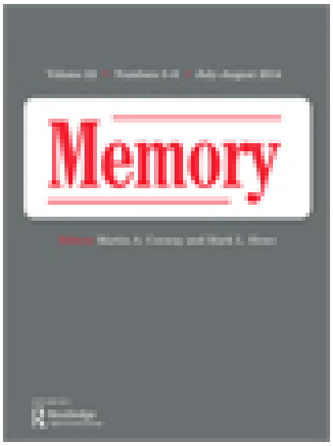

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Using warnings to reduce categorical false memories in younger and older adults

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Warnings about memory errors can reduce their incidence, although past work has largely focused on associative memory errors. The current study sought to explore whether warnings could be tailored to specifically reduce false recall of *categorical* information in both younger and older populations. Before encoding word pairs designed to induce categorical false memories, half of the younger and older participants were warned to avoid committing these types of memory errors. Older adults who received a warning committed fewer categorical memory errors, as well as other types of semantic memory errors, than those who did not receive a warning. In contrast, young adults' memory errors did not differ for the warning versus no-warning groups. Our findings provide evidence for the effectiveness of warnings at reducing categorical memory errors in older adults, perhaps by supporting source monitoring, reduction in reliance on gist traces, or through effective metacognitive strategies.

Keywords: False memory; Categorical memory; Aging; warnings; Long-term memory.

Decreases in veridical memory and increases in false memory typically occur with ageing (Norman & Schacter, 1997). False memories include remembering novel events that never occurred or misremembering events, and can occur in everyday situations such as confabulating details when retelling a story or mistakenly remembering an event as occurring to oneself when it actually occurred to someone else (as in the case of newscaster Brian Williams' false recollection of an episode in Iraq). Extensive research has investigated ways to evoke semantically related false memories in younger and older adults. One such method is the Deese-Roediger-McDermott (DRM) converging associates paradigm, in which meaningfully related words are presented (e.g., bed, rest, wake, dream) but a strongly related "critical lure" is omitted (e.g., sleep) (Deese, 1959; Roediger & McDermott, 1995). The DRM paradigm robustly elicits false memories, with studies revealing the pervasiveness of false memories of semantically related items across individuals of different ages and cultural backgrounds (Koutstaal & Schacter, 1997; Schacter, Koutstaal, & Norman, 1997; Schwartz, Boduroglu, & Gutchess, 2014; Tun, Wingfield, Rosen, & Blanchard, 1998).

False memories can occur when individuals encode generalised, semantic features of an event but do not encode distinctive details (Schacter, Israel, & Racine, 1999) and as such, one explanation that has been offered to help explain why older adults appear particularly susceptible to false memory production is fuzzy-trace theory (Brainerd & Reyna, 1990). This theory proposes that when encoding information, two types of memory traces are created: item-specific traces and gist traces. Distinct features of individual items are retained through item-specific traces whilst gist traces retain the general meaning of the event or item without specific details (Balota, Dolan, & Duchek, 2000; Brainerd & Reyna,

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1990; Dennis, Kim, & Cabeza, 2007; Jacoby & Rhodes, 2006). In converging associates paradigms such as the DRM paradigm and categorised word lists, older adults may incorrectly recall a memory for an item because it is semantically similar to a studied item and therefore matches the gist trace for the studied item even if they cannot remember specific information about said item (Dennis et al., 2007).

Memory errors to related information are also thought to occur due to activation of related associations, typically of a semantic nature (Gallo, 2010). In the DRM paradigm, this means that activation spreads to related concepts at the time of encoding, leading those items to be falsely remembered (Roediger, Balota, & Watson, 2001). To reduce the incidence of memory errors, monitoring is required, such as attempting to determine the relevant aspects of the information (e.g., the source of the items as actually studied on the list *vs.* self-generated) or to set strict decision criteria (Gallo, 2010; Gallo, Roberts, & Seamon, 1997). Ageing impairs source-monitoring abilities, particularly when such strategies must be self-initiated (McDonough, Wong, & Gallo, 2013; Mitchell, Johnson, & Mather, 2003).

Due to the persistent and robust nature of false memories, as well as the increase of their incidence with age, there have been many attempts to explore strategies to reduce their occurrence within a laboratory setting. When individuals are given explicit warnings about the false memory effect before encoding information, rates of false recognition and recall are reduced (Gallo et al., 1997; McCabe & Smith, 2002; McDermott & Roediger, 1998). These warnings typically involve providing information to participants about semantic false memories that can occur when studying lists of related words and participants are told to avoid making these types of memory errors. The effectiveness of warnings is accounted for by both the fuzzy trace and activation/monitoring explanations; errors are largely supported by gist and can be selectively reduced and warnings can increase the use of monitoring (Seamon et al., 2006). While a range of strategies to reduce false memory production in the DRM paradigm has been tested, including receiving warnings after encoding and before recall, explicit warnings before encoding have proved to be the most consistent at reducing semantically related false memory intrusions (McCabe & Smith, 2002; Read, 1996; Watson, McDermott, & Balota, 2004).

Consistent with findings in younger adults, older adults are able to utilise warnings to reduce semantic false memories in the DRM paradigm. Although older adults typically demonstrate higher levels of false recall compared to younger adults, studies have suggested that explicit warnings before encoding items can be effective at reducing false memory recall in older, as well as younger, adults (McCabe & Smith, 2002). It has been proposed that spontaneous self-initiated source-monitoring abilities decline with age (Dennis et al., 2007) and a study by Mitchell et al. (2003) revealed that older adults were not only more likely to make source-monitoring errors than younger adults, but they were also more confident in their source misattributions. As such, it has been proposed that experimenter initiated warnings in the DRM paradigm may provide older adults with a framework to discriminate between memory intrusions and items they studied (Watson et al., 2004) and as such, help older adults compensate for deficits in self-initiated source-monitoring.

Semantic relationships (such as those in the DRM paradigm) between items can be divided into several subcategories including functional, situational and categorical relationships (Rosch, 2002). Functional semantic associations are relationship-based and involve a casual and spatial relationship among items, like "monkey-banana" (i.e., a monkey eats bananas). Situational associations involve words that have the similar contextual meanings, like "rest-sleep", and categorical relationships involve words that are taxonomically related, like "apple-banana" (Ji, Zhang, & Nisbett, 2004). These types of semantic relationships have the potential to distort memory based on the associations one automatically makes when encoding lists or groups of related items.

When remembering information, coding items into simple categories has been shown to be an effective way to encode the maximum amount of information about items with the least cognitive effort (Rosch, 2002). Due to the efficiency of organising information this way, categorical organisation has been shown to not only assist episodic recall and recognition by providing facilitative cues, but also can lead to an increased production of false memories (Schwartz et al., 2014; Smith, Ward, Tindell, Sifonis, & Wilkenfeld, 2000). Categorical relationships are the second most frequent type of semantic relationship demonstrated in the DRM paradigm (Brainerd, Yang, Reyna, Howe, & Mills, 2008) and research has suggested that categorical relationships between items elicit one of the highest rates of false memory production among semantic relationships (Smith et al., 2000). Studies have revealed that younger adults falsely recall dominant items that were not presented with categorically related items in cued recall tasks (Smith et al., 2000). These dominant items are commonly associated members of categories that are omitted from word lists or word pairs (e.g., after studying the word pair "banana-table" participant may later falsely recall seeing "apple"). Despite the prevalence and pervasiveness of categorical false memories, to our knowledge there has been no research investigating whether warning strategies (such as those used in the DRM paradigm) can be used to specifically reduce the prevalence of categorical false memories in cued recall tasks.

In order to explore whether receiving warnings about categorical memory intrusions can reduce categorical memory errors, we instituted a warning at encoding based on those used to reduce false memories in the DRM paradigm. One key difference in the current study is that participants were not instructed to avoid reporting the "critical lure", as was the case in previous work (Gallo et al., 1997; McCabe & Smith, 2002; McDermott & Roediger III, 1998), but rather were warned of the pervasive nature of categorical false memories and instructed to pay careful attention to stimuli and avoid making categorical memory errors. Previous work, such as that by McCabe and Smith (2002) revealed that older adults failed to reduce false recognition when warnings were given before study if they did not specifically attempt to identify the critical lure, and thus we aimed to investigate whether warnings could be effective in the absence of a specific critical lure to identify. In the case of the present study, warnings were developed to remind participants to closely pay attention to the two words they are studying in order to avoid false memory intrusion and to prevent source-monitoring errors. Based on the success of warnings at encoding at reducing semantic false memories in younger and older adults in the DRM paradigm (McCabe & Smith, 2002; Watson et al., 2004), we predicted that warnings would be successful in reducing the incidence of categorical memory errors in response to studying word pairs, half of which shared a categorical relationship. Should these warnings prove effective, they would differ from previous studies using DRM word lists in that participants need not identify a critical lure. In this paradigm, several categorically related lures could be generated by the participant, rather than committing a false memory due to the activation of one unpresented word associate. More specifically, we hypothesised that younger and older adults who received a warning would show a greater reduction in categorical false memory rates compared to those who received no warning, consistent with past literature which has suggested that warnings may be particularly effective for older adults at the time of encoding (McCabe & Smith, 2002).

METHODS

Participants

Sixty-nine younger adults[1] (aged 18–23) recruited from the Brandeis University student population and 56 older adults (aged 66–96) recruited from the greater Boston area were included in the final sample. Participants were assigned to either a "no-warning" or a "warning" condition. Demographic information is outlined in Table 1. Participants provided consent prior to taking part in the study, and were reimbursed with either payment or course credit for their time.

Demographic information was collected from participants as well as additional measures including Operation Span (OSpan; Unsworth, Heitz, Schrock, & Engle, 2005) and Pattern-Matching (Salthouse, 1996) to ensure that cognitive abilities were matched across conditions and exclude any outliers (Table 1). For young adults, there were no significant differences in age, years of education or Pattern-Matching (p's > .30), although there is a trend for a difference in OSpan scores. For older adults across the warning conditions, there were no significant differences in age, education or OSpan scores (p's > .43). While Pattern-Matching

[1]Two additional participants (one from each warning condition) were not included in the analyses because they did not commit any memory errors. Data obtained from younger adult participants in no-warning condition have been published by Schwartz et al. (2014). Instructions to participants were identical to the prior study, with the warning added for participants in that condition. The raw data were rescored for the current study to ensure consistency in coding across conditions.

TABLE 1
Means (standard deviation) for descriptive information for participants

Descriptive statistic	*No-warning*	*Warning*	p-*Value*
Younger adults			
n	39	30	
Age (years)	19.10 (1.05)	18.97 (1.35)	.64
Education (years)	13.59 (1.21)	13.38 (1.26)	.49
OSpan[a]	65.05 (6.09)	59.57 (14.28)	.06
Pattern-Matching	36.26 (4.81)	37.60 (5.83)	.30
Older adults			
n[b]	31	25	
Age (years)	77.87 (7.05)	76.24 (8.49)	.44
Education (years)[b]	16.67 (3.58)	16.28 (2.35)	.63
OSpan	46.26 (15.77)	49.57 (16.61)	.50
Pattern-Matching	26.52 (8.12)	20.88 (6.55)	.007[c]

[a]Equal variances not assumed.
[b]One older adult in the no-warning group is missing years of education, and only a subsample completed the OSpan task ($n = 23$ in the no-warning group, $n = 21$ in the warning group). Others declined to complete the task or aborted it due to fatigue. Note: OSpan was the last task administered in the battery.
[c]Mean values are significantly different as determined by independent samples *t*-tests.

scores significantly differed, they tend to go in the opposite direction of OSpan, together indicating that our groups did not clearly differ in cognitive ability across conditions. All older adult participants scored above 27 on the Mini Mental State Exam (Folstein, Folstein, & McHugh, 1975), and therefore no participants were excluded on the basis of that exam.

Stimuli

Participants viewed 32 word pairs for 4 seconds each. Word pairs were developed by Schwartz et al. (2014) and consisted of 32 taxonomically related word pairs (see Appendix). Two counterbalanced versions of the word pair list were utilised in the study, with each list containing 16 words presented with their taxonomic partner (e.g., shirt-socks), and the remaining 16 word pairs were jumbled and repaired with other words on the list, to appear as unrelated word pairs (e.g., shirt-table; milk-socks).

Procedure

The experiment was conducted on a computer using E-Prime software (Psychology Software Tools, Pittsburgh, PA). Participants in the no-warning condition began the task by reading instructions about the memory task, including that they would be memorising word pairs. Participants in the warning condition received this instruction, and additionally received a warning about categorical false memory intrusions. Presenting the warning at encoding has been shown to be the most effective approach to reducing memory errors in older adults (McCabe & Smith, 2002). The warning in the current study was adapted from warnings utilised to effectively reduce semantic memory errors in the DRM paradigm (Gallo et al., 1997; McDermott & Roediger III, 1998) and read:

> Some word pairs you will study today will be made-up of related words (e.g., "France-Germany") and some will not be related (e.g., "jazz-cellphone"). For each word pair, you should pay attention to whether the two words presented in each pair are related or not related. When remembering word pairs or groups of words, sometimes people mistakenly "remember" categorically related words, even when the words they studied were not related.
>
> An example of this would be studying the unrelated word-pair "jazz-cellphone" and incorrectly recalling the related word-pair "jazz-classical". In this example, when you saw the word "jazz" you may have remembered the word "classical" because you saw it somewhere else in the list of word-pairs you read, or simply because it "came to mind".
>
> Try your best not to make this kind of error. Be sure to notice and remember whether or not the two words in each word pair are related or not. Do you have any questions before we begin the task? Please press the space bar to begin.

Participants were then presented with 32 word pairs in a single study block, with each word pair presented for 4 seconds in a random order unique to each subject. After completing the encoding task, participants completed a short distraction task for 30 seconds (to eliminate recency effects), and then completed a self-paced cued recall task on the computer using *E-Prime* software. Recall was self-paced, and participants were presented with the first word from each word pair in a random order, and were asked to write down the corresponding word that they saw presented with it during encoding. Participants were encouraged to try to provide an answer for each cue, although they were told that they were allowed to leave blanks if they could not recall any answer.

Scoring

Two separate coders scored results for different types of errors, and a third coder resolved any discrepancies in coding. A correct response was coded as a response that matched the word that participants were being asked to recall, ignoring pluralisation or simple spelling errors. Memory errors involved the mispairing of another word from the original list of word pairs encoded, or the generation of a novel word in response to the cue. On the basis of our prior work with this paradigm (Schwartz et al., 2014), memory errors were broken down into five types of errors: categorical (semantic) errors, other-semantic errors, non-semantic errors, other word list errors and unrelated errors. All errors could be in response to related (e.g., "pear-banana") or unrelated (e.g., "jazz-cell phone") word pairs, and the source of the memory (related or unrelated word pair) was not separated in the analysis. *Categorical errors* were classified as a response that is incorrect but taxonomically related to either the cue or the target (e.g., for the word pair "pear-banana", a categorical error could include "apple"). *Other-semantic errors* were related in any way other than categorically. A common type of other-semantic error included responses that were functionally related to the cue or the target (e.g., for the word pair "pear-banana", a response of "ripe"). A *non-semantic error* was classified as either rhyming words, homonyms or words with a one-letter difference to either the cue or target word (e.g., answering "parrot" in response to the word pair "pea-carrot"). *Other list word errors* involved reporting another word from the list of word pairs that was unrelated to both the target and the cue, but was present in the list of 32 word pairs. *Unrelated errors* were coded as the generation of a novel word that was in no way related to the cue or the target.

RESULTS

Correct responses

To investigate whether the number of correct responses differed between warning conditions across the age groups, we conducted a 2 (Age: Younger, Older) × 2 (Warning Condition: No-Warning, Warning) univariate analysis of variance (ANOVA). A significant effect of age was found (F[1, 121] = 23.38, $p < .001$, $\eta p^2 = .16$) with younger adults recalling more items correctly than older adults. There was no main effect of condition or interaction between age × condition (p's $> .88$) (Table 2).

Number of blanks

In order to explore whether there were any differences in the number of items left blank by participants across age groups or warning conditions, we conducted a 2 (Age: Younger, Older) × 2 (Warning Condition: No-Warning, Warning) univariate ANOVA with total number of blanks as the dependent variable. While there was no main effect of age (F[1, 121] = 2.50, $p = .12$, $\eta p^2 = .02$), there was a significant main effect of condition (F[1, 121] = 19.63, $p < .001$, $\eta p^2 = .14$) as well as an interaction between age and condition (F[1, 121] = 13.71, $p < .001$, $\eta p^2 = .10$).

Contrasts revealed there was no significant difference in the number of items left blank between warning conditions in younger adults (F[1, 67] = .28, $p = .60$); however, there was a significant difference between warning conditions for older adults (F[1, 54] = 32.51, $p < .001$), with older adults who received a warning leaving significantly more items blank than older adults who did not receive a warning (Table 2).

Error types

To examine the effects of warnings upon proportion of memory error types committed in younger and older adults, we conducted a 2 × 2 × 5 mixed-design ANOVA with age (younger adults/older adults) and warning condition (no-warning, warning) as the between-subjects variables and error type (categorical, other-semantic, non-semantic, other list word, unrelated) as the within-subjects variable.

The ANOVA revealed between-subjects main effects of age (F[1, 121] = 13.12, $p < .001$, $\eta p^2 = .098$) and condition (F[1, 121] = 17.21, $p < .001$, $\eta p^2 = .12$). These findings indicated that older adults tend to make more errors overall (M = 2.03, SE = .15) compared to younger adults (M = 1.28, SE = .14), averaged over warning groups and error types. In addition, individuals who received no-warning made more errors (M = 2.08, SE = .14) compared to those who received a warning (M = 1.22, SE = .16), averaged across age groups and error types. However, interactions

TABLE 2
The mean number of correct responses, blanks and total errors (standard deviations) made by younger and older adults across warning conditions

Age	*Warning condition*	*Correct*	*Blank*	*Total errors*
Younger	No-warning	18.44 (5.89)	6.82 (4.60)	6.74 (4.78)
	Warning	18.47 (6.40)	7.50 (6.12)	6.03 (5.10)
Older	No-warning	13.10 (6.27)	4.84 (5.45)	14.06 (8.08)
	Warning	13.36 (5.06)	12.44 (4.26)	6.20 (3.87)

There were a total of 32 trials.

qualify these interpretations. The ANOVA also revealed a significant interaction between age × condition (F[1, 121] = 78.00, $p = .001$, $\eta p^2 = .09$). While the mean number of memory errors committed by younger adults did not differ greatly between no-warning ($M = 1.35$, SE = .18) and warning conditions ($M = 1.21$, SE = .21), the number of memory errors committed by older adults who received no-warning was much higher ($M = 2.81$, SE = .21) than those who received a warning ($M = 1.24$, SE = .23). Our analysis of memory error type revealed a main effect of error type (F[4, 484] = 112.77, $p < .001$, $\eta p^2 = .48$) with contrasts revealing that participants overall committed the highest number of categorical memory errors, followed by other-semantic, other list word, new unrelated and finally non-semantic. The difference between all these error types was significant (p's < .049).

An interaction between error type × age revealed differences in error types committed by younger and older adults (F[4, 484] = 6.23, $p < .001$, $\eta p^2 = .049$). On average, older adults made numerically more of each error type than younger adults. Contrasts revealed that older adults made significantly more categorical errors (F[1, 123] = 10.93, $p = .001$), and other-semantic errors (F[1, 123] = 6.08, $p = .015$) compared to younger adults. There was no significant age-related difference in the number of new unrelated errors, non-semantic or other list word errors (p's > .11).

Of particular interest in the current study was the interaction involving error type and condition, which was significant (F[4, 484] = 15.31, $p < .001$, $\eta p^2 = .11$). Across all participants, those who received a warning reduced the number of categorical errors (F[1, 123] = 15.78, $p < .001$), supporting our hypothesis that receiving a warning would reduce the number of categorical memory errors made by younger and older adults. Unexpectedly, warnings also reduced the number of other-semantic errors (F[1, 123] = 6.17, $p = .014$). There was no significant difference in the number of non-semantic, other list word and new unrelated errors between warning conditions (p's > .52). This interaction, however, was qualified by a significant three-way interaction between age × condition × error type (F[4, 484] = 8.17, $p < .001$, $\eta p^2 = .063$) revealing that there were age-related differences in the way that warnings impacted the number of error types across conditions.

Planned comparisons were conducted to explore these age differences. Young adults did not differ across warning conditions in the number of each error type committed (p's > .22) (Figure 1(a)). However, older adults who received a warning significantly reduced the number of categorical memory errors (F[1, 54] = 22.32, $p < .001$) and other-semantic errors (F[1, 54] = 12.46, $p < .001$) compared to those who did not receive a warning. There was no significant difference in the frequency of non-semantic, other list word and new unrelated memory errors committed between warning conditions for older adults (p's > .29) (Figure 1(b)).

Thus, while memory warnings were effective in reducing categorical memory errors, the reduction also extended to other-semantic errors. The warnings were particularly effective for older adults, who reduced their incidence of these types of memory errors more than younger adults.

Potential strategy shift in categorical memory errors vs. blanks

Our initial analysis revealed that the number of memory errors and blanks differed across warning conditions for older adults. Based on these results, we made a *post hoc* prediction that there may have been a trade-off in strategy for older adults when they received a warning about categorical memory errors, such that they committed fewer categorical memory errors, but in turn compensated by leaving more items blanks.

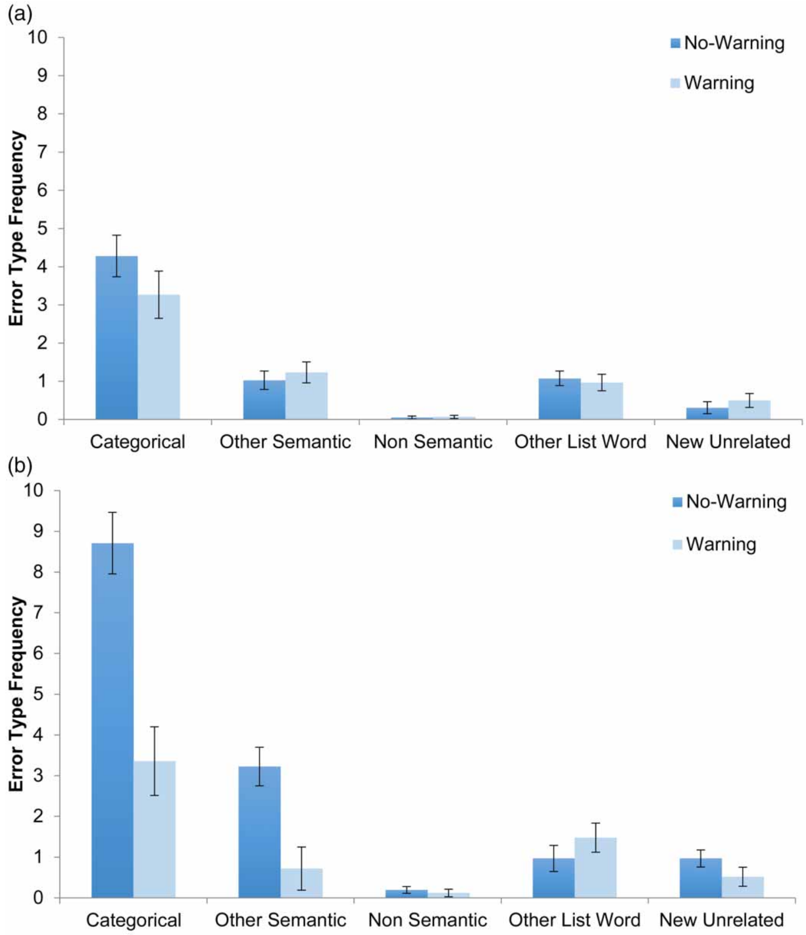

Figure 1. (a) Frequency of memory error types by warning condition for younger adults, out of a total of 32 trials. Error bars represent standard error. (b) Frequency of memory error types by warning condition for older adults, out of a total of 32 trials. Error bars represent standard error.

To test this *post hoc* prediction, we conducted an exploratory 2 (Response: Categorical Memory Errors, Blanks) × 2 (Warning Condition: No-warning, Warning) repeated-measures ANOVA. This analysis revealed a main effect of response type ($F[1, 54] = 6.08$, $p = .017$, $\eta p^2 = .10$), with older adults reporting more blanks ($M = 8.23$, SD = 6.22) than categorical memory errors ($M = 6.32$, SD = 4.96) across warning conditions.

In support of our hypothesis, an interaction between response × condition was also significant ($F[1, 54] = 37.58$, $p < .001$, $\eta p^2 = .41$). This trend revealed that older adults who received no-warning had fewer blanks ($M = 4.84$, SD = 5.45) than categorical errors ($M = 8.71$, SD = 5.29), whereas this trend was reversed in older adults who received a warning, with these participants having more blanks ($M = 12.44$, SD = 4.26) than categorical memory errors ($M = 3.36$, SD = 2.22). These findings are summarised in Figure 2.

For completeness, the same analysis was conducted for younger adults. The 2 (Response: Categorical Memory Errors, Blanks) × 2 (Warning Condition: No-Warning, Warning) repeated-measures ANOVA revealed a main effect for response ($F[1, 67] = 17.06$, $p < .001$, $\eta p^2 = .20$), with younger adults leaving more blanks ($M = 7.12$, SD = 5.29) than categorical errors ($M = 3.84$, SD = 3.40). Contrary to the pattern found with older adults, there was no error type × condition interaction found in younger adults ($p > .30$).

DISCUSSION

While categorical false memories can occur at high rates in younger adults (Schwartz et al., 2014; Smith et al., 2000), research has largely focused on other types of associative false memories. In this study, we extend prior research on the effectiveness of warnings at encoding in reducing the

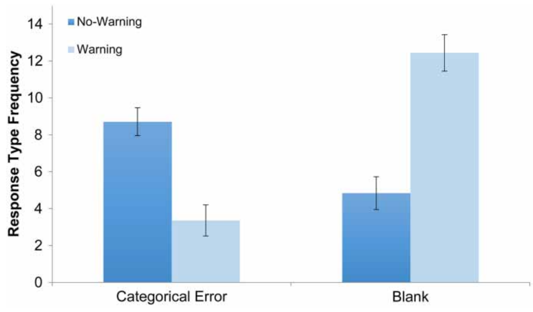

Figure 2. The mean number of items left blank and the mean number of categorical memory errors committed by older adults, out of a total of 32 trials. Error bars represent standard error.

incidence of false memories (McDermott & Roediger, 1998) to semantic categorical memory errors.

Our findings lend partial support to the hypothesis that warnings can effectively reduce categorical false memories in recall. Tailored warnings about categorical memory errors reduced the incidence of categorical false memories, but only in older adults. Contrary to previous literature (Smith et al., 2000; Watson et al., 2004), which has shown warnings to effectively reduce false memories in both older and younger adults, our findings revealed that only older adults effectively reduced categorical memory errors. This is particularly interesting, given prior research with young adults suggested that categorical errors were largely produced at retrieval, rather than at encoding (Smith, Gerkens, Pierce, & Choi, 2002) and because warnings benefit young adults more than older adults under some conditions (McCabe & Smith, 2002; Watson et al., 2004).

Older adults' reduction in memory errors was not selective to the categorical condition in our study, but revealed an overall tendency to reduce reporting of memory errors. While older adults with no warning made twice as many memory errors overall compared to younger adults, older adults who received a warning in the current paradigm made a number of errors that was comparable to younger adults. This marked reduction in errors for older adults who received a warning extended to the other-semantic memory condition, too.

In contrast to prior studies revealing the effectiveness of warnings across age groups (Gallo et al., 1997; McCabe & Smith, 2002; McDermott & Roediger, 1998) warnings did not reduce these errors in young adults. Although there was a numerical trend for a reduction in categorical false memories for young adults, there was no evidence that warnings affected other-semantic errors, as was the case for older adults. To further understand the effectiveness of warnings for categorical errors and the potential generalisation to other-semantic errors in young adults, it would be useful to investigate these processes under conditions in which memory is more vulnerable, such as after a longer delay or in participants highly prone to false memories.

One possible explanation for older adults' tendency to reduce other-semantic errors as well as categorical errors in response to the warning could be their predisposition to rely on gist-based processing (Balota et al., 2000; Brainerd & Reyna, 1990; Koutstaal & Schacter, 1997; Tun et al., 1998). That is, after receiving a warning about categorical memory errors, older adults may have generalised this warning to try to reduce all meaningfully related errors without specific regard to whether or not relationships were taxonomic. Somewhat surprisingly, attempting to reduce errors does not impact the number of correct responses, as these are comparable between the warning and no-warning groups for both younger and older adults. Fuzzy-trace theory suggests that errors are largely based on gist processes, whereas verbatim traces support actual list items (Brainerd & Reyna, 1990). Thus, warnings can be used to selectively target and reduce memory errors supported by gist (Seamon et al., 2006). It is also possible that older adults interpreted the instruction more broadly than young adults. These possibilities, and whether older adults can *selectively* reduce categorical errors under appropriate conditions, can be addressed in future research.

Prior studies using the DRM paradigm suggested that in order to avoid memory errors, it may be necessary to identify the critical lure, particularly at the time of encoding (McCabe & Smith, 2002). While that exact strategy is unlikely to eliminate memory errors in the present paradigm, as participants generated many different categorically and semantically related lures rather than one critical one, a similar underlying strategy could contribute to our older adults' reduction in memory errors with a warning. Older adults are known to have a deficit in self-initiated source-monitoring abilities (McDonough et al., 2013; Mitchell et al., 2003). Research has suggested, however, that when the source monitoring is provided by the experimenter (such as with an explicit warning about the false memory effect) older adults show increased abilities to discriminate between information and reduce false memory intrusions (Watson et al., 2004). Thus, under conditions requiring strict criteria, older adults may be able to utilise item-specific information to resist memory errors in contrast to their failure to spontaneously use such information in a self-initiated manner under lax conditions (Balota et al., 2000; McCabe & Smith, 2002; Watson et al., 2004). Older adults may have succeeded in reducing their frequency of their memory errors (to levels indistinguishable from younger adults) because warnings alleviated older adults' source-monitoring deficits by encouraging them to pay attention to the source of their information and avoid making categorical memory errors based on taxonomically similar relationships between items (Balota et al., 2000; Brainerd & Reyna, 1990). Older adults may fail to spontaneously engage such monitoring processes due to reduced cognitive abilities, such as working memory or attentional capacity (Balota et al., 2000; McCabe & Smith, 2002).

Older adults who received a warning were more likely to leave items blank than other groups. While this could be seen as reflecting a criterion shift, to reduce the number of memory errors, it is surprising that this strategy did not impact accurate recall, which was comparable across the warning and no-warning conditions. The interpretations that warnings enhanced self-initiated source-monitoring or reduced reliance on gist traces in older adults also could account for this pattern of data. According to these explanations, the experimenter-provided warning may have induced participants to leave an item blank rather than risk a false memory if they could not identify the source of the memory based on retrieving specific details or a high level of confidence.

Although we speculate that similar processes contribute to the reduction in memory errors for older adults as invoked in prior studies, our results differ from prior studies in that they show a *larger* benefit from warnings for older than younger adults. We suggest that this diverging pattern may reflect the use of a cued recall paradigm, in which the generation of responses induces more monitoring than a recognition paradigm. Furthermore, participants have the option to omit a response, which may invoke additional metacognitive strategies in older adults than recognition paradigms. In future studies, a forced guessing paradigm may also be useful to evaluate the strategy of using blanks and to probe age differences in the willingness to edit responses by using blanks.

The current study provides evidence that warnings about false memories can be successfully adapted from those utilised in the DRM paradigm and used in cued categorical recall tasks to reduce categorical memory errors in older adults. While previous studies have utilised warnings to encourage participants to identify the critical lure, our study was the first to our knowledge to utilise warnings about categorical false memories in an attempt to overcome self-initiated source-monitoring deficits and increased reliance on gist with age.

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APPENDIX. LIST OF RELATED WORD PAIRS

Cue	Target
ant	bee
aunt	uncle
beer	whiskey
blue	red
carrot	pea
chair	table
chemistry	physics
church	synagogue
cotton	wool
diamond	ruby
dog	cat
foot	inch
football	baseball
hour	minute
house	apartment
iron	copper
knife	spoon
legs	arms
lieutenant	general
magazine	book
milk	Coke
mountain	hill
murder	rape
oak	maple
oil	gas
pear	banana
priest	minister
rose	tulip
shirt	socks
shoe	boots
trout	bass
vice-president	senator