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Memory for the usual: the influence of schemas on memory for non-schematic information in younger and older adults

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Abstract

Schemas are abstract mental representations that influence perceptual and memory processes. Schemas can aide memory for information that is related or congruent with a given schema (i.e., schematic information), yet it is unclear how schemas affect memory for information that does not directly relate to the schema (i.e., non-schematic information). Using a novel scene paradigm, the current series of studies investigated how schemas affect memory for schematic and non-schematic information, as well as how directed encoding influences remembering of both types of information in younger and older adults. Results showed poorer accurate recognition of non-schematic information relative to schematic information, influenced largely by a bias in identifying non-schematic items as "new". While directed encoding was able to increase remembering of non-schematic information and decrease bias across both age groups, the present set of studies highlights the pervasive influence of a schema on memory for non-schematic information.

Keywords

Memory; schemas; aging; attention; false memory

Introduction

Schemas support memory and perception by providing an organizational framework within which we can encode and store relevant information, and efficiently incorporate new information. The original concept of schemas, introduced to cognitive psychology by Bartlett (1932), defined schemas as general knowledge structures that influence retrieval processes and memory reconstruction. In addition to their influence on retrieval, Anderson (1984) further emphasized the role of schemas in allocating attentional and encoding processes. More recently, Ghosh and Gilboa (2014) elaborated on this definition by specifying that schemas are associative in nature, such that they combine many different elements of an event or experience. They also noted that schemas are adaptable and flexible,

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and it is these features that help schemas shape memory reconstruction. To this end, schemas have been shown to aide accurate encoding, storage, and retrieval of information that is related or congruent with a given schema (i.e., schematic; Alba & Hasher, 1983; Brewer & Treyens, 1981; Castel, 2005; Davenport & Potter, 2004; Mandler, 1984; Miller & Gazzaniga, 1998; Palmer, 1975). While this is the case for information related to the schema, it is still unclear how a schema affects memory for information that is non-schematic, in that it does not directly relate to or support the schema.

Memory for schematic information has often been tested using a scene paradigm, in which a schematic context, centred on a common theme, is presented to participants. Memory is then subsequently tested for information that is either consistent or inconsistent with the schema. For example, in their iconic schema study, Brewer and Treyens (1981) placed participants in a graduate student office containing (1) schematic items that were directly supportive of the "office" schema (e.g., typewriter), (2) salient schema-inconsistent items that contradicted the schema (e.g., wine bottle), and (3) non-schematic items that were neither supportive of, nor contradicted, the schema (e.g., floor rug). A subsequent memory test found a positive correlation between schema expectancy and recognition, such that the schema facilitated recognition of more schematically related information, with poorer memory for less related, non-schematic items. The authors suggested that the schema served as encoding support and provided retrieval cues at test, strengthening memory for schematic items. However, they also demonstrated important effects of saliency on memory, such that more salient, schema-inconsistent items were also better remembered. In a similar vein, it was concluded that schema-inconsistent items generated a "pop-out" effect due to their unexpectedness in the context, thus garnering greater attention and resulting in a memory advantage at retrieval. Several later studies replicated this, showing that when presented in the context of a schematic scene, schema-inconsistent items are attended to earlier and for longer than schematic information, and this is associated with better memory (Friedman, 1979; Lampinen, Copeland, & Neuschatz, 2001; Loftus & Mackworth, 1978).

While much of everyday memory is embedded within schemas (e.g., memory for a birthday party or a trip to the beach), it is not common to encounter highly atypical, schema-inconsistent items in everyday instances. Thus, it is important to know how common, yet non-schematic items are remembered within the context of a schema, absent of salient schema-inconsistent items. This may be particularly important in the context of aging, where older adults exhibit an overreliance on schemas and gist-processing in memory tasks in an attempt to compensate for age-related deficits in episodic memory functioning (Devitt & Schacter, 2016; Hess, 1990; Koutstaal & Schacter, 1997; Schacter, Koutstaal, & Norman, 1997). While relatively little prior work on room schemas have included investigations of age, an age-related overreliance on schemas may lend itself to older adults paying more attention to salient, schematic information at the detriment to ordinary details of a scene, relative to younger adults. Alternatively, scene schemas that are absent of schema-inconsistent items, may exhibit a pervasive influence on memory across age, in which case both younger and older adults would demonstrate equivalent memory for schematic or non-schematic information (Castel, 2005; Hess & Slaughter, 1990).

In light of this, the goal of the present series of studies was to expand the current literature by identifying how a variety of strong schematic contexts at encoding influence memory for both schematic and non-schematic information in the absence of schema-inconsistent information. Both younger and older adults intentionally studied novel, complex scenes (e.g., a bathroom) that included both schematic items that supported the schema (e.g., toilet, bathtub) and non-schematic items that fit naturally in the scene, yet did not directly support the schema (e.g., flower vase, floor rug). At retrieval, participants were presented with schematic and non-schematic targets and lures and were asked to make memory judgments regarding these items. The first study both replicated and extended previous work by examining memory differences between schematic and non-schematic accurate and false memory in younger adults within various dynamic scenes absent of schema-inconsistent information. The second study then examined the effect of both age and encoding cue on memory. Specifically Study 2 tested whether memory for non-schematic items could be enhanced through the use of specific encoding instructions, and also tested for potential benefits of encoding instructions on older adults' memory in light of their propensity to over rely on schematic information in memory tasks.

An examination of memory for both schematic and non-schematic information in this context has important applications to everyday memory, as well as to such domains as eyewitness testimony. In these cases, memory for schema-related details, such as the events of the crime or the type of weapon used is critical; however, a witness is often asked to remember information about ordinary or peripheral details, such as the perpetrator's hair colour, or information regarding the layout of the room in which the crime occurred. In more everyday instances, it is important to remember commonplace information, such as where the light switch is located in rooms across different contexts, or where you placed your shoes in different rooms. Memory for the ordinary details can be as important, if not more so in some instances, than memory for the details related to the general schema of the situation. Therefore, the current set of studies aims to (1) replicate previous research regarding schematic influences on memory, while eliminating the attention-grabbing influence of schema inconsistent information, and (2) expand prior work by investigating the influence of explicit encoding instructions on memory for schematic and non-schematic information in younger and older age using a large number of real-world schemas.

Study 1

The goal of the first experiment was to examine the effects of a highly schematic encoding context on memory for both schematic and non-schematic information. Critically, past studies have failed to examine whether a schema framework can aid in memory for all items within the scene when encoding resources are not captured by salient schema-inconsistent information. We posit that, in the absence of schema-inconsistent items, more encoding resources may be available to process non-schematic items, thereby allowing the schema to act as a retrieval framework for remembering all information contained within the scene. However, in accord with Brewer and Treyens (1981) and other previous studies, schematic targets should still be associated with greater hit rates than non-schematic items as they capture more encoding resources and one can rely on schematic gist as retrieval support (Alba & Hasher, 1983; Davenport & Potter, 2004; DeWitt, Knight, Hicks, & Ball, 2012;

Mandler, 1984). Schematically-related lures should also be associated with greater false alarms, as the schema affects reconstructive retrieval processes (Brainerd & Reyna, 2002; Koutstaal & Schacter, 1997; Reyna & Brainerd, 1995).

Methods

Participants

Thirty participants (mean age = 19.70 years, 21 female) were recruited from The Pennsylvania State University psychology department's subject pool. Three participants were excluded from analyses due to a high no response rate (> 20%), leaving a total of 27 participants included in the sample. All participants provided written informed consent and were given course credit for participating. Experimental procedures were approved by The Pennsylvania State University's Institutional Review Board.

Stimuli

Twenty-four schematic scenes were created using clipart images gathered through Internet searches and edited with Photoshop (see Appendix for list of scenes and items). Clipart images were compiled and organized to create cohesive scenes with realistic layouts (see Figure 1). Critically, each scene contained both schematic and non-schematic items. Schematic items were those that corresponded to the overarching theme of the scene (e.g., Bathroom scene: toilet, bathtub), and non-schematic items were those that were not directly supportive of the theme of the scene and could be found in a variety of scenes (e.g., flower vase, rug). Of these items, one schematic and one non-schematic item were chosen to serve as targets and one schematic and one non-schematic item were chosen as lures at retrieval. Two versions of each scene were created to counterbalance targets/lures, such that each of the schematic and non-schematic items served as both a target (Version A) and a lure (Version B). Due to the nature of the design of the items, it was not possible to counter balance schematic and non-schematic items. For example, it would be difficult to consider a toilet as non-schematic in any other scene and have it not elicit a schema-inconsistent "pop-out" effect. Items at retrieval were equated for size and were presented centrally against a white background on the computer monitor at a resolution of 800 (H) × 600 (V) at 60 Hz using COGENT in MATLAB (MATLAB and Statistics Toolbox, The MathWorks, Inc., Natick, MA, USA).

A multi-step validation of both the scenes and individual schematic and non-schematic items was conducted with an independent group of participants (see Webb, Turney, & Dennis, 2016 for a detailed description). Briefly, participants all verbally identified the scenes in order to ensure that they depicted the intended schema. Individual schematic items were then identified as being related or not related to the schema using a "Yes"/"No" rating procedure, with items that were deemed as not related to the schema (i.e., that did not reach 100% consensus) replaced with appropriate alternatives. To ensure that non-schematic items were indeed not inherently schematic to any scene, we switched to an ordinal rating scale (1-unrelated to 4-related). Non-schematic items were deemed as those that met a relatedness rating of 2.5 or below on the scale across all scenes. Items that failed to meet this criterion were replaced with appropriate alternatives. The mean rating for schematic items was 3.70

(0.41 SD; Mode = 3.90) and the mean rating of non-schematic items was 1.48 (0.32 SD; Mode = 1.14).

Procedure

During encoding, participants viewed 24 schematic scenes, across two blocks, on the computer. Scenes were presented on the screen for 10 s each with a one second fixation between scenes. Participants were instructed to look over each scene and try their best to remember the items presented in the scene, as they would be asked about individual items that were presented in the scenes during the second part of the experiment. No mention was made as to the schematic or non-schematic nature of the items. Retrieval took place immediately following the encoding task and consisted of an “Old”/“New” recognition decision. During retrieval, participants were instructed to indicate an item was “Old” if they remembered seeing the item presented in one of the scenes from encoding, and to indicate an item was “New” if they did not remember seeing the item previously in any of the scenes. Ninety-six items (24 schematic targets, 24 schematic lures, 24 non-schematic targets, 24 non-schematic lures; one per scene) were pseudo-randomly presented across four blocks at retrieval (Figure 1). Each item was presented for 3000 ms each, with a 1000 ms fixation ITI. As noted previously, to control for any item differences, items were counterbalanced such that each schematic and non-schematic target served as a lure and vice versa. All results are presented collapsed across test version.

Results

Statistics were computed using SPSS Version 23 and all tests of significance were performed with an alpha value of .05. Table 1 presents means and standard errors for memory discriminability (d’), criterion (c; Macmillan & Creelman, 2005), and proportion of hits and false alarms for Study 1. Interestingly, results from Study 1 showed no difference in memory discriminability (d’),[1] between schematic and non-schematic items [$t(26) = 0.50$, $p = 0.62$]. Participants, however, did display a significantly larger conservative response bias (c) to say “New” to non-schematic than schematic items [$t(26) = -7.59$, $p < .001$]. Further investigation of the hit and false alarm rates showed that participants made a greater proportion of hits to schematic targets than non-schematic targets [$t(26) = 7.77$, $p < .001$], as well as more false alarms to schematic lures than non-schematic lures [$t(26) = 5.34$, $p < .001$]. It is important to note that while the hit rate for schematic items was significantly above chance ($M = 0.61$, chance = 0.50; $t(26) = 3.73$, $p = 0.001$), the hit rate for non-schematic items fell significantly below chance ($M = 0.38$; $t(26) = 4.87$, $p < .001$). Together, results indicate that despite the overall reduced hit rate for non-schematic compared to schematic items, participants showed equitable memory discriminability for both types of items, yet this was underscored by the large bias to label non-schematic items as “New”.

[1]. Across both studies, when calculating d’ and c, individual hit and false alarm rates of 1 were replaced by (1–1/2N) and rates of 0 were replaced by (1/2N), where N is the number of relevant trials for that stimulus type (Macmillan & Kaplan, 1985).

Discussion

Results from Study 1 showed no differences in overall memory discriminability between schematic and non-schematic stimuli. While this was surprising given previous research suggesting a schematic memory advantage, examination of the hit and false alarm rates revealed higher hit rates associated with accurate retrieval of schematic compared to non-schematic targets, with the hit rate of non-schematic targets occurring significantly below chance. This advantage in accurate recognition for schematic items was countered by the fact that participants committed a greater proportion of false alarms to lures in the schematic compared to non-schematic conditions, thereby resulting in equivalent discrimination rates (d') across both conditions. Critically, memory for non-schematic items was associated with a large conservative response bias that was absent for schematic items, suggesting that people adopt different criteria when making memory decisions based on schema relevance.

Establishing a conservative response criterion indicates a reduced willingness to say that information presented at retrieval was previously seen and represents greater propensity to report more non-schematic information as new, regardless of past history (Macmillan & Creelman, 2005). This greater non-schematic conservative response bias indicates that the strength of memory traces for non-schematic targets was not sufficient to accurately recognize the items above chance level, and suggests that the schema does not effectively serve as retrieval support for ordinary elements of a scene. Moreover, we posit that this heightened bias is also likely a reflection of poorer encoding of non-schematic items within the context of naturally viewing a schematic scene, a process which consequently influences decisions at retrieval. Previous research has shown that the context guides visual search of a scene, and more focus is given to contextually relevant or informative aspects of the scene (Chun & Jiang, 1998; Friedman, 1979; Lampinen et al., 2001; Loftus & Mackworth, 1978). In the absence of schema-inconsistent items, schematic items become the most salient information, defining the identity of the scene and capturing the majority of encoding resources. This contributes to greater accurate recognition of schematic targets, but also results in greater erroneous recognition of schematic lure information, consistent with a Fuzzy Trace Theory of recognition memory (Brainerd & Reyna, 2002; Koutstaal & Schacter, 1997; Reyna & Brainerd, 1995). We also posit that this focus on schemas, in turn, reduces available attentional resources for non-schematic information, affecting the strength of its memory trace.

To this end, our results are generally consistent with that of Brewer and Treyens (1981) who suggested that the schema facilitates recall of schematically relevant information. However, because their analysis was based on a regression in which schema expectancy and saliency predicted memory, Brewer and Treyens (1981) only implied a memory impairment for non-schematic items compared to schematic and schema-inconsistent items. In comparison to this and other previous scene studies (e.g., Lampinen et al., 2001; Loftus & Mackworth, 1978; Miller & Gazzaniga, 1998), our study is unique in that we were able to directly show that, not only was accurate recognition of non-schematic targets significantly below that for schematic items, but that non-schematic targets were not remembered above chance level when encoded within a highly schematic context. This has important implications for everyday memory, as the type of schemas used in the present studies include contexts similar to those experienced in everyday life (e.g., kitchen, bathroom, park). Additionally, our results suggest that examining rates of accurate endorsement, along with false memory rates and bias measures, reveals important insight into the mechanisms behind schema memory more than memory discriminability alone. Because of these hypothesized influences of the schema at the level of encoding, the second study aimed to examine whether memory for non-schematic items could be enhanced and bias could be reduced through the use of specific encoding instructions. Additionally, given older adults' propensity to rely on the gist and/or schema to guide memory processing (Schacter et al., 1997), we aimed to extend this examination of cueing effects on schematic and non-schematic memory processing to aging.

Study 2

Study 2 was designed to identify whether directing of attention, or cueing, of a particular stimulus type (i.e., schematic items, non-schematic items, or all items) prior to encoding would boost later memory for that type of item. In particular, we wanted to test whether the strong influence of the schema on attention and memory (as seen in Study 1) could be overcome by directing encoding resources to other aspects of the scene (i.e., non-schematic information). There is precedent in prior research that the use of explicit experimental support (e.g., through directed instructions or blocked encoding), can encourage strategic processing and enhance recognition of relevant information (Dai, Thomas, & Taylor, 2018; Pezdek & Evans, 1979; Thomas, Bonura, & Taylor, 2012); however there has been little work examining this in the context of object-scene memory. Moreover, given that the tendency to rely on schematic or gist processing in memory tasks increases with age (Devitt & Schacter, 2016; Hess, 1990; Schacter et al., 1997), we also sought to identify whether older adults would show similar benefits from this type of pre-encoding attentional support as younger adults. It is expected that cueing participants to focus on schematic items should replicate the general trends observed in younger adults in Study 1, as participants should naturally direct focus to the more salient, schematically related items. Critically, if, as we suggest above, non-schematic item memory is hindered by a lack of encoding resources allocated to the processing of these items, then we predict that cueing participants to focus on non-schematic items should ameliorate this memory deficit. Specifically, enhanced attention to non-schematic items as a result of the encoding cue should result in increased non-schematic target recognition and should reduce the influence of bias on memory responding. This may be especially beneficial for older adults who likely experience difficulty disengaging from the schematic properties of a scene to focus encoding resources on non-schematic information. While older adults do not tend to self-initiate encoding strategies, research also shows that older adults display benefits from strategy utilization when one is provided, resulting in both improvements in memory relative to no strategy and elimination of age differences in memory (Castel, McGillivray, & Worden, 2013; Kirchhoff, Anderson, Barch, & Jacoby, 2012; Naveh-Benjamin, Brav, & Levy, 2007; Paxton, Barch, Storandt, & Braver, 2006). To this end, we posit that both younger and older adults should benefit from directed encoding instructions to attend to non-schematic items in order to overcome negative influences of the schema on memory for less relevant, non-schematic information. Additionally, cueing participants to focus on all items in the scene may also serve to reduce the influence of the strong schema on memory, allowing attentional resources to be devoted to encoding of each individual item, schematic and non-schematic alike. While we expect the influence of the instruction to focus on all items to increase non-schematic recognition above what was found in younger adults in Study 1, we do not expect it to be as effective as the cue to focus on non-schematic items alone.

It is not clear, however, the effect that cueing will have on memory for schematic items. It is possible that due to the strong gist associated with schematic items, cueing participants to attend to non-schematic items may not affect memory for schematic items; however if attention is truly shifted to non-schematic items, as has been the case in previous studies with schema-inconsistent items (e.g., Loftus & Mackworth, 1978), we should observe a reduction in memory for schematic items when participants are instructed to focus on non-schematic items. Furthermore, if schematic false recognition is based on gist retrieval, cueing participants to focus solely on the schematic items may serve to increase the occurrence of gist-based false recognition (Koutstaal, Schacter, Galluccio, & Stofer, 1999). Overreliance on the gist of information is often adaptive for older adults in that it helps compensate for age-related episodic memory decline; however, it also contributes to age-related increases in gist-based false recognition (Koutstaal & Schacter, 1997; Lampinen, Neuschatz, & Payne, 1997; Schacter et al., 1997). Identifying effects of directed encoding on both younger and older adults will provide a critical extension of previous work and will indicate potential ways to improve memory for everyday information that is experienced within a schematic setting.

Methods

Participants

Study 2 included a group of both younger and older adults. Thirty-five younger adult participants (mean age = 19.09 years, 33 female) were recruited from The Pennsylvania State University psychology department's undergraduate subject pool. Four participants were excluded from analyses due to a high no response rate (> 20%), leaving a total of 31 participants included in the sample. Forty-one healthy older adult participants (mean age = 69.50 (± 6.93) years, 32 female) were recruited from State College, PA and surrounding communities. Two participants were excluded from analyses due to a high no response rate (>20%), leaving a total of 39 participants included in the sample. Participants were screened using the MMSE (Folstein, Folstein, & McHugh, 1975) and were free of major cognitive impairments or signs of dementia (mean MMSE = 29.9; range 29–30). All participants provided written informed consent and were given course credit for participating. The Pennsylvania State University Institutional Review Board approved all experimental procedures.

Stimuli

To examine whether older adults perceive item-schema associations differently than younger adults, an identical rating procedure to that in younger adults was conducted in a group of older adults ($N = 8$), using a four-point response scale (1-unrelated to 4-related). The mean rating for schematic items was 3.79 (0.32 SD; Mode = 4) and the mean rating of non-schematic items was 1.48 (0.35 SD; Mode = 1). While there was a small difference in the ratings of schematic items between age group, with older adults on average reporting higher item-schema relatedness for schematic items [$M_{YOUNGER} = 3.70$, $M_{OLDER} = 3.79$; $t(418) = 2.56$, $p < .05$], there was no difference between younger and older adults' ratings of non-schematic item-schema relatedness [$t(120) = -0.01$, $p = 0.99$].

Procedure

The key manipulation in Study 2 included cueing participants at encoding to focus on certain categories of items in the scene for a later memory test. Specifically, the encoding setup from the previous study was divided into three blocks of 8 scenes each. Each block was preceded by a cue, presented centrally on the screen, directing participants to focus on studying the schematic items ("Schematic Cue"), on studying the non-schematic items ("Non-schematic Cue"), or on studying all of the items ("All Cue"). Participants were told to study each scene for 10 s and try their best to remember the items they were instructed to focus on. The order of the cues was counterbalanced across participants to account for potential order effects. Retrieval was identical to that of Study 1. Because no overall differences were found based on the order of encoding cues across blocks in either age group, the data was collapsed across these versions of the study.

Results

Table 2 present means and standard error for d', c, hit rates, and false alarm rates by cue type for both younger and older adults. We first aimed to determine whether the "Schematic Cue" condition served to replicate results from Study 1 in the younger adults. To test this we conducted separate ANOVAs on d',c, hit, and FA values with schema type (schematic, non-schematic) as a within-subject factor and study as a between-subjects factor. These analyses revealed no significant effects of study on any measure (all *F*s< 1.25, all *p*s > 0.27). Thus this condition was successful in replicating the results of Study 1.

To test for differential effects of encoding cue or schema type across age, we conducted separate 2 (schema type: schematic, non-schematic) × 3 (encoding cue type: all items, schematic items, non schematic items) × 2 (age group: younger adults, older adults) ANOVAs on all memory metrics (d', c, hit and false alarm rate) with schema type and encoding cue as within subject factors and age group as a between-subjects factor. The ANOVA on memory sensitivity (d') revealed a main effect of cue [$F(2,136) = 5.88$, $p < 0.005$, $\eta_p^2 = 0.08$], but no main effects of schema [$F(1,68) = 0.04$, $p = 0.85$, $\eta_p^2 = 0.001$] or age [$F(1,68) = 1.56$, $p = 0.22$, $\eta_p^2 = 0.02$]. There was also a significant cue by schema interaction [$F(2,136) = 6.36$, $p < 0.005$, $\eta_p^2 = 0.09$]. This interaction was driven by differences in target-lure discriminability for non-schematic items across the three cue conditions. As predicted, non-schematic d' was greater in the "Non-schematic Cue" condition compared to both the "Schematic Cue" condition [$t(69) = 4.71$, $p < .001$] and the "All Cue" condition [$t(69) = 2.93$, $p < .005$], as well as in the "All Cue" compared to the "Schematic Cue" condition [$t(69) = 2.36$, $p < .05$] regardless of age. This indicates that the "Non-schematic Cue" was effective in increasing overall memory performance. No differences were observed for schematic items across the cue conditions (all *t*s < 1.13, all *p*s > 0.26). Additionally, memory discriminability for non-schematic items was greater than that for schematic items only under the “Non-schematic Cue” [$t(69) = 3.03$, $p < .005$]. No other interaction on memory discriminability reached significance (all Fs < 0.79, all ps > 0.46).

When examining response criterion (c), a significant main effect of schema type [$F(1,68) = 130.97$, $p < .001$, $\eta_p^2 = 0.66$] was observed, such that across cue type, non-schematic items were associated with greater bias to say “New” than were schematic items. There were no main effects of cue type [$F(2,136) = 1.54$, $p = 0.22$, $\eta_p^2 = 0.02$] or age [$F(1,68) = 49.47$, $p = 0.47$, $\eta_p^2 = 0.01$]. Moreover, a significant schema by cue type interaction was observed [$F(2,136) = 8.52$, $p < .001$, $\eta_p^2 = 0.11$]. Follow up planned comparisons showed that a conservative bias to respond “New” to non-schematic items was reduced under the “Non-schematic Cue” compared to the “Schematic Cue” [$t(69) = -3.71$, $p < .001$] and the “All Cue” conditions [$t(69) = -2.71$, $p < .01$], suggesting that the “Non-schematic Cue” was successful in decreasing the conservative bias on memory responses to non-schematic information across age groups. Additionally, response criterion was greater for schematic items under the “Non-schematic Cue” compared to the “Schematic Cue” [$t(69) = 2.10$, $p < .05$], indicating that the “Non-schematic Cue” had a negative influence on bias in schematic memory responses. No other comparisons revealed significant effects of cue type on criterion measures, and no other interactions on criterion measures reached significance (all Fs < 0.93, all ps> 0.40).

We next examined cueing effects on hit and false alarm rates using the same 2 (schema type) × 3 (encoding cue type) × 2 (age group) ANOVA. Significant main effects of schema type [$F(1,68) = 108.52$, $p < .001$, $\eta_p^2 = 0.62$] and cue type [$F(2,136) = 3.96$, $p < .05$, $\eta_p^2 = 0.06$] were observed on hit rates across age groups. There was no main effect of age group [$F(1,68) = 1.67$, $p = 0.20$, $\eta_p^2 = 0.01$]. Furthermore, a significant schema by cue type interaction was observed [$F(2,136) = 12.95$, $p < .001$, $\eta_p^2 = 0.16$]. Follow up comp parisons showed that hit rates for schematic targets were significantly greater than hit rates for non-schematic targets in the “All Cue” [$t(69) = 6.81$, $p < .001$] and “Schematic Cue” conditions [$t(69) = 9.17$, $p < .001$]. Critically, no significant difference in hit rate was observed between schematic and non-schematic targets when participants were cued to focus encoding on non-schematic items [$t(69) = 1.90$, $p = 0.06$]. This finding was driven by the fact that non-schematic hit rate was significantly increased under the “Non-schematic Cue” condition compared to the “All Cue” condition [$t(69) = 3.84$, $p < .001$] and the “Schematic Cue” condition [$t(69) = 5.36$, $p < .001$]. This further highlights the significance of directed encoding on accurate recognition of typical, non-schematic information presented within a schematic scene across age. Taken together with the increase in memory discriminability and reduced bias, this suggests that both younger adults and older adults’ non-schematic memory was particularly benefitted by explicitly cueing attention to these items during encoding.

Finally, an ANOVA investigating false alarm rates revealed a significant main effect of schema type [$F(1,68) = 89.60$, $p < .001$, $\eta_p^2 = 0.57$], with greater false alarms for schematic compared to non-schematic items across all cue conditions. There was also a significant main effect of cue type [$F(2,136) = 3.13$, $p < .05$, $\eta_p^2 = 0.04$], with greater false alarms under the "Schematic Cue" compared to the "All Cue" [$t(139) = 2.35$, $p < .05$], and marginally compared to the "Non-schematic Cue" [$t(139) = 1.69$, $p = 0.09$], regardless of schema type, indicating some potential negative influence of the "Schematic Cue" on accurate memory for all information contained in a schematic scene. Future studies are needed to fully elucidate the influences of encoding cues on false memory for schematic information across age. Overall, these results suggest that effects of cue on all memory metrics for both schematic and non-schematic information are age-invariant.

Discussion

Results from Study 2's "Schematic Cue" condition in both ages groups served to replicate that from younger adults in Study 1, such that schematic targets were associated with greater hit and false alarm rates, and non-schematic memory responses were accompanied by greater bias than responses to schematic items. In line with Study 1, Study 2 showed that, across both age groups, non-schematic information was poorly remembered when naturally encoded within the context of a highly schematic scene (i.e., under the "Schematic Cue"), highlighting the pervasive influence of a schema on memory encoding and retrieval processes. Critically, Study 2 also demonstrated that both younger and older adults were able to successfully benefit from focused encoding instructions to enhance memory for non-schematic information within the context of a strong schema.

Specifically, the influence of a conservative response bias on non-schematic memory was significantly reduced when participants were cued to focus on non-schematic items in the scene compared to when participants were cued to focus on either all items or only schematic items, suggesting that the focused encoding supported greater familiarity for non-schematic targets and encouraged less of a tendency to say that items were new under conditions of uncertainty. Moreover, overall memory discriminability for non-schematic items was significantly better when younger and older adults were instructed to focus attention on non-schematic items in the scene, compared to the other cue conditions. This was driven by increases in accurate recognition of non-schematic targets across age groups, highlighting advantageous effects of the "Non-schematic Cue" on the successful shifting of attention to non-schematic information. Critical to our manipulation, when participants were cued to focus on non-schematic items, the difference in hit rate between schematic and non-schematic items was eliminated. Specifically, across age groups, the "Non-schematic Cue" resulted in a rise in non-schematic target memory to the level of that for schematic targets.

While a cue to attend to non-schematic information improved non-schematic memory, a cue to attend to schematic items at encoding did not affect the hit rate for schematic items. In fact, there was no difference in schematic hit rate across any cue condition. This highlights the ubiquitous role of schematic gist in supporting accurate memory for items that are directly related to the schema across age (Alba & Hasher, 1983; Brewer & Treyens, 1981; Lampinen et al., 2001; Miller & Gazzaniga, 1998). This also provides support for the notion that schematically-related information is automatically attended to and processed during search of a scene (Oliva & Torralba, 2006; Potter, 1976; Potter, Staub, O'Connor, & Potter, 2004; Tatler, Gilchrist, & Rusted, 2003), even when the attentional goal is directed elsewhere. Consistent with a Fuzzy Trace Theory of memory, schematic lures were associated with greater false alarms than non-schematic lures, highlighting the contribution of the schema to erroneous recognition across age. Interestingly, false alarms to lure items, regardless of schema-relatedness were greater under the "Schematic Cue" relative to the other cues. This suggests that despite the lack of differences in schematic hit rates across cues, explicitly focusing attention on the schema has the potential to increase erroneous memory for unpresented schematic and non-schematic information.

Together, results from Study 2 indicate that when experienced in a schematic scene, secondary items that are not directly related to the schema are difficult to remember *unless* encoding is directly focused on these items. At the same time, schematic items appear to have a pervasive advantage in recognition memory, regardless of the focus of encoding, as our manipulation was still only able to bring non-schematic hit rate to the level of chance. Finally, the lack of age differences suggest that, in the context of schematic scene encoding, both older and younger adults can take advantage of strategic encoding instructions to ameliorate differences in recognition across items based on their schema relevance. This has important implications for understanding one's ability to direct attention and encoding resources across the lifespan.

General discussion

Study 1 extended previous research, showing that even in the absence of schema-inconsistent items that have been shown to capture encoding resources, schematic items were associated with both higher hit rates and higher false alarm rates than non-schematic items, which were not remembered above chance level. This was accompanied by a sizeable conservative response bias in memory for non-schematic information. Together, this suggests that non-schematic information was not attended to during encoding to the extent necessary to build a strong episodic trace for their later retrieval. This further highlights shifts in memory response decisions based on information's schema-relatedness. Study 2 replicated this finding and further showed that an instructional cue focusing encoding resources towards non-schematic information within the schema facilitated memory for non-schematic targets across both younger and older age groups. Specifically, the cue served to equate hit rates for non-schematic and schematic items, increase non-schematic memory discriminability, and reduce response bias. This suggests an increase in familiarity for non-schematic items when the focus of attention was directed toward this information. Taken together, the foregoing studies shed light on memory processing when a strong schema is experienced, and also highlight the malleability of memory across age when resources can be directed to specific content within a schematic scene.

Schemas represent conceptual knowledge structures that shape attention and memory processes, as well as aid accurate encoding, consolidation, and recognition of information that is congruent with a given schema (i.e., schematic; Alba & Hasher, 1983; Brewer & Treyens, 1981; Castel, 2005; Davenport & Potter, 2004; Mandler, 1984; Miller & Gazzaniga, 1998; Palmer, 1975). Studies presenting information in a schematic scene framework show high rates of accurate retrieval of both schematic and schema-inconsistent information (e.g., Brewer & Treyens, 1981; Loftus & Mackworth, 1978). It is posited that memory encoding and subsequent recognition of schematic information is facilitated through integration into organized schematic frameworks (Alba & Hasher, 1983). At the same time, schema-inconsistent items, or items that are not characteristic of that schema (i.e., an octopus on a farm; Loftus & Mackworth, 1978), also gain an encoding advantage as a result of their salient, attention-grabbing nature. Critically, such memory advantages come at the cost of memory for non-schematic information in the same scene, which does not appear to naturally capture attention and encoding resources, and therefore is not as readily incorporated into the schematic framework or retained in memory (Alba & Hasher, 1983; DeWitt et al., 2012).

In regard to this, the current set of findings exemplifies how difficult it is to encode and remember non-schematic items in the presence of a schema, even when salient schema-inconsistent items are absent. Specifically, results across both studies suggest that it is not solely the presence of schema inconsistent items drawing on attention and pulling encoding resources away from non-schematic items, but the schema itself that captures encoding resources and prevents non-schematic items from being encoded to the degree necessary to create strong memory traces. Supporting this, schematic hit rates were consistently higher than non-schematic hit rates across both studies and age groups, emphasizing the prioritization of encoding resources towards processing of schematic information (Alba & Hasher, 1983; Brewer & Treyens, 1981; Castel, 2005; Davenport & Potter, 2004; DeWitt et al., 2012; Mandler, 1984; Miller & Gazzaniga, 1998; Palmer, 1975). This prioritizing of schematic information was only reduced when the focus of encoding was overtly directed toward non-schematic items in Study 2. Thus, our results importantly suggest that this bias can be reduced and is not a fixed aspect of schematic processing.

The observed schematic memory advantage in hit rate, however, was accompanied by a high false alarm rate to schematic lures presented at retrieval across both studies and age groups. As such, our findings are also consistent with conclusions from previous research and with theories of schema memory suggesting that relying on schematic gist to guide encoding and retrieval leads to a bias in memory for gist-related information, irrespective of the veracity of the information (e.g., Brainerd & Reyna, 2002; Gallo, Roediger, & McDermott, 2001; Lampinen et al., 1997; Miller & Gazzaniga, 1998; Webb et al., 2016; Webb & Dennis, 2018). Interestingly, despite older adults' tendency to over rely on schematic gist to guide memory processes (Devitt & Schacter, 2016; Koutstaal & Schacter, 1997; Schacter et al., 1997), older adults in our study did not show elevated false recognition of related information compared to younger adults. Rather, in the current study it appeared to be difficult for any individual, regardless of age, to inhibit the schematic gist and avoid erroneously endorsing a related lure during retrieval. This is not altogether surprising as previous research has demonstrated that age differences are minimized when new information is schematically, or conceptually, related to studied information (see Hess, 1990; Umanath & Marsh, 2014, for review). Additionally, a previous study from our lab using the same scenes as in the current study also found little differences in hit or false alarm rates for schematic and non-schematic information across age (Webb & Dennis, 2018). Therefore, our results suggest that despite elevated false alarm rates often found in the aging literature, a strong schematic context can have an equally detrimental effect on both true and false memory across the lifespan (Brainerd & Reyna, 2002; Koutstaal & Schacter, 1997; Reyna & Brainerd, 1995).

In contrast to schematic memory, our results suggest that non-schematic items, or those that were not directly related to the encoding schema, could not readily be incorporated into the schematic framework, resulting in weakened encoding into long-term memory. Consequently, these items exhibited a reduced probability of accurate recognition, as retrieval was driven by the schema (Alba & Hasher, 1983). This finding was consistent across both younger and older adults who displayed significantly poorer recognition of non-schematic compared to schematic targets, with non-schematic hit rates in Study 1 and in the "Schematic Cue" condition of Study 2 occurring below chance. This preference for schema-related memories is supported by neuroimaging studies which show that enhanced neural activity in the medial prefrontal cortex (mPFC) preferentially supports encoding of schematic versus non-schematic memory, whereby mPFC is theorized to facilitate integration of such information with pre-existing schema representations in cortical regions (van Kesteren et al., 2013; van Kesteren, Rijpkema, Ruiter, & Fernandez, 2010). Information that is less schematically related does not benefit from this enhanced processing, but rather relies on more bottom up encoding supported by the medial temporal lobes (MTL; van Kesteren et al., 2013; van Kesteren, Fernandez, Norris, & Hermans, 2010). Additionally, research has shown that schematic compared to non-schematic memory is supported by greater activation in the hippocampus, visual cortices, and mPFC, regions that are often associated with successful retrieval and reactivation of details from encoding, whereas non-schematic information shows reduced engagement of this successful memory network, especially in older adults (Webb et al., 2016; Webb & Dennis, 2018). Together, both behavioural and neuroimaging evidence support the notion that schematically-related information is more readily incorporated into existing schematic frameworks at encoding and this facilitates greater memory accuracy of schematic compared to non-schematic information.

In line with our predictions, it was not until encoding instructions explicitly directed participants to focus resources on non-schematic items that successful memory for these items rose to the level of schematic memory. This increase in non-schematic hit rate was not accompanied by an increase in false recognition for non-schematic items, suggesting that this effect of encoding instructions was beneficial to overall memory discriminability. The analysis on d' supported this notion, with overall memory discriminability higher when encoding was directed toward non-schematic items, compared to the other two cues. Thus the "Non-schematic Cue" was effective in increasing overall memory performance for non-schematic items. Critically, this benefit was observed in both age groups, suggesting that memory discriminability for non-schematic items can be improved by instructions that direct attention to focus on these items, compared to natural encoding conditions. Moreover, this benefit importantly occurs regardless of age.

Supporting this idea is research showing that individuals can prioritize processing of particular aspects of a scene through top-down, goal-directed mechanisms, which serve to direct what information is encoded and retained in memory (e.g., Intraub, 1984; Potter & Levy, 1969; Schmidt, Vogel, Woodman, & Luck, 2002; Thomas et al., 2012). In line with this, older adults show recognition benefits when they are encouraged to use specific strategic processes, such as allocating additional study time to relevant or high-value information (Castel, Murayama, Friedman, McGillivray, & Link, 2013), or engaging associative or semantic encoding strategies (Kirchhoff et al., 2012; Naveh-Benjamin et al., 2007). Research has also found that older adults exhibit comparable benefits to younger adults when an organizational framework can support memory for information, compared to when information is unstructured (Arbuckle, Cooney, Milne, & Melchior, 1994; Castel, 2005; Hess & Slaughter, 1990; Prull, 2015; Waddell & Rogoff, 1981). Moreover, evidence from neuroimaging studies indicate important interactions between brain networks supporting attention and memory processes (Chun & Turk-Browne, 2007), and more specifically research shows that directed attention influences hippocampal encoding responses and reduces engagement of post-retrieval monitoring processes across age (e.g., Aly & Turk-Browne, 2016; Dulas & Duarte, 2014). Similar mechanisms likely underlie the cue advantage evidenced in the current study, with potentially greater hippocampal-based encoding resources directed toward processing and integration of non-schematic information into memory under the relevant cue condition. Taken together with this past work, our results add to the aging and memory literature by showing that older adults can utilize directed encoding instructions to counter their propensity to over-rely on schematic information and promote greater non-schematic item memory.

A conservative response bias accompanied the reduced non-schematic hit rate and poorer memory discriminability observed under natural encoding conditions (“Schematic” or “All” Cue). This bias indicates an increased tendency to identify non-schematic items as new during retrieval under these conditions. Conservatively biased memory responses occur as a result of uncertainty at retrieval (Macmillan & Creelman, 2005) and, in the current studies, indicate a lack of familiarity with information that is not directly inherent to the schema. We posit that this lack of familiarity implies that these items were indeed poorly encoded by both younger and older adults under natural encoding conditions. Thus, even in the absence of schema-inconsistent items capturing attentional focus, non-schematic target memory remains inferior to memory for schematic items and is associated with a large retrieval bias. These results further highlight the negative influence of the schema on memory for everyday information across age. Together with observed false alarm differences across schema type, differences in response bias suggest that distinct memory mechanisms may contribute to schematic and non-schematic encoding and retrieval processes.

The fact that focusing encoding toward non-schematic items significantly reduced conservative memory responses to these items again highlights the benefit of encoding cues to non-schematic memory. Specifically, a reduction in response bias as a result of directed encoding indicates a decrease in the level of uncertainty at the time of response, an effect seen across both age groups. Combined with the increase in overall memory discriminability, this suggests that the “Non-schematic Cue” led to a strengthened memory trace and increase in familiarity for non-schematic information. Interestingly, the benefit of the encoding cue was unique to non-schematic memory, as the cue to focus encoding on schematic items did not improve either schematic hit rate or d’ relative to the other cues, nor did it affect the measure of response criterion. The fact that both younger and older adults could utilize the encoding cue instructions to increase non-schematic hit rate and memory discriminability, and reduce bias, suggests that the focus of encoding was indeed shifted towards non-schematic items and was not as impeded by the strong influence of the schema.

Similar findings to those presented here have been shown in the emotion memory literature, where, when both emotional and neutral stimuli are present in a scenario, neutral information is more poorly remembered, or even forgotten completely, compared to emotional information (Levine & Edelstein, 2009; Reisberg & Heuer, 2004). This “memory narrowing” is thought to occur because the emotional content captures the focus of encoding and creates a stronger memory trace that can be capitalized on at retrieval. In a similar vein, we posit that schemas captures encoding resources, leading to stronger memory traces and better memory for schematic than non-schematic items. Our results add to this previous work by showing that even when information is completely neutral, as is the case with typical contexts (e.g., a vase in a bathroom scene or rug in a kitchen scene), memory for non-salient information suffers, as this information cannot as successfully capitalize on encoding resources captured by the strong schematic or emotional context. Results from both domains of memory research underscore the influence that the encoding context has on guiding encoding resources. This contributes to memory advantages when information is highly related to the context, but also can have detrimental effects on memory for information that is not directly supportive of the context. It should be noted that while the cue manipulation succeeded in shifting attention to non-schematic information, research has also shown that focusing of spatial processing does not mean that attention is fully disengaged from surrounding information (Olson, Moore, & Drowos, 2008), which may explain why schematic memory remained largely unchanged across all three memory instructions. In a similar vein, the fact that non-schematic hit rate and overall discriminability improved under the non-schematic cue compared to the other conditions could indicate a carry-over effect from an increased focus on specific details of the scene, whether they be schematic or non-schematic in nature. Despite this, the effect on non-schematic memory was still strongest when encoding resources were specifically focused toward non-schematic aspects of the scene. Taken together, these results highlight the critical role of top-down processes in successfully supporting memory for non-schematic information that cannot effectively rely on the schema as retrieval support.

Limitations and future directions

Several limitations of the foregoing studies should be acknowledged. As these studies did not track eye movements, they cannot speak to quantitative aspects of attention allocation. However, the reductions in conservatively biased responding, and increases in non-schematic memory discriminability with the instructional cue manipulation, provide strong support for the success of focused cueing on influencing attentional processes at encoding. In particular, a lack of focus on non-schematic items under typical encoding instructions would corroborate our observed behavioural data showing poorer memory for these items compared to schematic items. Future research should aim to identify whether location or duration of fixation on schematic versus non-schematic information in a scene correlates with memory for that information, particularly in contexts where schema-inconsistent information is not present. Including investigations of age in eye tracking studies would also shed light onto potential similarities or differences in the way younger and older adults process and retain information of differing schematic relevance.

While the current research advances our understanding of schematic memory processes as they relate to memory for aspects of a scene, future research should continue to investigate the influence of schemas. Specifically, while the current study, along with much of the previous research, utilized already established schemas (albeit the scenes were novel to the participants), several studies have begun to identify the effects of experimentally created schemas on memory and their neural correlates across age (Tse et al., 2007;van Buuren et al., 2014; van Kesteren, Rijpkema, et al., 2010). The advantage of this research is the ability to identify whether newly learned schemas act in the same way as already well-established schemas. By using newly learned schemas in conjunction with the foregoing design, one could examine how the strength of a created schema moderates memory performance, and potentially differentially across age. Moreover, neuroimaging research could lend insight into specifically how directed encoding cues facilitate non-schematic memory and dissociate the role of these cues at the level of both encoding and retrieval. This could additionally lend insight into whether younger and older adults differentially utilize these encoding cues to support equivalent memory.

Conclusion

The current studies extend previous research in identifying how both schematic and non-schematic information is remembered when experienced within a variety of schematic contexts similar to those encountered in everyday life. Results also highlight the pervasive nature of schematic contexts on memory across age. Specifically, the schema was shown to support accurate memory for schematic information, yet this benefit was countered by an increase in false memories for schematic lures in both younger and older adults. Comparatively, both age groups exhibited poor recognition of non-schematic information unless encoding resources were specifically directed toward processing of non-schematic information. These results have important implications for both everyday memory, including scenarios where schematic memory has critical consequences such as eyewitness testimony. While details about information related to the schema of an event are remembered well regardless of encoding focus, less relevant details of the context require greater attention in order to be remembered. Together, these studies shed light on schematic memory processing, and also highlight the malleability of memory across age when resources can be directed to non-schematic content within a schematic scene.

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Appendix

List of scenes and corresponding schematic and non-schematic items

Scene	Schematic items	Non-schematic items
Airport		
	Luggage cart	End table
	Traveler	TV
Bathroom		
	Plunger	Flower vase
	Toilet paper	Mirror
Beach		
	Sand Castle	Camera
	Shovel and pail	Music player
Birthday Party		
	Birthday cake	Picture frame
	Presents	Rug
Christmas		
	Nutcracker	Cat
	Santa sleigh	Pillow
Church		
	Bible	Flower arrangement
	Crucifix	Wall lamp
Circus		
	Ringmaster	Light
	Tightrope walker	Bowling pins
Classroom		
	Backpack	Recycling bin
	Pencil sharpener	Speaker
Disney's Cinderella		
	The Grand Duke	Barrel
	Godmother	Potted tree
Doctor's Office		
	Doctor tools	Calendar
	Doctor bag	Magazine
Farm		
	Hay bale	Dog
	Pig	Terracotta pots
Football Game		
	Cheerleaders	Banana peel
	Goalpost	Canteen
Fourth of July		
	Grill	Bike
	Uncle Sam hat	Burger
Golf		

Scene	Schematic items	Non-schematic items
	Golf cart	Bunny rabbit
	Golf clubs	Hot air balloon
Gym		
	Punching bag	Coat rack
	Hand weights	Paper towel holder
Halloween		
	Black cat	Candle
	Jack-O-Lantern	Moon
Kitchen		
	Oven mitt	Book
	Teapot	Trashcan
Nursery		
	Playpen	Smoke detector
	Rattle	Laundry
Park		
	Riding toy spring horse	Bird
	Slide	Butterfly
Pool		
	Pool noodle	Keys
	Inner tube	Water bottle
African Safari		
	Giraffe	Rock
	Lion	Water well
Ski Slope		
	Snowmobile	Beaver
	Ski sign	Shovel
Thanksgiving		
	Native American man	Leaves
	Pilgrim	Stool
Underwater		
	Blowfish	Glass bottle
	Seahorse	Tire

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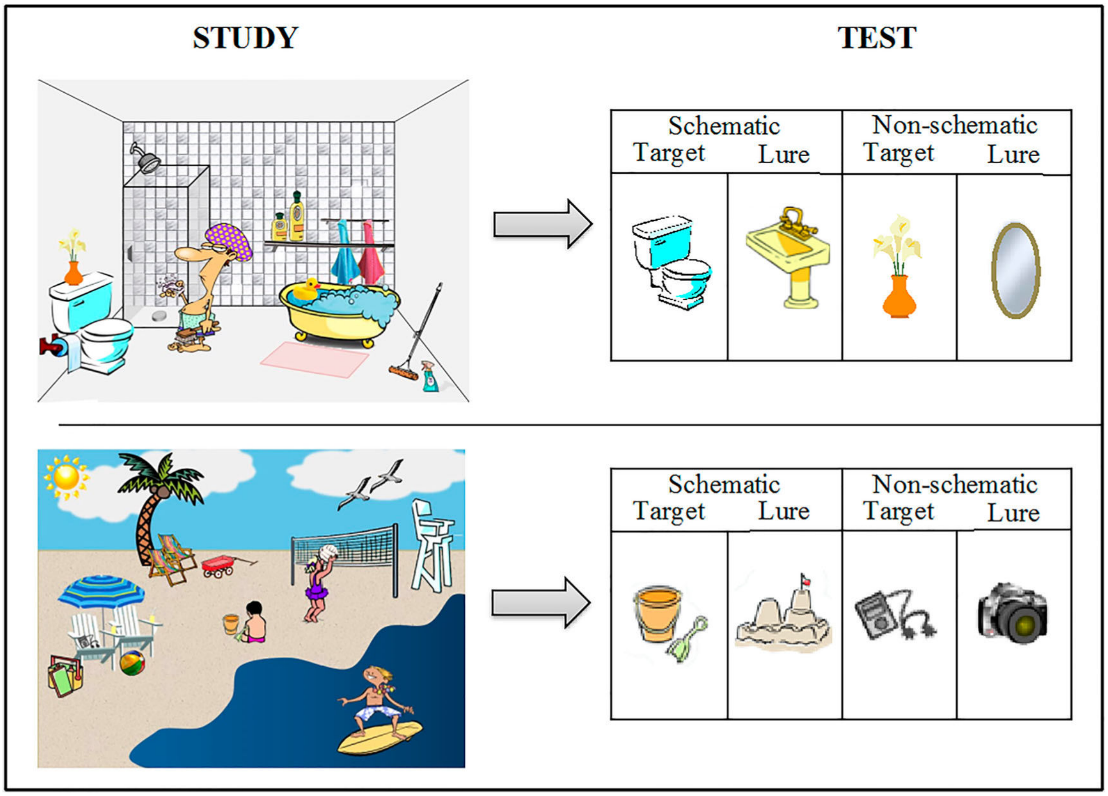

Figure 1. Experimental paradigm.

At encoding, participants were presented with schematic scenes (e.g., bathroom, beach) containing both schematic and non-schematic targets. At retrieval, participants were individually shown schematic and non-schematic targets and lures (see Appendix). Note: Targets and lures were counterbalanced across two versions; for simplicity this figure depicts only one version.

Table 1.

Memory and response metrics from Study 1.

	Schematic	Non-schematic
d′	0.61 (0.11)	0.55 (0.11)
c	−0.003 (0.08)	0.62 (0.06)
Hit	0.61 (0.03)	0.38 (0.03)
FA	0.40 (0.03)	0.21 0(.02)

Note: Means and standard errors of memory discriminability (d′), response bias (c), hits, and false alarms (FA) in Study 1.

Table 2.

Memory and response metrics from Study 2.

	All cue		Schematic cue		Non-schematic cue	
	Schematic	**Non-schematic**	**Schematic**	**Non-schematic**	**Schematic**	**Non-schematic**
Younger adults						
d′	0.70 (0.16)	0.55 (0.15)	0.52 (0.12)	0.37 (0.12)	0.66 (0.13)	0.85 (0.14)
c	0.17 (0.09)	0.58 (0.08)	−0.03 (0.09)	0.65 (0.10)	0.10 (0.08)	0.45 (0.09)
Hit	0.56 (0.04)	0.39 (0.04)	0.61 (0.03)	0.35 (0.04)	0.58 (0.04)	0.50 (0.04)
FA	0.32 (0.04)	0.21 (0.03)	0.43 (0.04)	0.22 (0.03)	0.35 (0.03)	0.21 (0.03)
Older adults						
d′	0.84 (0.11)	0.72 (0.10)	0.75 (0.14)	0.46 (0.10)	0.62 (0.13)	1.07 (0.14)
c	−0.03 (0.09)	0.59 (0.07)	−0.07 (0.09)	0.62 (0.07)	0.05 (0.09)	0.39 (0.07)
Hit	0.65 (0.04)	0.42 (0.03)	0.65 (0.04)	0.37 (0.03)	0.59 (0.03)	0.55 (0.04)
FA	0.37 (0.04)	0.18 (0.03)	0.40 (0.04)	0.21 (0.03)	0.38 (0.04)	0.19 (0.03)

Note: Means and standard errors of memory discriminability (d′), response bias (c), and hit and false alarm (FA) rates for schematic and non-schematic items across cue type in Younger Adults and Older Adults.