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The influence of strategic encoding on false memory in patients with mild cognitive impairment and Alzheimer's disease dementia

Michelle J. Tat[a,b,*], **Anothai Soonsawat**[a,b], **Corinne B. Nagle**[a,b], **Rebecca G. Deason**[c], **Maureen K. O'Connor**[a,b,d], and **Andrew E. Budson**[a,b]

[a]Center for Translational Cognitive Neuroscience, VA Boston Healthcare System, Boston, MA, United States

[b]Boston University Alzheimer's Disease Center, Boston University School of Medicine, Boston, MA, United States

[c]Department of Psychology, Texas State University, San Marcos, TX, United States

[d]Edith Nourse Rogers Veterans Memorial Hospital, Bedford, MA, United States

Abstract

Patients with Alzheimer's disease (AD) dementia exhibit high rates of memory distortions in addition to their impairments in episodic memory. Several investigations have demonstrated that when healthy individuals (young and old) engaged in an encoding strategy that emphasized the uniqueness of study items (an item-specific encoding strategy), they were able to improve their discrimination between old items and unstudied critical lure items in a false memory task. In the present study we examined if patients with AD could also improve their memory discrimination when engaging in an item-specific encoding strategy. Healthy older adult controls, patients with mild cognitive impairment (MCI) due to AD, and patients with mild AD dementia were asked to study lists of categorized words. In the Item-Specific condition, participants were asked to provide a unique detail or personal experience with each study item. In the Relational condition, they were asked to determine how each item in the list was related to the others. To assess the influence of both strategies, recall and recognition memory tests were administered. Overall, both patient groups exhibited poorer memory in both recall and recognition tests compared to controls. In terms of recognition, healthy older controls and patients with MCI due to AD exhibited improved memory discrimination in the Item-Specific condition compared to the Relational condition, whereas patients with AD dementia did not. We speculate that patients with MCI due to AD use intact frontal networks to effectively engage in this strategy.

Keywords

Alzheimer's disease; False memory; Memory strategies; Mild cognitive impairment

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[*]Corresponding author at: VA Boston Healthcare System, 150 S. Huntington Ave Mailstop 151C, Boston, MA 02130, United States., mjtat@bu.edu (M.J. Tat).

1. Introduction

Patients with mild cognitive impairment (MCI) due to Alzheimer's disease (AD) and patients with AD dementia commonly exhibit impairments in episodic memory and rapidly forget newly learned information. In addition, these patients exhibit a higher incidence of memory distortions compared to their cognitively healthy older peers. These memory distortions can be severe, such as confabulation (Nedjam, Devouche, & Dalla Barba, 2004), though generally they are more mundane. For example, a patient may have thought they have turned off their stove when they simply *misremembered* that they turned off the stove. Organizational strategies, such as using pillboxes for medication, can help in the remembering of daily living activities. However, this type of strategy does not help when patients experience false memories—not looking in their pillbox, for example, because they falsely remember taking their medication. It is, therefore, important to examine strategies that can reduce false memory in these patients.

False memory has often been examined variations of the Deese-Roediger-McDermott (DRM) false memory paradigm (Roediger & McDermott, 1995). In this paradigm participants study lists of semantically related words (e.g., *door*, *glass*, *pane*, *shade*, etc.). In a recognition memory test, participants are tested on their memory for studied old words (e.g., *door*), unrelated new words (e.g., *lawyer*), and strongly related but unstudied *critical lure* words (e.g., *window*). High rates of false recall and recognition of critical lure items has been consistently observed in healthy young adults across variations of the DRM-false memory paradigm (for a review see Gallo, 2010). False memories arise from the spread of activation to semantically related items in memory, strengthening gist-information, causing individuals to endorse critical lure words more readily (Reyna & Brainerd, 1998; Roediger, Watson, McDermott, & Gallo, 2001). Individuals typically engage in different memory strategies to combat the influences of spreading activation and gist, which can involve the use of *item-specific information*. Item-specific information refers to distinctive features of individually studied items. When more item-specific information is stored into memory, individuals can more readily use retrieval monitoring mechanisms to reduce gist-based false memory.

Relative to healthy young adults, healthy older adults are more susceptible to false memory. Healthy older adults have been shown to rely more on gist for their memory judgments (Gallo, Bell, Beier, & Schacter, 2006; Koutstaal & Schacter, 1997; Norman & Schacter, 1997). In comparison to healthy older individuals, patients with AD dementia exhibit more false memories and memory distortions (Balota et al., 1999; Budson, Daffner, Desikan, & Schacter, 2000; Budson, Sitarski, Daffner, & Schacter, 2002; Budson, Todman, Chong, et al., 2006; Budson, Todman, & Schacter, 2006; Budson et al., 2003; O'Connor et al., 2015). Patients with AD dementia have been shown to have higher rates of false memory to critical lures when matched on true memory performance (Balota et al., 1999). Furthermore, when gist is strengthened through repetition of study lists, patients with AD become more likely than healthy older adults to endorse critical lure items (Budson et al., 2000).

Prior studies have focused on memorial strategies that patients could use to reduce false memories by reducing their reliance on gist-information. Two specific strategies that have been examined in healthy individuals and in patients with AD are the *distinctiveness heuristic* and the *recall-to-reject* strategy. The distinctiveness heuristic refers to a strategy whereby participants reject unstudied new items in a memory test when they are sufficiently unique or distinctive. For example, “If I had seen that gigantic spider before, I’m sure I would have remembered it.” Patients with AD are less able to use the distinctiveness heuristic to reduce their false recognition to critical lures (Budson et al., 2002). Budson, Dodson, Daffner, and Schacter (2005) found that patients were aware of the distinctiveness heuristic as a viable memory retrieval strategy; however, due to impairments to item-specific recollection, they were unable to use it selectively, reducing both false and true recognition (see also Gallo, Chen, Wiseman, Schacter, & Budson, 2007). Recall-to-reject is another strategy that can be used to reduce false recognition, when a participant sees an item in one of two contexts, and can recall enough details of the item in one context to know that it was not seen in the other. Using an associative recognition memory paradigm, Gallo, Sullivan, Daffner, Schacter, and Budson (2004) demonstrated that patients with AD dementia, relative to healthy individuals, were less able to engage in a recall-to-reject strategy to combat the influence of gist (and memorial familiarity) because of their impaired item-specific recollection. By contrast, with intact item-specific recollection, healthy older controls were able to use a recall-to-reject strategy to reject unstudied associative word pairings.

These studies show that patients with AD are generally limited in the use of the distinctiveness heuristic and recall-to-reject strategies to reduce their false recognition. Other investigations have focused on examining the effectiveness of an *Item-Specific* encoding strategy. This strategy aims to enhance the encoding of unique perceptual and contextual characteristics of an item and to prevent the strengthening of gist information, leading to reductions in false memory and improvement in memory discrimination (higher hit rates, lower false alarm rates). Item-Specific encoding has usually been contrasted with a strategy where individuals are asked to remember items in a more associative manner (referred to as *Relational* encoding). McCabe, Presmanes, Robertson, and Smith (2004) compared Item-Specific and Relational encoding strategies in healthy young adults using a DRM paradigm. For each word in the Item-Specific condition, participants were instructed to think about one unique characteristic that differentiated that item from others in the same list. In the Relational condition, participants were instructed to relate an item to others in the same list, and to focus on what they had in common. After each condition, participants were given a recognition memory test. Their results showed that memory discrimination was higher in the Item-Specific condition compared to the Relational condition. Extending these findings, Huff and Bodner (2013) compared Item-Specific and Relational encoding strategies to a “Read Only” strategy, whereby participants simply read each word aloud. They discovered a similar pattern of results: Item-Specific encoding led to improved discrimination when compared to Relational and “Read Only” encoding. In healthy older adults, Thomas and McDaniel (2013) found that older adults with higher frontal lobe functioning had lower false recall when they engaged in Item-Specific encoding compared to older adults with lower frontal lobe functioning. These studies demonstrate that Item-Specific encoding strategies—perhaps engaged by the frontal lobes—enhance detailed oriented information in memory, making memory cues more readily available for memory retrieval, thus facilitating the use of different retrieval strategies.

Given that prior studies have shown that Item-Specific encoding was effective in reducing false memory in older adults, we investigated the efficacy of this strategy in patients with MCI due to AD and in patients with mild AD dementia in a false memory paradigm with categorized word lists. Item-Specific encoding was expected to enhance item-specific recollection across all groups, preventing the strengthening of gist-information and the spread of activation which should, in turn, reduce false recognition and improve memory discrimination. We were interested in investigating the efficacy of this strategy with both patient groups, because we hypothesized that the severity of cognitive impairment may influence a patient's ability to use this encoding strategy. As Thomas and McDaniel (2013) indicated, frontal lobe ability might underlie the ability to engage in an Item-Specific encoding strategy. Patients with MCI due to AD have been shown to have fewer frontal/executive deficits than patients with mild AD dementia (e.g., Marshall et al., 2011), and therefore the former may be able to use encoding strategies more readily than the latter. We therefore predicted that, following the use of an Item-Specific encoding strategy, the largest increase in memory discrimination would be observed in the healthy older control group, followed by patients with MCI due to AD, with the smallest increase observed in patients with mild AD dementia. These predictions are based on the idea that as the AD pathology spreads to other cortical areas (e.g., medial temporal lobe, parietal lobe, frontal lobe) impairments in item-specific recollection and the ability to engage in encoding and retrieval strategies would become more apparent.

We contrasted Item-Specific encoding by asking patients to engage in relational encoding. In daily life, individuals may engage in relational/associative processing when attempting to remember related items (e.g., purchasing groceries for a meal) (unpublished observations). For healthy individuals, this is often an efficient memory strategy. For patients with MCI due to AD and mild AD dementia, however, engaging in this type of strategy may actually promote the strengthening of gist, and may thereby decrease their overall ability to discriminate between old desired versus new related but non-desired items. For this reason, we believed that the use of a relational strategy would provide an ideal appropriate contrast to the implementation of a more item-specific encoding strategy.

2. Method

2.1. Participants

Sixteen healthy older controls (OCs) (4 male), 13 patients with a clinical diagnosis of MCI due to AD (for brevity, referred to as "patients with MCI") (12 male), and 14 patients with a clinical diagnosis of mild AD dementia (for brevity referred to as "patients with AD") (12 male) were recruited for this study. (Note: because unequal numbers of males and females were present in the groups, gender analyses were performed for all major analyses. These analyses, which may be found in the Supplementary Materials, did not reveal reliable effects or interactions.) OCs were recruited from online and community postings in the Boston area. Additionally, some of the OCs were spouses and friends (but not blood relatives) of patients that participated in this study. Patients met criteria for MCI due to AD or probable AD dementia as described by the National Institutes of Aging – Alzheimer's Association (NIA-AA) (Albert et al., 2011; McKhann et al., 2011). Patients were recruited from the Memory

Disorders Clinic at the VA Boston Healthcare System, Boston, MA and the Boston University Alzheimer's Disease Center, Boston, MA. Patients were assessed and diagnosed by a neurologist and/or neuropsychologist and were otherwise healthy. All participants were screened for clinically significant depression, alcohol and drug use, past stroke, traumatic brain injury, or other neurological disorder. All participants were native English speakers and had normal or corrected to normal vision. The study was approved by the Human Studies Committees at the VA Boston Healthcare System and Boston University. Written informed consent was obtained from all participants. Participants were paid $10/h for their participation.

All participants completed a brief 45-min neuropsychological battery prior to the administration of the experimental tasks. This battery included the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) Word List Memory Test (Morris et al., 1989), Trail Making Tests Part A & B (Adjutant General's Office, 1944), verbal fluency to letters (F, A, and S) and categories (Animals, Vegetables, and Fruits) (Monsch et al., 1992), and the 15-item version of the Boston Naming Test (BNT-15; Mack, Freed, Williams, & Henderson, 1992). One patient with AD did not complete the CERAD word list test.

Mean age and years of education for OCs was 80.37 years (*SD* = 5.69) and 16.09 (*SD* = 0.199). For patients with MCI, mean age was 76.61 years (*SD* = 5.89) and mean years of education was 15.34 (*SD* = 3.61). For patients with AD, mean age was 81.43 (*SD* = 5.78) and mean years of education was 15.21 (*SD* = 3.04) There were no significant differences in Age [$F(2,42) = 2.57$, $p = 0.089$, $\eta_{\mathrm{p}}^{2}=0.114$] or years of education [$F(2,42) = 0.411$, $p = 0.666$, $\eta_{\mathrm{p}}^{2}=0.020$] between groups. Group differences were observed for most neuropsychological assessments. Pair-wise comparisons were conducted to determine which groups differed on each test. Mean scores on tests in our neuropsychological battery for each participant group, with associated *t*- and *p*-values from pair-wise comparisons, are shown in Table 1.

2.2. Materials

The stimuli were 16 categorized lists of words taken from an updated version of the Battig and Montague (1969) category norms (Van Overschelde, Rawson, & Dunlosky, 2004). The first 17 words were used from each list. The first two items in each category were the most frequently named items from each chosen category in the Van Overschelde et al. (2004) norms, and were thus used as unstudied critical lure words during the recognition memory test. These critical lure words were never presented during any study phase. The remaining 15 words were used as study items. For example, for the category "An article of furniture," the first two items in the list, *chair* and *table*, were reserved as the critical lure items. The 16 categorized word lists were organized into 2 sets of 8. Each set of 8 categorized word lists were used in the *Item-Specific* or *Relational* encoding conditions. All categorized word lists were fully counterbalanced across each encoding condition. In each encoding condition, participants studied of 120 words (240 total).

A total of 96 items were used during the recognition memory test phases in the experiment. These 96 items were split evenly between the Item-Specific and Relational encoding conditions, with each individual memory test consisting of 48 memory test items each. For each of these 48 memory test items, 16 were old words that were previously studied, 16 items were unstudied critical lure words, and 16 items were unrelated new words, taken from unused categories from Van Overschelde et al. (2004). Old items were the 6th and 8th item from each categorized list.

2.3. Design & procedure

The experiment was completed in a single 2 h session. There were two conditions, the *Item-Specific* encoding condition and the *Relational* encoding condition. The Item-Specific and Relational conditions were administered as two separate blocks. Each condition consisted of several parts: four study and recall sessions consisting of two lists each, followed by a recognition memory test for all eight lists. Participants were randomly assigned to complete either the Item-Specific or Relational encoding conditions first. The ordering of these conditions was fully counter-balanced.

In the study phase of the Item-Specific encoding condition, participants were told that words would appear on the computer screen and that these words would be organized into sets of categorized lists. For each item that appeared on the screen, participants were instructed to read each word out loud, and then to explain how the item was unique compared to other items seen in that list. Participants were instructed to name at least one unique characteristic of that item. They were told that they could provide a personal experience with the item, or provide at least one characteristic that would differentiate it from other items in that list (e.g., taste, color, texture, etc.). Participants were instructed to provide a unique answer for each item that was presented on the screen. In the Relational encoding condition, participants were given the same instructions with the following modification: they were instructed to explain how the word was related to other words within the same list, or in other words, determine what the words had in common. Participants were told that they could repeat the same answer for each item. Each trial in the study phase began with a 250 ms blank screen, followed by a study word for 2500 ms, which participants were asked to read aloud. A 250 ms blank screen followed the presentation of the word and then they were prompted on the screen to either describe the item’s uniqueness (Item-Specific condition) or how it was related to all other items in the same list (Relational condition). For both conditions, instructions re-appeared on the screen on every study item. Their responses were self-paced. After they provided a response, the experimenter begin the next trial.

After every two categorized study lists, participants were asked to work on a number search puzzle for 1 min. Participants were then given 5 min to recall as many words as possible from the previous two categorized word lists. When the recall period ended, the next two categorized lists were presented. Participants repeated the study and recall phases until all eight lists within the Item-Specific or Relational conditions were presented.

After the last recall phase of each block, participants completed a 5 min filler task consisting of a number puzzle or a maze task. Participants were then administered the recognition memory test. In the recognition memory test, participants were instructed that words would appear on the screen one at a time. They were told to respond “OLD” if they thought the word was one they studied before or “NEW” of they thought the word was one they did not see on the study list. Each trial began with a 500 ms blank screen, followed by the memory probe that would appear on the screen until the participant provided a response. Afterwards, the next memory test trial would begin.

3. Results

3.1. Free recall data

Four types of recall data were analyzed (Table 2). All recall data was analyzed using separate 3 (Group: OCs, patients with MCI, patients with AD) × 2 (Encoding Condition: Item-Specific, Relational) mixed factor analyses of variance (ANOVAs). First, we analyzed the amount of correct recall across encoding conditions. There was a main effect of Group [$F(2,40) = 90.37$, $p < 0.001$, $\eta_{\mathrm{p}}^{2}=0.819$], whereby OCs had higher correct recall compared to patients with MCI and patients with AD. Patients with MCI also had higher correct recall compared to patients with AD [$t(25) = 7.59$, $p < 0.001$, Cohen’s $d = 3.04$]. No main effect was observed for Encoding Condition [$F(1,40) = 1.59$, $p = 0.214$, $\eta_{\mathrm{p}}^{2}=0.038$], nor was there an Encoding Condition × Group interaction [$F(2,40) = 0.358$, $p = 0.701$, $\eta_{\mathrm{p}}^{2}=0.018$].

We also examined the amount of *cross list* false recall. Cross list false recall is defined as recalling an item that was not on the lists immediately preceding the recall period, but was on another word list presented at some point during the experiment. No main effect of Group was observed [$F(2,40) = 1.25$, $p = 0.295$, $\eta_{\mathrm{p}}^{2}=0.059$]. Additionally, there was no significant main effect of Encoding Type, nor was there a significant Encoding Type × Group interaction [$F < 1$, $p > 0.1$ for both respectively].

Next, the amount of general *semantic* false recall was examined. Semantic false recall is defined as the recall of semantically related items associated with the preceding lists that were not the critical lure items or other study items in that list. These items were evaluated by at least two of the authors, and was labeled as a semantically related item if both authors agreed on its relatedness to the category. A main effect of Group was observed [$F(2,40) = 33.45$, $p = 0.018$, $\eta_{\mathrm{p}}^{2}=0.181$]. Follow-up pair-wise comparisons indicated that semantic false recall was marginally lower in OCs compared with patients with MCI [$t(27) = -1.98$, $p = 0.058$, Cohen’s $d = -0.762$], but not compared to patients with AD [$t(27) = 1.07$, $p = 0.29$, Cohen’s $d = 0.412$]. Patients with MCI had significantly higher semantic false recall compared to patients with AD [$t(25) = 2.26$, $p = 0.032$, Cohen’s $d = 0.903$].

Finally, false recall of critical lure items was examined. A significant main effect of Group was observed [$F(2,40) = 4.30$, $p = 0.020$, $\eta_{\mathrm{p}}^{2}=0.177$]. Pair-wise comparisons revealed that OCs had significantly less false recall of critical lure items compared to patients with MCI [$t(27) = -2.22$, $p = 0.035$, Cohen’s $d = -0.854$]. OCs and patients with AD did not significantly differ with respect to the false recall of critical lures [$t < 1$, $p > 0.1$]. Patients with MCI had significantly higher false recall of critical lure items compared to patients with AD [$t(25) = 2.35$, $p = 0.026$, Cohen’s $d = 0.940$]. A significant main effect of Encoding Condition was observed [$F(1,40) = 5.75$, $p = 0.021$, $\eta_{\mathrm{p}}^{2}=0.126$]. Across all groups, false recall of critical lures was higher in the Relational Encoding condition ($M = 1.61$, $SD =$

2.16) compared to the Item-Specific Encoding condition ($M = 1.00$, $SD = 2.16$). No significant Encoding Condition × Group interaction was observed, [$F < 1$, $p > 0.1$].

3.2. True recognition

Mean hit and false recognition rates can be seen in Table 3. A 3 (Group) × 2 (Encoding Condition) mixed factor ANOVA was first conducted on the proportion of “old” responses (true recognition (hit) rates) to studied items. A significant main effect of Group was observed [$F(2,40) = 12.20$, $p < 0.001$, $\eta_p^2=0.379$]. Pair-wise comparisons indicated that OCs had significantly higher hit rates compared to patients with AD [$t(28) = 3.91$, $p = 0.001$, Cohen’s $d = 1.47$]. Patients with MCI also had significantly higher hit rates compared to patients with AD [$t(25) = 3.38$, $p = 0.002$, Cohen’s $d = 1.35$]. Hit rates did not significantly differ between OCs and patients with MCI [$t < 1$, $p > 0.1$]. A significant main effect of Encoding Condition was observed [$F(2,40) = 13.11$, $p = 0.001$, $\eta_p^2=0.247$]. In general, hit rates were higher in the Item-Specific encoding condition ($M = 0.88$, $SD = 0.17$) compared to the Relational encoding condition ($M = 0.81$, $SD = 0.22$). No significant Group × Encoding Condition interaction was observed [$F < 1$, $p > 0.1$].

3.3. False recognition

A 3 (Group) × 2 (Encoding Condition) × 2 (Item Type: Critical Lure Item, Unrelated New Item) mixed factor ANOVA was conducted on the proportion of “old” responses to critical lure and unrelated new items (false recognitions). A significant main effect of Group was observed [$F(2,40) = 5.39$, $p < 0.001$, $\eta_p^2=0.212$]. Pairwise comparisons showed patients with MCI and patients with AD had significantly higher false recognition rates compared to OCs [$t(27) = 2.91$, $p = 0.007$, Cohen’s $d = 1.12$ and $t(28) = 3.16$, $p = 0.004$, Cohen’s $d = 1.19$, respectively]. Patients with MCI and patients with AD did not significantly differ in terms of overall false recognition [$t < 1$, $p > 0.1$]. A main effect of Encoding Condition was observed [$F(1,40) = 6.82$, $p = 0.013$, $\eta_p^2=0.146$], indicating that false recognition was higher in the Relational Encoding condition ($M = 0.32$, $SD = 0.18$) than in the Item-Specific Encoding condition ($M = 0.27$, $SD = 0.19$). A main effect of Item Type was also observed [$F(1,40) = 109.42$, $p < 0.001$, $\eta_p^2=0.732$]. This indicated that false alarms to critical lures ($M = 0.46$, $SD = 0.24$) was higher than false alarms to unrelated new items ($M = 0.13$, $SD = 0.14$).

There was a significant Encoding Condition × Item Type interaction [$F(1,40) = 10.88$, $p = 0.002$, $\eta_p^2=0.214$]. To explore the source of this interaction, two separate repeated measure ANOVAs were conducted for each individual Item Type, comparing false alarm rates across Encoding Conditions. For unrelated new items, no significant main effect of Encoding Condition was observed [$F < 1$, $p > 0.1$]. For critical lure items, there was a significant main effect of Encoding Condition [$F(1,42) = 10.81$, $p = 0.002$, $\eta_p^2=0.205$]. False alarm rates to critical lure items were significantly higher in the Relational Encoding condition ($M = 0.50$, $SD = 0.27$) compared to the Item-Specific Encoding condition ($M = 0.40$, $SD = 0.26$).

Finally, no significant Group × Encoding condition interaction was observed [$F(2,40) = 1.56$, $p = 0.221$, $\eta_p^2=0.073$]. No significant Group × Item Type interaction was observed

[F(2,40) = 1.85, $p = 0.171$, $\eta_p^2 = 0.085$], nor was there a significant three-way Group × Encoding Condition × Item Type interaction [F(2,40) = 2.53, $p = 0.092$, $\eta_p^2 = 0.112$].

3.4. Signal detection analyses

We conducted signal detection analyses to determine if the overall decrease of false alarms and overall increase in hit rates across Encoding Conditions also translated into improved memory discrimination in the Item-Specific versus Relational Encoding condition. Following prior studies that have compared true recognition versus false recognition memory data (e.g., Budson et al., 2000; Koutstaal & Schacter, 1997), we used non-parametric signal detection parameters A' and B_D'' (Macmillan & Creelman, 2005). The parameter A' represents a quantitative measure of memory discrimination. Values of A' vary between 0 and 1 with higher values indicating better memory discrimination (i.e., better discrimination between studied old items and unstudied new items) and chance being 0.5. Using these parameters, we examined *True Memory* (memory discrimination between hits to old items and false alarms to unrelated new items) and *Item-Specific Recollection* (memory discrimination between hits to old items and false alarms to critical lure items). Mean A' values can be found in Fig. 1. The value B_D'' represents a measure of response bias. Meaningful response bias results cannot, however, be discerned in a false memory paradigm such as this one. For completeness, the analyses of B_D'' are in the Supplementary Materials section. They are not discussed.

Separate 3 (Group) × 2 (Encoding Condition) mixed factor ANOVAs were conducted on True Memory A' values. For True Memory A' values, a significant main effect of Group was observed [F(2,40) = 11.82, $p < 0.001$, $\eta_p^2 = 0.372$]. Pair-wise comparisons revealed that OCs showed higher A' values than patients with MCI [t(27) = 2.72, $p = 0.017$, Cohen's $d = 1.05$], who in turn showed higher A' values compared to patients with AD [t(28) = 2.82, $p = 0.011$, Cohen's $d = 1.07$]. No significant main effect of Encoding Condition was observed [F(1,40) = 2.44, $p = 0.126$, $\eta_p^2 = 0.058$], nor was there a significant Group × Encoding Condition interaction [$F < 1$, $p > 0.1$].

Individual 3 (Group) × 2 (Encoding Condition) mixed factor ANOVAs were conducted on Item-Specific Recollection A' values. For Item-Specific Recollection A' values, a significant main effect of Group was observed [F(2,40) = 27.16, $p < 0.001$, $\eta_p^2 = 0.576$]. Pair-wise comparisons revealed that OCs had higher A' values compared to patients with MCI [t(27) = 2.84, $p = 0.008$, Cohen's $d = 1.09$] who in turn showed higher A' values compared to patients with AD [t(25) = 4.05, $p < 0.001$, Cohen's $d = 1.62$]. A significant main effect of Encoding Condition was also observed [F(2,40) = 0.141, $p < 0.001$, $\eta_p^2 = 0.316$]. This effect indicated that A' values were higher in the Item-Specific Encoding condition ($M = 0.81$, $SD = 0.15$) compared to the Relational Encoding condition ($M = 0.73$, $SD = 0.14$). No significant Group × Encoding condition interaction was observed [$F < 1$, $p > 0.1$]. No significant correlations were observed between A' values and data from our neuropsychological battery.

3.5. Post-hoc comparisons in patients with AD dementia

At the suggestion of an anonymous reviewer, additional post-hoc comparisons were conducted to determine if there were differences between in the Item-Specific and Relational conditions for hit rates, false alarm rates to critical lures, and Item-Specific Recollection A' values, specifically in patients with AD dementia. Pair-wise comparisons showed that hit rates in the Item-Specific condition were significantly higher than hit rates in the Relational condition ($t(13) = 2.92$, $p = 0.047$, Cohen's $d = 0.610$). There was no difference between critical lure false alarms in the Item-Specific and Relational conditions ($t(13) < 1$, $p > 0.1$). There was no difference between True Memory A' values in the Item-Specific and Relational conditions ($t(13) = 1.19$, $p = 0.253$). There was no difference between Item-Specific Recollection A' values in the Item-Specific and Relational conditions ($t(13) = 1.42$, $p = 0.179$).

4. General discussion

4.1. Main findings

The goal of the current study was to compare the effectiveness of an Item-Specific encoding strategy to a Relational processing strategy in healthy older adults, patients with MCI due to AD, and patients with mild AD dementia. If one or both patient groups could effectively improve their memory discrimination when using an Item-Specific encoding strategy, this result could lead to practical interventions that could improve overall memory and daily function in patients. Our results revealed that healthy older controls and patients with MCI due to AD could utilize an Item-Specific encoding strategy to improve their memory discrimination, while patients with mild AD dementia could not. We would note that this effect was more apparent in the recognition memory results than the recall results.

For both recall and recognition, we had hypothesized that Item-Specific encoding would increase true memory for studied items and reduce false memory for non-studied items, thereby improving overall discrimination relative to a Relational encoding strategy. It was thought that an Item-Specific strategy would enable participants to better encode perceptual or contextual information more strongly into memory, reducing the influences of gist and the spread of semantic activation. This strategy would therefore improve the availability of memory cues, helping individuals differentiate between actual studied items and self-generated items in memory (i.e., critical lure items).

The recall data revealed two general results. First, healthy older adults had the highest correct recall of old items, followed by patients with MCI due to AD, with patients with mild AD dementia having the lowest overall correct recall. Second, false recall of critical lure items was lower in the Item-Specific encoding condition relative to the Relational encoding condition, consistent with our original hypothesis. (Note, however, that follow-up comparisons of these recall data revealed no differences within each group, potentially due to lack of statistical power. We address this and other related concerns in our limitations section.)

The recognition memory data (specifically, the A' data) provide more detailed insight on the influence of each encoding strategy on false memory. Item-Specific Recollection A' data reveal that healthy older controls and patients MCI due to AD were able to use Item-Specific encoding to strengthen their recollection of details for studied items. This stronger recollection led to improved discrimination between studied and non-studied critical lure items in the Item-Specific encoding condition, relative to the Relational encoding condition.

It is likely that frontal and medial temporal lobe function enable the use of an Item-Specific encoding strategy. These cortical areas remain relatively more intact in healthy older individuals and patients with MCI due to AD, compared with patients with AD dementia. Neuroimaging studies have demonstrated that frontal lobe structures are important for encoding and retrieval strategies, and both frontal lobe and medial temporal regions are important for Item-Specific recollection (e.g., Cabeza, Rao, Wagner, Mayer, & Schacter, 2001; Gallo, Mcdonough, & Scimeca, 2009). In patients with MCI due to AD, volume loss due to cortical atrophy is present mainly in medial temporal lobe structures, though the degree of atrophy is not as severe as in patients with AD dementia. As the disease progresses, and patients convert to more mild or moderate forms of AD dementia, the pathology spreads to the lateral temporal, parietal, and later frontal lobes, causing destruction in these regions as well (Apostolova et al., 2006; Scahill, Schott, Stevens, Rossor, & Fox, 2002). In patients with mild AD dementia, damage to frontal lobe structures is more likely to further impair the efficient implementation of encoding strategies and retrieval monitoring strategies. This idea is consistent with our current data. Patients with MCI due to AD, like older adult controls, are able to engage in an Item-Specific strategy, although the patients' overall discrimination is impaired likely due to some dysfunction of medial temporal lobe structures. Patients with mild AD dementia, however, with more frontal lobe dysfunction—in addition to more medial temporal lobe dysfunction—were unable to make use of an Item-Specific encoding strategy to improve their memory discrimination. Although we did not observe significant correlations between false alarm rates in the Item-Specific encoding condition and our tests of frontal lobe function (e.g., Trail Making Part B, letter fluency), it is possible that our tests lacked the required sensitivity to detect frontal lobe functions that may be involved with the usage of an Item-Specific strategy.

4.2. Gist memory in patients with MCI and AD

Interestingly, false recall of critical lure items in general (irrespective of Encoding Condition) was higher in patients with MCI due to AD compared to patients with mild AD dementia. In addition, in regards to the recall data, encoding manipulations only influenced false recall and correct recall (which diverged from the Item-Specific Recollection A' data). However, we note that patients with AD are functionally on the floor in terms of recall in general. Participants studied 8 lists of words per condition (15 words per list) and patients with AD dementia could only remember approximately 1 per each categorized list.

Our patients' relative level of cognitive impairment and their use of gist may explain the pattern of false recall data. Patients with AD dementia are reliant on gist to inform their memory decisions, but their use of gist information is more impaired than that of patients with MCI due to AD (see Budson et al., 2006; Deason, Hussey, Ally, & Budson, 2012; Pierce, Sullivan, Schacter, & Budson, 2005; Simons et al., 2005). Patients with MCI due to

AD have been shown to extract the gist of categorically related items and use that gist information in a later memory test, exhibiting gist memory performance similar to healthy older adults (Deason et al., 2012) whereas patients with AD are less able to extract and use gist information to inform their memory decisions. In a study by Budson et al. (2006), patients with mild AD dementia studied lists of categorized pictures. In a later memory test, in one condition patients were asked to respond “Yes” if a test item fit a category that they studied previously—regardless of whether it was previously studied. Patients with AD were less likely to endorse test items that fit categories they had studied previously, relative to healthy older controls, indicating impairments in their ability to extract and/or use gist information. Additionally, in a study conducted by Gallo et al. (2006) using DRM lists, the use of gist information was manipulated through organizing study lists in blocks or by associative strength. Blocking and strength manipulations had smaller effects on false recognition in patients with AD dementia compared to healthy older controls, again suggestive of impairment in the use of gist. Another potential explanation for the false recall data is that patients with AD dementia may have degraded semantic networks, impairing their ability to develop semantic gist (Budson et al., 2004).

In terms of differences between false recall and false recognition, if patients with mild AD dementia had the slightest gist memory or familiarity they might falsely endorse the critical lure item as having been studied—which they did to at least half of them. As mentioned previously, patients with AD dementia did not false alarm to all critical lure items due to degradations to stored gist information.

4.3. Self-referential and relational processing

In our study, we gave the option for participants to generate a unique characteristic of each item, or to provide personal experience they have had with the item. Other similar studies have either simply asked to provide a unique characteristic of an item (e.g., Huff & Bodner, 2013) or to determine a specific use for an item (e.g., Thomas & McDaniel, 2013). Although we did not specifically collect data on the type of item-specific information patients used (e.g., autobiographical/self-referential or unique perceptual characteristics) there is some indication that self-referential processing could improve memory. Though patients with mild AD dementia are impaired in more recent autobiographical memory, remote autobiographical memories remain less degraded and can be recalled more readily (e.g., Leyhe, Müller, Milian, Eschweiler, & Saur, 2009). Additionally, studies have shown that when patients with MCI due to AD engage in self-referencing during a memory task, they are able to improve their memory (Kalenzaga, Bugaïska, & Clarys, 2013; Kalenzaga & Clarys, 2013; Rosa, Deason, Budson, & Gutchess, 2014). Future studies are necessary to determine which type of information is more effective when using an Item-Specific encoding strategy.

In contrast to self-referential processing, relational type processing that emphasizes episodic information over semantic information may improve or impair memory in patients with AD in the MCI and mild dementia stages. For example, when participants are asked to generate words to complete sentences, they are more likely to remember sentences in which they generated words compared to sentences in which they did not (Multhaup & Balota, 1997). In contrast to this result, we have shown that elaborative processing can be detrimental to memory in these patients. In O’Connor et al. (2015), participants were asked to perform, imagine, or listen to actions. Later, they re-imagined performing all actions 0, 1, or 3 times (regardless if they performed it, imagined it, or listened to it initially). We found that the more they imagined an action, the more likely they would falsely remember performing the action, even when they did not. Patients may benefit from relational processing only when it limits the processing of semantic information and is self-referential in nature.

4.4. Limitations

Despite having sufficient power for our main findings, one general limitation was the size of our sample population and the potential lack of power for some follow-up analyses. We obtained main effects for Encoding Strategy for the false recall data and recognition memory data (specifically false recognition of critical lures and Item-Specific Recollection A' data). However, follow-up statistical comparisons made clear that patients with AD dementia did not benefit from an Item-Specific encoding strategy.

A second limitation in the current study was the absence of a true baseline condition to assess the effectiveness of an itemspecific encoding strategy compared to no strategy. Although false alarm rates to lures were lower in the Item-Specific compared to the Relational encoding condition in the current study, it is unclear how Item-Specific encoding rates would compare to no strategy. The use of a baseline condition, such as having participants read words silently or aloud, would allow for an evaluation as to whether item-specific encoding yields true positive benefits to memory discrimination. Although Huff and Bodner (2013) showed that item-specific encoding increases hits and reduces false alarms relative to a baseline read-only condition, they examined the use of these strategies in healthy young adults. As noted earlier in our discussion, strategy implementation requires recruitment of frontal lobe regions. Healthy older adults show declines in frontal lobe functioning due to normal aging, and patients exhibit impairments to the frontal lobes due to the progression of AD pathology. Based on evidence showing declines or impairments to the frontal lobes, healthy older adults and patients may not use item-specific encoding as efficiently as their healthy younger peers. It is possible that the hit and false alarm rates in a proposed baseline condition might not differ from that of item-specific encoding. Thus, our Relational Strategy condition may be thought to represent a “straw-man” condition. Because participants are explicitly asked to create semantic relationships between items, strongly enhancing the encoding of gist information, it may be that the effects observed are due to the inflation of false alarm rates due to very explicit semantic encoding, rather than an actual increase in hit rates and decrease in false alarm rates afforded by item-specific encoding. However, even if that were the case, our results still demonstrate that patients with MCI due to AD are able to utilize different strategies that result in different memorial performances, which is likely attributable to these patients’ relatively intact frontal lobe function. Thus, our study’s fundamental finding, that patients with MCI due to AD but not mild AD dementia can use different memory strategies to improve their relative memory performance, remains unchanged.

A final limitation is that our study asked participants to recall studied items prior to recognition testing. Although this method is the same used by prior studies (Balota et al., 1999; Butler, McDaniel, Dornburg, Price, & Roediger, 2004; Norman & Schacter, 1997; Roediger & McDermott, 1995), recall testing could have strengthened gist and promoted source memory confusion (Budson et al., 2000). It is possible that the recognition results may have been different if there was not a prior recall test. However, the actual number of critical lures recalled was quite low across groups and conditions, making it unlikely that the results would have been materially different.

4.5. Conclusions

In summary, the current study extends prior investigations demonstrating that an Item-Specific encoding strategy is able to improve memory discrimination in healthy older adults and in patients with MCI due to AD. Patients with mild AD dementia were less able to utilize this strategy to improve their memory discrimination. These results have direct clinical relevance. To reduce memory distortions and help maximize any residual memory ability, healthy older adults and patients with MCI due to AD can be taught to avoid relational strategies for memory. Instead, they can be taught to focus on specific detailed characteristics of information they might need to remember for later. This strategy may help them to complete daily activities, such as taking the right medications or arriving to a scheduled appointment on time, potentially translating to improved quality of life for patients and their caregivers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.bandc.2016.08.003.

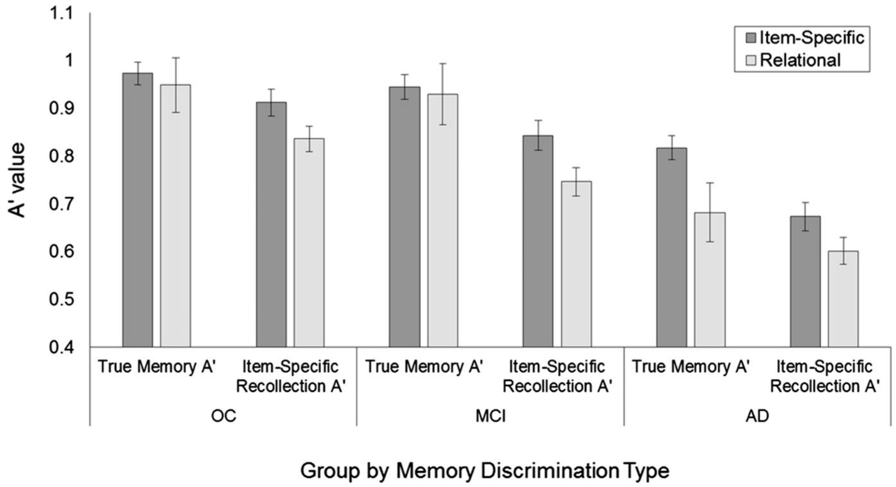

Fig. 1.

The mean discrimination (A') values for healthy older adults, patients with MCI due to AD, and patients with mild AD dementia by Encoding Condition (Item-Specific, Relational) and memory discrimination type (True Memory, Item-Specific Recollection). Error bars are standard errors.

Table 1

Neuropsychological information.

Test	Healthy Older Controls *M* (*SD*)	Patients with MCI *M* (*SD*)	Patients with AD *M* (*SD*)	*p*-Value between Controls and MCI	*p*-Value between MCI and AD
MMSE	28.9 (1.36)	27.5 (1.80)	23.2 (3.42)	0.031	<0.001
CERAD					
Immediate	21.2 (5.11)	16.4 (3.57)	12.8 (3.03)	0.008	0.010
Delayed	7.6 (1.62)	4.0 (1.58)	1.2 (1.42)	<0.001	0.001
Recognition	9.4 (0.89)	8.6 (1.49)	6.6 (1.71)	0.107	0.003
Trails A	40.1 (12.19)	48.8 (17.74)	60.2 (30.07)	0.128	0.248
Trails B	96.5 (36.99)	126.8 (20.98)	240.9 (20.20)	0.170	0.001
Letter Fluency	45.2 (15.82)	39.3 (9.51)	32.1 (2.44)	0.245	0.057
Category Fluency	42.3 (9.11)	34.2 (4.28)	24.4 (6.76)	0.007	0.001
BNT-15					
No cue	14.3 (1.34)	14.1 (1.44)	11.7 (2.33)	0.741	0.004
Semantic cue	0.06 (0.25)	0 (0)	0.07 (0.26)	0.377	0.345
Phonemic cue	0.56 (1.09)	0.38 (0.65)	2.1 (1.23)	0.610	0.001

Note: Values represent means. Standard deviations are in parentheses.

Table 2

Mean recall by group and recall type.

Recall type	**Healthy older controls**		**Patients with MCI**		**Patients with AD**	
	Item-Specific	**Relational**	**Item-Specific**	**Relational**	**Item-Specific**	**Relational**
Correct Recall	65.00 (12.67)	66.93 (9.62)	44.15 (15.73)	47.92 (17.53)	9.64 (8.39)	10.00 (10.35)
Cross List False Recall	1.18 (3.01)	0.438 (0.81)	1.30 (2.32)	1.53 (2.06)	2.21 (3.86)	2.14 (3.30)
Semantic False Recall	1.18 (1.37)	1.75 (1.73)	3.00 (3.89)	3.38 (2.3)	0.64 (1.01)	1.57 (2.44)
Critical Lure False Recall	0.56 (1.03)	1.18 (1.97)	2.00 (2.27)	2.76 (2.74)	0.57 (0.85)	1.00 (1.30)

Note: Values represent mean recall. Standard deviations are in parentheses.

Table 3

Mean proportion of “old” responses by group and item type.

Item type	**Healthy older controls**		**Patients with MCI**		**Patients with AD**	
	Item-Specific	**Relational**	**Item-Specific**	**Relational**	**Item-Specific**	**Relational**
Studied Old	0.961 (0.038)	0.898 (0.096)	0.961 (0.047)	0.894 (0.096)	0.727 (0.233)	0.639 (0.276)
Critical Lure	0.253 (0.190)	0.405 (0.186)	0.485 (0.254)	0.605 (0.280)	0.499 (0.269)	0.511 (0.321)
Unrelated New	0.027 (0.050)	0.058 (0.095)	0.139 (0.153)	0.119 (0.123)	0.219 (0.211)	0.218 (0.189)

Note: Standard deviations are in parentheses.