Press.

Gallo, D. A., & Roediger, H. L. (2003). The effects of associations and aging on illusory recollection. *Memory & Cognition 2003 31:7*, *31*(7), 1036–1044. https://doi.org/10.3758/BF03196124

Gerard, L., Zacks, R. T., Hasher, L., & Radvansky, G. A. (1991). Age deficits in retrieval: The fan effect. *JournalofGerontology: Psychological Sciences*, 131–136.

Giovanello, K. S., Schnyer, D., & Verfaellie, M. (2009). Distinct hippocampal regions make unique contributions to relational memory. *Hippocampus*, *19*(2), 111–117. https://doi.org/10.1002/HIPO.20491

Greene, N. R., & Naveh-Benjamin, M. (2020). A Specificity Principle of Memory: Evidence From Aging and Associative Memory: *Https://Doi.Org/10.1177/0956797620901760*, *31*(3), 316–331. https://doi.org/10.1177/0956797620901760

Guerin, S. A., Robbins, C. A., Gilmore, A. W., & Schacter, D. L. (2012). Retrieval failure contributes to gist-based false recognition. *Journal of Memory and Language*, *66*(1), 68–78. https://doi.org/10.1016/J.JML.2011.07.002

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In *The psychology of learning and motivation: Advances in research and theory, Vol. 22* (pp. 193–225). Academic Press. https://doi.org/10.1016/S0079-7421(08)60041-9

Huffman, D. J., & Stark, C. E. L. (2017). Age-Related Impairment on a Forced-Choice Version of the Mnemonic Similarity Task. *Behavioral Neuroscience*, *131*(1), 55. https://doi.org/10.1037/BNE0000180

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, *30*(5), 513–541. https://doi.org/10.1016/0749-596X(91)90025-F

Jennings, J. M., & Jacoby, L. L. (1997). An opposition procedure for detecting age-related deficits in recollection: Telling effects of repetition. *Psychology and Aging*, *12*(2), 352–361. https://doi.org/10.1037/0882-7974.12.2.352

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*(1), 3–28. https://doi.org/10.1037//0033-2909.114.1.3

Jones, T. C., & Jacoby, L. L. (2001). Feature and Conjunction Errors in Recognition Memory: Evidence for Dual-Process Theory. *Journal of Memory and Language*, *45*(1), 82–102. https://doi.org/10.1006/jmla.2000.2761

Kelley, R., & Wixted, J. T. (2001). On the Nature of Associative Information in Recognition Memory. *Journal of Experimental Psychology: Learning Memory and Cognition*, *27*(3), 701–722. https://doi.org/10.1037/0278-7393.27.3.701

Kilb, A., & Naveh-Benjamin, M. (2011). The Effects of Pure Pair Repetition on Younger and Older Adults’ Associative Memory. *Journal of Experimental Psychology: Learning Memory and Cognition*, *37*(3), 706–719. https://doi.org/10.1037/A0022525

Koutstaal, W., & Schacter, D. L. (1997). Gist-Based False Recognition of Pictures in Older and Younger Adults. *Journal of Memory and Language*, *37*(4), 555–583. https://doi.org/10.1006/JMLA.1997.2529

Ly, M., Murray, E., & Yassa, M. A. (2013). Perceptual versus conceptual interference and pattern separation of verbal stimuli in young and older adults. *Hippocampus*, *23*(6), 425–430. https://doi.org/10.1002/HIPO.22110

Martinez, A. M., & Benavente, R. (1998). *The AR face database*. (CVC Technical Report No. 24).

Migo, E., Montaldi, D., Norman, K. A., Quamme, J., & Mayes, A. (2009). The contribution of familiarity to recognition memory is a function of test format when using similar foils: *Https://Doi.Org/10.1080/17470210802391599*, *62*(6), 1198–1215. https://doi.org/10.1080/17470210802391599

Minear, M., & Park, D. C. (2004). A lifespan database of adult facial stimuli. *Behavior Research Methods, Instruments, & Computers 2004 36:4*, *36*(4), 630–633. https://doi.org/10.3758/BF03206543

Naveh-Benjamin, M., & Craik, F. I. M. (1995). Memory for context and its use in item memory: Comparisons of younger and older persons. *Psychology and Aging*, *10*(2), 284–293. https://doi.org/10.1037/0882-7974.10.2.284

Naveh-Benjamin, M., Hussain, Z., Guez, J., & Bar-On, M. (2003). Adult Age Differences in Episodic Memory: Further Support for an Associative-Deficit Hypothesis. *Journal of Experimental Psychology: Learning Memory and Cognition*, *29*(5), 826–837. https://doi.org/10.1037/0278-7393.29.5.826

Naveh-Benjamin, M., & Mayr, U. (2018). Age-Related Differences in Associative Memory: Empirical Evidence and Theoretical Perspectives. *Psychology and Aging*, *33*(1), 1–6.

Old, S. R., & Naveh-Benjamin, M. (2008). Differential Effects of Age on Item and Associative Measures of Memory: A Meta-Analysis. *Psychology and Aging*, *23*(1), 104–118. https://doi.org/10.1037/0882-7974.23.1.104

Overman, A. A., & Becker, J. T. (2009). The Associative Deficit in Older Adult Memory: Recognition of Pairs Is Not Improved by Repetition. *Psychology and Aging*, *24*(2), 501–506. https://doi.org/10.1037/A0015086

Overman, A. A., McCormick-Huhn, J. M., Dennis, N. A., Salerno, J. M., & Giglio, A. P. (2018). Older adults’ associative memory is modified by manner of presentation at encoding and retrieval. *Psychology and Aging*, *33*(1), 82–92. https://doi.org/10.1037/PAG0000215

Overman, A. A., & Stephens, J. D. (2013). Synergistic effects of encoding strategy and context salience on associative memory in older adults. *Psychology and Aging*, *28*(3), 654.

Phillips, P. J., Wechsler, H., Huang, J., & Rauss, P. J. (1998). The FERET database and evaluation procedure for face-recognition algorithms. *Image and Vision Computing*, *16*(5), 295–306. https://doi.org/10.1016/S0262-8856(97)00070-X

Radvansky, G. (1999). The fan effect: A tale of two theories. *Journal of Experimental Psychology. General*, *128*, 198–206. https://doi.org/10.1037//0096-3445.128.2.198

Rahhal, T. A., May, C. P., & Hasher, L. (2016). Truth and Character: Sources That Older Adults Can Remember: *Https://Doi.Org/10.1111/1467-9280.00419*, *13*(2), 101–105. https://doi.org/10.1111/1467-9280.00419

Reyna, V. F., & Brainerd, C. J. (1995). Fuzzy-trace theory: An interim synthesis. *Learning and Individual Differences*, *7*(1), 1–75. https://doi.org/10.1016/1041-6080(95)90031-4

Rotello, C. M., & Heit, E. (2000). Associative recognition: A case of recall-to-reject processing. *Memory & Cognition 2000 28:6*, *28*(6), 907–922. https://doi.org/10.3758/BF03209339

Schacter, D. L., Israel, L., & Racine, C. (1999). Suppressing False Recognition in Younger and Older Adults: The Distinctiveness Heuristic. *Journal of Memory and Language*, *40*(1), 1–24. https://doi.org/10.1006/JMLA.1998.2611

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review 2001 8:2*, *8*(2), 203–220. https://doi.org/10.3758/BF03196157

Solina, F., Peer, P., Batageli, B., Juvan, S., & Kovac, J. (2003). Color-based face detection in the B15 seconds of fame^ art installation. *Paper Presented at the Conference on Computer Vision/Computer Graphics Collaboration for Model-Based Imaging, Rendering, Image Analysis and Graphical Special Effects, INRIA Rocquencourt, France.*

Stark, S. M., & Stark, C. E. L. (2017). Age-related deficits in the mnemonic similarity task for objects and scenes. *Behavioural Brain Research*, *333*, 109–117. https://doi.org/10.1016/J.BBR.2017.06.049

Stark, S. M., Yassa, M. A., Lacy, J. W., & Stark, C. E. L. (2013). A task to assess behavioral pattern separation (BPS) in humans: Data from healthy aging and mild cognitive impairment. *Neuropsychologia*, *51*(12), 2442–2449. https://doi.org/10.1016/j.neuropsychologia.2012.12.014

Tun, P. A., Wingfield, A., Rosen, M. J., & Blanchard, L. (1998). Response latencies for false memories: Gist-based processes in normal aging. *Psychology and Aging*, *13*(2), 230.

Webb, C. E., & Dennis, N. A. (2018). Differentiating True and False Schematic Memories in Older Adults. *The Journals of Gerontology: Series B*. https://doi.org/10.1093/geronb/gby011

Webb, C. E., & Dennis, N. A. (2019). Differentiating True and False Schematic Memories in Older Adults. *The Journals of Gerontology: Series B*, *74*(7), 1111–1120. https://doi.org/10.1093/GERONB/GBY011

Wulff, D. U., De Deyne, S., Aeschbach, S., & Mata, R. (2022). Using Network Science to Understand the Aging Lexicon: Linking Individuals’ Experience, Semantic Networks, and Cognitive Performance. *Topics in Cognitive Science*, *14*(1), 93–110. https://doi.org/10.1111/tops.12586

Yonelinas, A. P. (1997). Recognition memory ROCs for item and associative information: The contribution of recollection and familiarity. *Memory & Cognition 1997 25:6*, *25*(6), 747–763. https://doi.org/10.3758/BF03211318