Neuropsychology
2007, Vol. 21, No. 5, 559–568

0894-4105/07/$12.00 DOI: 10.1037/0894-4105.21.5.559

Retrieval Monitoring and Anosognosia in Alzheimer's Disease

David A. Gallo
University of Chicago

Jennifer M. Chen
Harvard University

Amy L. Wiseman
Allegheny College

Daniel L. Schacter
Harvard University

Andrew E. Budson
Edith Nourse Rogers Memorial Veterans Hospital, Bedford, MA, and Boston University School of Medicine

This study explored the relationship between episodic memory and anosognosia (a lack of deficit awareness) among patients with mild Alzheimer's disease (AD). Participants studied words and pictures for subsequent memory tests. Healthy older adults made fewer false recognition errors when trying to remember pictures compared with words, suggesting that the perceptual distinctiveness of picture memories enhanced retrieval monitoring (the distinctiveness heuristic). In contrast, although participants with AD could discriminate between studied and nonstudied items, they had difficulty recollecting the specific presentation formats (words or pictures), and they had limited use of the distinctiveness heuristic. Critically, the demands of the memory test modulated the relationship between memory accuracy and anosognosia. Greater anosognosia was associated with impaired memory accuracy when participants with AD tried to remember words but not when they tried to remember pictures. These data further delineate the retrieval monitoring difficulties among individuals with AD and suggest that anosognosia measures are most likely to correlate with memory tests that require the effortful retrieval of nondistinctive information.

Keywords: recollection, source memory, false recognition

Patients with Alzheimer's disease (AD) suffer from forgetfulness, disorientation, and a variety of other cognitive deficits that worsen as the disease progresses. Difficulties forming and retrieving episodic memories are well documented in the early stages of the disease, and research indicates that patients with AD are more susceptible to memory errors and distortions than their healthy cohorts (e.g., Balota et al., 1999; Budson, Daffner, Desikan, & Schacter, 2000; Dalla Barba & Wong, 1995; Gallo, Sullivan, Daffner, Schacter, & Budson, 2004; Knight, 1998). Elevated levels of false memories indicate that retrieval monitoring, or the ability to strategically regulate the accuracy of responding, is impaired among individuals with AD. However, relatively little is known about how different components of retrieval monitoring are affected. Can these monitoring deficits be attributed entirely to impaired recollection of studied information, or can they be caused by additional problems in the self-initiation of retrieval strategies, expectations, or other metacognitive skills?

If metacognitive declines influence memory accuracy among individuals with AD, then one would expect a relationship between memory accuracy and anosognosia, a clinical condition characterized by a lack of insight or awareness into one's own cognitive impairments (Kaszniak & Zak, 1996; McGlynn & Schacter, 1989; Pannu & Kaszniak, 2005). It is difficult to specify a prevalence of anosognosia in AD, because of measurement differences, variability in patient populations, and the potentially varied etiologies of anosognosia (Agnew & Morris, 1998; Clare, 2004). Nevertheless, prevalence estimates can be quite high (e.g., 39% in Starkstein et al., 1997), with many studies documenting awareness deficits in the early stages of the disease (e.g., Kalbe et al., 2005; McGlynn & Kaszniak, 1991; Vogel et al., 2004, 2005). Further, several studies have reported increased anosognosia as a function of disease severity or progression (Migliorelli et al.,1995; Reisberg, Gordon, McCarthy, Ferris, & deLeon, 1985; Smith, Henderson, McCleary, Murdock, & Buckwalter, 2000; Starkstein et al., 1997; Vogel et al., 2005). The prevalence of anosognosia in AD has important consequences for memory functioning and quality of life. Depending on whether individuals are aware of their memory problems, they might be more or less likely to engage in monitoring strategies to minimize their memory distortion.

Surprisingly, research has not revealed a consistent relationship between anosognosia and episodic memory performance in patients with AD. The majority of studies in this area have relied on neuropsychological tests of recall or recognition. Although a relationship between poor memory and anosognosia has been reported

David A. Gallo, Department of Psychology, University of Chicago; Jennifer M. Chen and Daniel L. Schacter, Department of Psychology, Harvard University; Amy L. Wiseman, Department of Psychology, Allegheny College; Andrew E. Budson, Geriatric Research Education Clinical Center, Edith Nourse Rogers Memorial Veterans Hospital, Bedford, Massachusetts, and Boston University Alzheimer's Disease Center, Department of Neurology, Boston University School of Medicine.

This research was supported by National Institute on Aging Grants AG021369 (to David A. Gallo), R01 AG025815 and P30 AG13846 (to Andrew E. Budson), and AG08441 (to Daniel L. Schacter) and by a Brigham and Women's Hospital Faculty Award in translational neurosciences (to Andrew E. Budson).

Correspondence concerning this article should be addressed to David A. Gallo, Department of Psychology, University of Chicago, Chicago, IL 60657. E-mail:dgallo@uchicago.edu

(e.g., Feher, Mahurin, Inbody, Crook, & Pirozzolo, 1991; Migliorelli et al., 1995; Reed, Jagust, & Coulter, 1993), the relationship usually is not strong, and failures to find relationships also have been reported (e.g., Derouesné et al., 1999; Starkstein et al., 1995; Vogel et al., 2005). The lack of a definitive link between memory and anosognosia in AD might be attributed to the use of standardized memory tests that typically do not require effortful retrieval monitoring, processes that are known to rely heavily on the frontal lobes. As reviewed by McGlynn and Schacter (1989) and others, frontal lesions are more likely to result in memory-related anosognosia relative to damage restricted to medial temporal regions, suggesting that the frontal lobes are critical for awareness or insight into memory impairments. Consistent with this idea, anosognosia among individuals with AD has been linked to poor performance on several neuropsychological tests of frontal functioning (e.g., Dalla Barba, Parlato, Iavarone, & Boller, 1995; Michon, Deweer, Pillon, Agid, & Dubois, 1994). Neuroimaging studies have provided additional evidence for frontal involvement in anosognosia among individuals with AD. Using single photon emission computed tomography, Reed et al. (1993) found that patients with AD who exhibited some lack of awareness (measured via clinical interviews) had lower perfusion ratios in a right dorsolateral frontal region, compared with fully aware patients, but had minimal or no differences in other regions of interest (see Derouesné et al., 1999, and Starkstein et al., 1995, for similar results).

On the basis of this emerging neurocognitive profile of anosognosia in AD, one would expect that memory tests that require effortful retrieval monitoring, and that thus place heavier demands on frontal processes, would be most likely to correlate with anosognosia. In the present study, we used the criterial recollection task to test this hypothesis (Gallo, Weiss, & Schacter, 2004). In this task, participants studied a list of red words and pictures (see Figure 1) and then took three memory tests with black words as retrieval cues. The tests differed only in terms of the instructions. On the standard test, participants responded "yes" to any test word that was studied, regardless of whether it had been associated with a red font or a picture at study, and "no" to nonstudied words. Participants did not need to recollect specific information on this test, because studied and nonstudied items could be discriminated solely on a feeling of familiarity, without regard to the study context. In contrast, participants needed to search their memory for specific recollections on the other two tests. On the red word test, participants responded "yes" to test words that had been associated with a red font at study, whereas on the picture test they responded "yes" only to test words that had been associated with a picture.

Using this task in young adults, Gallo, Weiss, et al. (2004) found that false recognition errors were lower on the picture test, relative to the red word test. They argued that searching memory for more distinctive recollections (pictures) helped participants to avoid memory confusions, a process called the distinctiveness heuristic (e.g., Schacter, Israel, & Racine, 1999; for a review, see Schacter & Wiseman, 2006). In a subsequent functional magnetic resonance imaging study, Gallo, Kensinger, and Schacter (2006) found that several frontal regions, including dorsolateral prefrontal cortex, were more active on the red word test than on the picture test (and, in some comparisons, the standard test). These results suggest that the red word test was more likely than the other tests to recruit effortful retrieval monitoring processes that rely on prefrontal cortex (cf. Rugg, 2004).

If anosognosia in AD is related to these same frontally based monitoring processes, then the relationship between anosognosia and memory accuracy should be modulated by the demands of the memory test. Specifically, the correlation between anosognosia and memory accuracy should be greatest on the red word test, which is most likely to require frontally mediated monitoring processes, relative to the picture test or to the standard recognition test. This prediction differs from one based exclusively on recollection impairments, without considering metacognitive processes, such as the distinctiveness heuristic. For instance, damage to

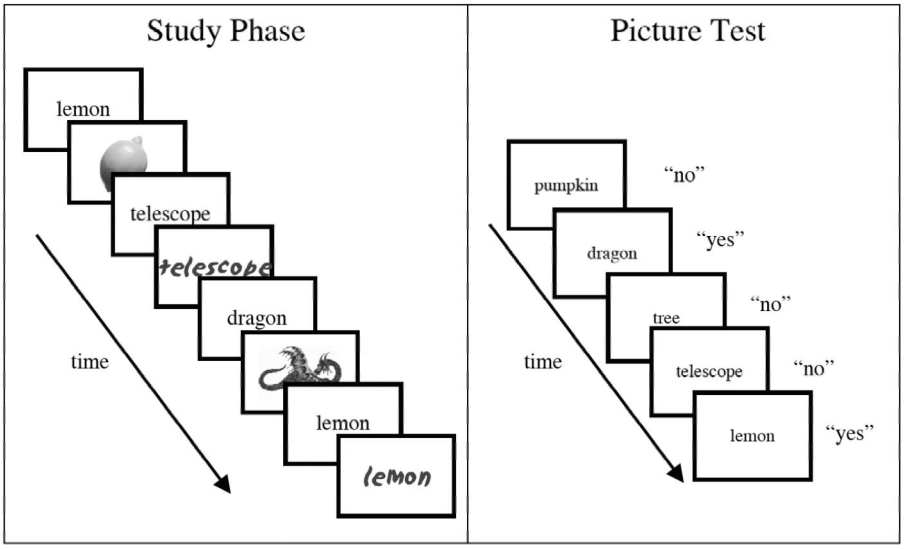

Figure 1. Schematic of the criterial recollection task. At study, each black word was followed by the same word in red letters (depicted in italics) or by a colored picture. Black words were used at test as retrieval cues, under various retrieval instructions (picture test shown, with correct responses in quotes).

medial temporal regions might cause a fundamental deficit in recollection, adversely affecting performance on any test requiring specific recollections, as well as impairing personal memory for one's own cognitive deficits (a potential cause of anosognosia). By this view, performance on the red word test and on the picture test should be equally likely to correlate with anosognosia, because both tests require recollection.

AD and the Distinctiveness Heuristic

In addition to exploring the relationship between anosognosia and memory accuracy, the current study provided a stronger test of whether patients with AD can use the distinctiveness heuristic than did prior studies. Prior research has indicated that healthy older adults are just as likely as younger adults to reduce false recognition when they study pictures relative to words (e.g., Dodson & Schacter, 2002; Schacter et al., 1999), and this pattern has been found by researchers using the criterial recollection task (Gallo, Cotel, Moore, & Schacter, 2007). These findings suggest that the distinctiveness heuristic is relatively spared during healthy aging. The results among patients with AD have been less consistent (Budson, Dodson, Daffner, & Schacter, 2005; Budson, Sitarski, Daffner, & Schacter, 2002). In Budson et al. (2002), participants either studied semantically related words (word condition) or studied these same words accompanied with a distinctive picture of the item (picture condition). In contrast to healthy older adults, patients with AD showed *increased* false recognition after studying pictures, compared with participants in the word condition. Budson et al. (2002) argued that the pictures boosted semantic processing among patients with AD, thereby enhancing semantically based false recognition. To eliminate this possible confound, Budson, Dodson, et al. (2005) used a task consisting of unrelated items. In this study, the patients with AD who studied pictures did show reduced false recognition compared with those who studied words, but true recognition also was reduced, such that the discrimination of the picture group was not improved. Budson, Dodson, et al. (2005) argued that patients with AD were able to engage the distinctiveness heuristic but that their episodic memory impairment limited both the scope and the effectiveness of this strategy.

One potential limitation of these prior studies was that the tasks did not explicitly require participants to use recollection. This is a problematic task design, because compared with studying words, studying pictures may elevate true recognition and reduce false recognition simply because pictures enhance familiarity. As discussed by Gallo, Weiss, et al. (2004), even if participants do not use recollection, they can reduce false recognition by adopting a more conservative familiarity-based response criterion when the to-be-recognized stimuli are more familiar. This interpretative limitation is especially problematic for studies of individuals with AD, because familiarity-based responses are thought to predominate in these individuals (e.g., Knight, 1998; Pierce, Sullivan, Schacter, & Budson, 2005). Thus, prior evidence for a recollection-based distinctiveness heuristic in individuals with AD (e.g., Budson, Dodson, et al., 2005) might instead have reflected familiarity-based responding.

Such familiarity confounds can be minimized with the criterial recollection task. By repeating the red words at study, the researcher can manipulate the relative familiarity of the items independently of recollective distinctiveness (e.g., Gallo, Weiss, et al., 2004). In the current task, we repeated red words at study, so that true recognition of pictures and words would be equated. Thus, participants could not simply use a vague sense of familiarity to discriminate targets from lures on the criterial recollection tests. Instead, they would need to focus on the to-be-recollected information (i.e., detailed recall of either red word or picture presentation). By explicitly focusing participants on the recollection of each type of information, this task also should make it easier for participants with AD to engage the distinctiveness heuristic. Of course, because the criterial recollection task depends on specific or "source" memories, we expected that participants with AD would perform less well than control participants (see, e.g., Dalla Barba, Nedjam, & DuBois, 1999; Multhaup & Balota, 1997). The more central questions were whether participants with AD would show a benefit from distinctive picture stimuli similar to that shown by control participants, and the degree to which performance on the different tests would be related to anosognosia.

Method

Participants

A sample of 24 patients with clinical diagnosis of probable AD and 24 healthy controls participated in the experiment (diagnosis followed U.S. National Institute for Neurological and Communicative Disorders and Alzheimer's Disease Related Disorders Association criteria; McKhann et al., 1984). Patients with AD were recruited from the Memory Disorders Unit at Brigham and Women's Hospital (Boston, MA), and age-matched controls resided in the surrounding community. All participants (and their caregivers, where appropriate) gave written informed consent prior to being in the study, and human subjects review boards at both Brigham and Women's Hospital and Harvard University approved all procedures. The groups were not reliably different in age (control participants, $M = 75.2$ years, range = 56–85; participants with AD, $M = 76.3$ years, range = 59–90, $p > .05$) or years of education (16.8 vs. 15.3, $p > .05$), and they were roughly matched on sex (15 female control participants, 9 female participants with AD). All participants had normal or corrected-to-normal vision. Control participants outperformed participants with AD on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), control participants, $M = 29.4$, range = 28–30; participants with AD, $M = 25.4$, range = 18–30, $t(46) = 6.79$, standard error of measurement (*SEM*) = .586; on the Frontal Assessment Battery (Dubois, Slachevsky, Litvan, & Pillon, 2000), *M*s = 17.9 versus 5.5, $t(46) = 5.17$, $SEM = .452$; and on the three memory subtests of the Consortium to Establish a Registry for Alzheimer's Disease (Morris et al., 1989): immediate recall, *M*s = 21.9 versus 12.4; delayed recall, *M*s = 6.8 versus 1.0; and delayed recognition, *M*s = 9.1 versus 5.9; all *p*s < .001 (note that the three memory subtests were not available for 1 participant in each group). Potential participants were excluded if they had a history of clinical depression, alcohol or drug use, cerebrovascular disease, or traumatic brain damage, or if English was not their primary language. All participants were paid $10 per hour for their participation.

Materials and Design

The experimental design from Gallo, Weiss, et al. (2004, Experiment 2) was adapted. Stimuli were 288 common words and

corresponding colored line drawings (e.g., *telescope, pumpkin*). Each participant studied 216 words, and the nonstudied words were used as control lures on the memory tests. Each study word was presented on the computer screen (black font on a white background) for 700 ms, was immediately followed by the same word in larger red letters (1,500 ms) or by a picture of the object (2,000 ms), and was separated from the next item by a 700-ms interstimulus interval. Pictures were presented longer than red words so that participants would have additional time to process the perceptual features of each object. Out of the 216 study words, one third were studied as red words (red word only), one third were studied as pictures (picture only), and one third were studied (nonconsecutively) as both red words and pictures ("both" items). To minimize familiarity differences between red words and pictures, we presented each red word three times at study. Red words and pictures were mixed throughout the list, and the different item types (and repetitions) were evenly distributed across the study phase.

Test items were presented in three blocks, corresponding to the three types of test. Each test consisted of 96 words, presented in the same black font as in the study phase, with one quarter of the words nonstudied, one quarter associated with both items, one quarter associated with red words, and one quarter associated with pictures. Within each test block, the items were presented randomly for each participant. The test was self-paced, with each item remaining on the screen until a response was recorded. For counterbalancing, each stimulus was rotated across the four study presentation conditions (red word only, picture only, both, nonstudied) and the three tests (standard test, red word test, picture test), resulting in 12 conditions. These conditions were then crossed with two different test orders (standard test, red word test, picture test, or standard test, picture test, red word test), necessitating 24 participants for a complete counterbalancing.

Procedure

Participants were told that they would study a list of items and that they should pay attention to both the words and pictures because their memory would later be tested. The total study phase took approximately 30 min and was divided by two brief breaks. Immediately following the study phase, participants took the standard memory test. They were told that they would be presented with studied (as red words, pictures, or both) and nonstudied items. Regardless of the study format, they were to say "yes" for those items that had been studied and "no" for those items that had not been studied. The experimenter recorded all verbal responses using the keyboard. At the conclusion of the standard test, participants took the criterial recollection tests. They were told that they would see the same types of items as on the standard test, but the instructions were different. For the red word test, they were to say "yes" only if they could remember that the item had been presented as a red word, regardless of whether they remembered a picture (vice versa on the picture test). Because some items had been studied in both formats, participants could not use the recollection of one format to exclude the other. Instead, they had to search their memory carefully for the to-be-recollected format.

Anosognosia Questionnaire

To measure anosognosia, or personal awareness of one's cognitive deficits, each participant with AD and a significant other (usually a spouse or family member) completed confidential surveys that estimated the severity of the participant's cognitive and behavioral deficits in daily living. Participants with AD were surveyed via oral interview, and significant others completed the surveys on paper in a separate session. Questions were drawn from both the Anosognosia Questionnaire—Dementia (AQ–D; Migliorelli et al., 1995) and subscales from the Memory Functioning Questionnaire (Gilewski, Zelinski, & Schaie, 1990), although we consider only the AQ–D here, because it is a more comprehensive measure with demonstrated reliability and validity. This scale contains 30 questions regarding intellectual functioning in everyday life (e.g., problems remembering dates and conversations, orienting to new environments, or balancing checkbooks) as well as behavioral problems (e.g., irritability, lessened interest in hobbies, depression). The frequency with which the participant with AD experienced problems in each dimension was estimated on a range from 0 (*never*) to 3 (*always*). This assessment technique assumes that the significant other has provided a relatively accurate estimate of the participant's deficits, and the participant's total score (across the 30 items) was subtracted from the significant other's total score as an index of the participant's degree of anosognosia (most participants rated their deficits as less severe, relative to the ratings obtained from significant others). Note that it is difficult to distinguish between awareness of deficits and denial of deficits, but the AQ–D has been shown to agree with independent assessments of patients' insight into their deficits, as determined by clinical interviews (see Migliorelli et al., 1995).

Results

Recognition data for each group are presented in Table 1 and were analyzed on the basis of prior results with this task (e.g., Gallo, Weiss, et al., 2004; Gallo et al., 2007). First, to provide an

Table 1
Mean Proportion of Items Recognized in Each Group (n = 24) Under Each Memory Test, Collapsing Across Test Order

Test	Control participants	Participants with AD
Standard test		
Both hits	.93 (.02)	.69 (.04)
Red word hits	.76 (.03)	.52 (.05)
Picture hits	.71 (.03)	.54 (.05)
Nonstudied FAs	.07 (.02)	.28 (.05)
Red word test		
Both hits	.81 (.04)	.51 (.05)
Red word hits	.67 (.04)	.49 (.05)
Picture FAs	.51 (.05)	.46 (.05)
Nonstudied FAs	.11 (.03)	.34 (.06)
Picture test		
Both hits	.77 (.03)	.57 (.04)
Red word FAs	.18 (.04)	.43 (.06)
Picture hits	.63 (.03)	.48 (.04)
Nonstudied FAs	.06 (.02)	.25 (.04)

Note. Standard errors of each mean are in parentheses. FAs = false alarms.

overall picture of performance, we analyzed the data separately for each test, comparing the performance of the two groups. We then directly compared false recognition data across the criterial recollection tests, in order to investigate the use of a distinctiveness heuristic. Preliminary analyses did not reveal any consistent effects of test-block order in either participant group, and so all analyses were collapsed across this variable. Unless otherwise noted, all results were significant at $p < .05$, two tailed.

Standard Test

A 2 (Group) × 4 (Item Type) analysis of variance on data from the standard test revealed a main effect of group, $F(1, 46) = 5.82$, mean square error (*MSE*) = .099; a main effect of item type, $F(3, 138) = 231.46$, *MSE* = .015; and an interaction between the two, $F(3, 138) = 35.93$, *MSE* = .015. As expected, control participants correctly recognized more studied items than did participants with AD, and they were less likely to falsely recognize nonstudied items (all *p*s < .01). For control participants, both hits (*M* = .93) were greater than red word hits (*M* = .76) or picture hits (*M* = .71), because both items were studied in each format (both *p*s < .01). By design, repeating the red words at study equated their recognition performance to pictures, $t(23) = 1.34$, $p = .19$, and all hit rates were greater than false recognition of nonstudied items (*M* = .07, all *p*s < .01). Participants with AD showed item effects similar to those of control participants, and they were able to discriminate studied items from nonstudied items. Both hits (*M* = .69) were greater than red word hits (*M* = .52) or picture hits (*M* = .54), and all three hit rates were greater than false recognition of nonstudied items (*M* = .28, all *p*s < .01). As for control participants, hits to red words and pictures were equated ($t < 1$), which suggests that repetition of red words at study was successful in minimizing familiarity differences between the two classes of items. As discussed, equating memory strength in this way is theoretically important for interpreting false recognition differences across the criterial recollection tests (considered below).

Red Word Test

On the red word test, there was a main effect of item type, $F(3, 138) = 78.31$, *MSE* = .021, and an interaction between item type and group, $F(3, 138) = 28.70$, *MSE* = .021. As on the standard test, control participants correctly recognized more studied items than did participants with AD, and they were less likely to falsely recognize nonstudied items (all *p*s < .01). False recognition of pictures did not differ across groups, $t(46) < 1$. For control participants, both hits (*M* = .81) were greater than red word hits (*M* = .67), $t(23) = 6.35$, *SEM* = .021, $d = 0.73$, as on the standard test. More important, red word hits (*M* = .67) were greater than false recognition of pictures (*M* = .51), $t(23) = 3.27$, *SEM* = .050, $d = 0.76$, demonstrating control participants' significant source recollection. Despite their ability to discriminate between red words and pictures, their false recognition of pictures was greater than their false recognition of nonstudied items (*M*s = .51 and .11), $t(23) = 9.36$, *SEM* = .042, $d = 1.95$, demonstrating the effects of familiarity (via prior presentation) on source confusions. For AD participants, there were no differences between both hits (*M* = .51), red word hits (*M* = .49), or false recognition of pictures (*M* = .46), but all three were greater than false recognition of nonstudied items (*M* = .34, all *p*s < .05). This pattern indicates that participants with AD again were able to discriminate studied items from nonstudied items, but unlike control participants, they were not able to make the source discrimination between red word and pictures. Whereas the former type of discrimination could be based solely on the familiarity of the test word, the latter required the recollection of more specific information about the item's prior occurrence.

Picture Test

On the picture test, there was a main effect of item type, $F(3, 138) = 155.76$, *MSE* = .017, and an interaction between item type and group, $F(3, 138) = 38.02$, *MSE* = .017. Control participants again correctly recognized more studied items than did patients, and they were less likely to falsely recognize nonstudied items (all *p*s < .01). The item effects for control participants were similar to those on the red word test. Both hits (*M* = .77) were greater than picture hits (*M* = .63), $t(23) = 4.96$, *SEM* = .028, $d = 0.88$; picture hits (*M* = .63) were greater than false recognition of red words (*M* = .18), $t(23) = 10.71$, *SEM* = .042, $d = 2.37$; and false recognition of red words (*M* = .18) was greater than false recognition of nonstudied items (*M* = .06), $t(23) = 3.41$, *SEM* = .036, $d = 0.65$. For participants with AD, both hits (*M* = .57) were greater than picture hits (*M* = .48), $t(23) = 2.74$, *SEM* = .03, $d = 0.41$; picture hits (*M* = .48) did not differ from false recognition of red words (*M* = .43), $t(23) = 1.19$, $p = .25$, *SEM* = .047; and all three were greater than false recognition of nonstudied items (*M* = .25, all *p*s < .01). As on the red word test, this pattern indicates that participants with AD were able to discriminate studied items from nonstudied items but that they were not able to make the more fine-grained source discrimination.

Distinctiveness Heuristic

In evaluating the distinctiveness heuristic hypothesis, the critical data are false recognition rates on the criterial recollection tests (i.e., incorrectly saying "yes" to items that were never studied [nonstudied lures] or to items that were only studied in the noncriterial format [studied lures]). A 2 (Group) × 2 (Lure Type) × 2 (Test Type) analysis of variance revealed a main effect of test type (red word test > picture test), a main effect of lure type (studied lure > nonstudied lure), a main effect of group (participants with AD > control participants), and three significant interactions (Lure × Group, Lure × Test, Lure × Group × Test). To follow up these interactions, we analyzed studied lures separately from nonstudied lures.

For studied lures, there was a main effect of test type (red word test > picture test), $F(1, 46) = 16.13$, *MSE* = .049, $\eta_p^2 = .26$, consistent with the distinctiveness heuristic; no effect of group, $F(1, 46) = 3.31$, $p = .08$; and a significant interaction between test type and group, $F(1, 46) = 10.43$, *MSE* = .049, $\eta_p^2 = .19$. The interaction indicates that the distinctiveness effect was found for control participants but not for participants with AD. Among control participants, false recognition of to-be-excluded studied items on the picture test (red word items, *M* = .18) was lower than false recognition of the corresponding items on the red word test (picture items, *M* =.51), $t(23) = 5.13$, *SEM* = .063, $d = 1.46$. Among participants with AD, false recognition of to-be-excluded

studied items was not reliably different on the red word test (picture items, $M = .46$) and on the picture test (red word items, $M = .43$), $t(23) < 1$. These data suggest that control participants used the distinctiveness heuristic to reduce false recognition of familiar lures but that participants with AD did not.

A different pattern emerged on false recognition of nonstudied lures. There was a main effect of participant group, $F(1, 46) = 20.70$, $MSE = .052$, $\eta_p^2 = .31$, indicating that false recognition of nonstudied items was greater among participants with AD ($M = .30$) than among control participants ($M = .09$). There also was an effect of test type (red word test > picture test), $F(1, 46) = 6.37$, $MSE = .020$, $\eta_p^2 = .12$, consistent with the distinctiveness heuristic. Unlike studied lures, though, there was no interaction between group and test type ($F < 1$). The lack of interaction suggests that both groups had used the distinctiveness heuristic to suppress false recognition of nonstudied lures. We examine the implications of these findings in the Discussion section, after presenting analyses of the anosognosia data.

Anosognosia

The average AQ–D score for our sample of patients with AD was 8.3 ($SD = 11.4$, range = −10.3 to 31.5), indicating that participants with AD tended to underestimate the severity of their symptoms, on average, relative to the estimates of their significant other (i.e., they lacked insight into their condition). None of these scores passed the criteria for anosognosia adopted by Migliorelli et al. (1995)—a score equal to or greater than 32—probably because our sample contained relatively high-functioning individuals in the early stages of AD. Nevertheless, there was considerable variability within our sample.

To explore the potential relationship between memory performance and anosognosia, we computed correlations between the AQ–D and three accuracy measures among participants with AD. Discrimination on the standard recognition test was defined as hits to studied items (collapsing across all three target types) minus false recognition of nonstudied lures. Participants did not need to recollect study format (red word or picture) to make this discrimination and instead could have based their decision solely on the familiarity of the test item. Discrimination on the criterial recollection tests was calculated to reflect each participant's ability to recollect the appropriate study format (or source memory), independent of familiarity. On the red word test, this discrimination measure was calculated as hits to items studied as red words only, minus false recognition of items studied as pictures only (and vice versa on the picture test). Because anosognosia has previously correlated with memory errors (Dalla Barba et al., 1995; Reed et al., 1993), we also correlated AQ–D performance with false recognition of studied lures on the two criterial recollection tests. Given a priori predictions, we used directional (one-tailed) tests.

The primary result from these analyses was that the AQ–D correlated negatively with discrimination on the red word test, $r(24) = -.44$, $p = .02$, whereas the AQ–D did not correlate with discrimination on the standard test ($r = .02$) or the picture test ($r = .07$), or with false recognition on the red word test, $r(24) = .31$, $p = .07$, or the picture test, $r(24) = -.18$, $p = .21$. Scatter plots depicting the relationship between memory discrimination and anosognosia on each of these three tests are presented in Figure 2. From this figure, it can be seen that, if anything, the variability in memory accuracy was greater on the picture test than on the red word test, indicating that restriction of range on the picture test was unlikely to mask a relationship with AQ–D scores (also note that discrimination on the standard test was restricted to positive values, reflecting the relative ease of this test). There did appear to be one outlier on the picture test (i.e., the participant with the greatest score on each dimension), but even with this participant excluded, the correlation was high on the red word test, $r(24) = -.45$, $p = .02$, but was not significant on the picture test, $r(24) = -.23$, $p = .14$, or the standard test, $r(24) = -.09$, $p = .34$. To further explore the relationship between anosognosia and red word test performance, we calculated a partial correlation factoring out the influence of dementia severity (measured via the Mini-Mental State Examination) and found that the correlation remained high, $r(24) = -.39$, $p = .03$.[1] Taken as a whole, these findings indicate that participants with less insight were differentially impaired on the red word test.

Discussion

The current results support the hypothesis that the relationship between anosognosia and memory accuracy is modulated by the retrieval demands of the memory task. We found that the degree of anosognosia in participants with AD correlated with their performance on the red word test but not on the picture test or the standard test. Compared with their performance on these other tests, participants were most likely to search their memory for nondistinctive recollections on the red word test. These results are consistent with prior findings that anosognosia correlates negatively with episodic memory performance (e.g., Feher et al., 1991; Migliorelli et al., 1995) and suggest that one factor leading to previous failures to find this relationship may have been the use of memory tests that did not require effortful retrieval monitoring (e.g., standard recognition tests). More generally, these results suggest that realistic expectations about one's own memory abilities can play an important role in one's monitoring of retrieval accuracy.

As discussed in the introduction, both behavioral and neuroimaging evidence suggest that prefrontal cortex is involved in awareness of one's own memory abilities, particularly in dorsolateral regions (e.g., Reed et al., 1993). Neuroimaging evidence from the current task suggests that searching memory for red words is more likely to depend on these same prefrontal regions than is searching memory for distinctive picture recollections (Gallo et al., 2006), a finding consistent with prior findings that dorsolateral prefrontal regions are involved in effortful retrieval monitoring (see also

[1] We also conducted exploratory correlations between the Ansognosia Questionnaire—Dementia (AQ–D) and the neuropsychological assessments (again using directional, one-tailed tests). Consistent with findings reported by Migliorelli et al. and Vogel et al. (1995), we found that the AQ–D correlated negatively with the Mini-Mental State Examination, $r(24) = -.48$, $p = .009$, indicating that participants with more advanced dementia were less aware of their deficits. The AQ–D did not correlate significantly with the Frontal Assessment Battery, $r(24) = -.28$, $p = .09$, or with the three memory subtests of the Consortium to Establish a Registry for Alzheimer's Disease (CERAD), $r(23) = -.30$, $p = .09$, and the sizable correlation between the AQ–D and the Mini-Mental State Examination was maintained after we controlled for the Frontal Assault Battery and CERAD in a partial correlation, $r(23) = -.47$, $p = .03$.

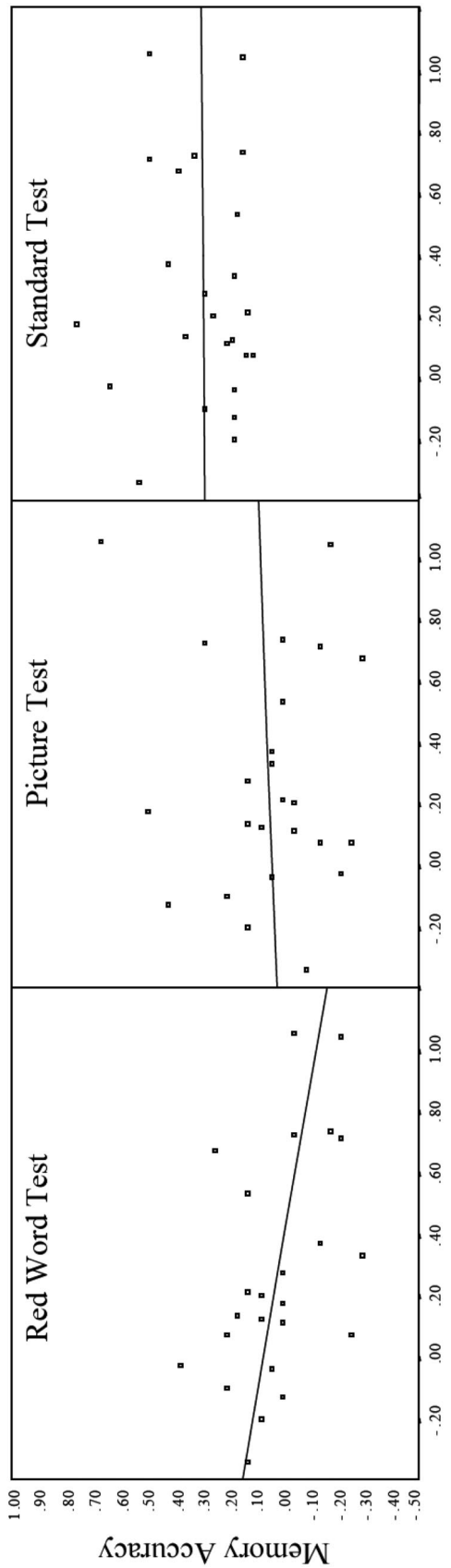

Figure 2. Scatter plots of anosognosia and memory discrimination (hits minus false alarms) on each of the three memory tests. Each patient's anosognosia score represents the average difference between the significant other and the patient on the Anosognosia Questionnaire—Dementia questions. Responses ranged from 0 (*never experience problems*) to 3 (*always experience problems*), and higher discrepancy scores reflect less awareness.

Budson, Droller, et al., 2005; Cansino, Maquet, Dolan, & Rugg, 2002). Considered along with these other results, the current results suggest that anosognosia and effortful retrieval monitoring processes may involve some of the same frontal processes. Our data provide only indirect evidence for this link, but this conclusion is consistent with models of metamemory that are based on the neuropsychological literature. In a recent review of neuropsychological populations, Pannu and Kaszniak (2005) observed that deficits in metamemory tend to be associated with damage to the frontal lobes, as opposed to selective damage to other regions (e.g., medial temporal lesions). They further observed that metamemory deficits are most likely to be observed on memory tests that require participants to search memory for "weak" or difficult items, much like the red word test of the current experiment. From the present perspective, the critical factor is the degree to which the test requires effortful retrieval monitoring processes.

Even though the results of the red word test were consistent with current models of anosognosia, the picture test results require further consideration. The relatively poor memory for pictures shown by participants with AD should have increased their need to monitor retrieval on the picture test, and so one might have expected performance on this test to correlate with anosognosia. This is a reasonable prediction, but as discussed below, there was some evidence for a distinctiveness heuristic on the picture test even in participants with AD, suggesting that the red word test imposed larger retrieval monitoring demands. It also should be emphasized that memory impairments for words and pictures might have a different neurological basis in AD. Impaired recollection among participants with AD likely resulted from damage to medial temporal regions, including the hippocampus, that are affected in the early stages of the disease (e.g., Price & Morris, 1999). These structures, along with prefrontal structures, are critically involved in the encoding and retrieval of episodic memories. However, an additional factor that might contribute to impaired picture recollections among individuals with AD is visual dysfunction (e.g., Cronin-Golomb & Gilmore, 2003; Rizzo, Anderson, Dawson, & Nawrot, 2000). Although our participants reported normal (or corrected to normal) vision and could read all of the words presented on the screen, the participants with AD may nevertheless have had difficulty integrating the complex features of the picture stimuli at encoding, because of deficits in the higher order processing of visual information. Damage to these regions may have added an additional source of variability to their performance on the picture test, one that was not necessarily related to anosognosia.

In addition to linking memory performance to anosognosia in AD, the current experiment furthered our understanding of the distinctiveness heuristic in AD. Healthy older adults made fewer false recognition errors when tested for distinctive memories (pictures) relative to less distinctive memories (red words). These effects replicate prior findings in younger adults (Gallo, Weiss, et al., 2004; Gallo et al., 2006) and suggest that older adults had used the distinctiveness heuristic to suppress false recognition on the picture test. Participants with AD also showed evidence for a distinctiveness heuristic but only for certain types of recognition test items. Consistent with other tasks (Budson et al., 2002; Budson, Dodson, et al., 2005), participants with AD did not show a distinctiveness effect for familiar lures, but unlike with these other tasks, participants with AD did show the predicted distinctiveness effect on relatively less familiar (nonstudied) lures. This outcome suggests that participants with AD did expect more distinctive recollections for pictures (relative to red words) and had used these expectations to inform their memory decisions. Unlike earlier studies, the current task directly tested memory for each of the candidate sources. Providing this sort of retrieval focus may have facilitated the use of recollective expectations for participants with AD.

A question raised by these and other findings is why individuals with AD have not shown the distinctiveness heuristic for familiar lures. One explanation is that participants with AD are biased to guess "yes" more than control participants are, as is evident from the elevated false recognition of nonstudied items in all conditions of the current experiment. This effect is found in many studies of recognition memory in AD (e.g., Budson, Wolk, Chong, & Waring, 2006) and might reflect the desire for participants to perform well in the testing situation. If participants with AD were biased to respond positively to any item that might be a target, one would expect this bias to be greater for items that are familiar, potentially precluding the use of the distinctiveness heuristic. Because nonstudied lures were relatively less familiar, the apparent need to guess "yes" to these items was less intense, allowing the effect of other processes (such as the distinctiveness heuristic) to be detected. As recently discussed by Jacoby et al., both healthy aging and brain damage can leave one more susceptible to the automatic influences of memory (i.e., being "captured" by familiarity), thereby interfering with recollection-based responding (Dockree et al., 2006; Jacoby, Bishara, Hessels, & Toth, 2005). Individuals with AD might be especially prone to such capture, and it is clear across a variety of tasks that participants with AD are more likely than control participants to respond on the basis of familiarity than on the basis of recollection (e.g., Gallo, Sullivan, et al., 2004; Knight, 1998; Pierce et al., 2005).

In conclusion, our results provide additional evidence that memory retrieval and metamemory involve dissociable processes (see Pannu & Kaszniak, 2005). Whereas our participants with AD had severely impaired recollection, they nevertheless demonstrated some use of a metamemory process dubbed the distinctiveness heuristic. Our anosognosia results provide additional evidence for this conclusion, showing that one's subjective awareness of one's cognitive abilities is only sometimes related to objective memory accuracy. Given these findings, further work aimed at understanding the relationship between episodic memory and metacognitive awareness in AD, as well as the neural correlates, seems warranted. If metamemory abilities can be spared, even in the face of retrieval deficits, then some individuals with AD might benefit from interventions that target awareness of those metacognitive processes that remain viable.

References

Agnew, S. K., & Morris, R. G. (1998). The heterogeneity of anosognosia for memory impairment in Alzheimer's disease: A review of the literature and a proposed model. *Aging & Mental Health, 2,* 7–19.

Balota, D. A., Cortese, M. J., Duchek, J. M., Adams, D., Roediger, H. L., III, McDermott, K. B., & Yerys, B. E. (1999). Veridical and false memories in healthy older adults and in dementia of the Alzheimer's type. *Cognitive Neuropsychology, 16,* 361–384.

Budson, A. E., Daffner, K. R., Desikan, R., & Schacter, D. L. (2000). When false recognition is unopposed by true recognition: Gist-based memory distortion in Alzheimer's disease. *Neuropsychology, 14,* 277–287.

Budson, A. E., Dodson, C. S., Daffner, K. R., & Schacter, D. L. (2005). Metacognition and false recognition in Alzheimer's disease: Further exploration of the distinctiveness heuristic. *Neuropsychology, 19,* 253–258.

Budson, A. E., Droller, D. B. J., Dodson, C. S., Schacter, D. L., Rugg, M. D., Holcomb, P. J., & Daffner, K. R. (2005). Electrophysiological dissociation of picture versus word encoding: Understanding the distinctiveness heuristic as a retrieval orientation. *Journal of Cognitive Neuroscience, 17,* 1181–1193.

Budson, A. E., Sitarski, J., Daffner, K. R., & Schacter, D. L. (2002). False recognition of pictures versus words in Alzheimer's disease: The distinctiveness heuristic. *Neuropsychology, 16,* 163–173.

Budson, A. E., Wolk, D. A., Chong, H., & Waring, J. D. (2006). Episodic memory in Alzheimer's disease: Separating response bias from discrimination. *Neuropsychologia, 44,* 2222–2232.

Cansino, S., Maquet, P., Dolan, R. J., & Rugg, M. D. (2002). Brain activity underlying encoding and retrieval of source memory. *Cerebral Cortex, 12,* 1048–1056.

Clare, L. (2004). Awareness in early-stage Alzheimer's disease: A review of methods and evidence. *British Journal of Clinical Psychology, 43,* 177–196.

Cronin-Golomb, A., & Gilmore, G. C. (2003). Visual factors in cognitive dysfunction and enhancement in Alzheimer's disease. In S. Soraci and K. Murata-Soraci (Eds.), *Visual information processing* (pp. 3–34). Westport, CT: Praeger.

Dalla Barba, G., Nedjam, Z., & DuBois, B. (1999). Confabulation, executive functions, and source memory in Alzheimer's disease. *Cognitive Neuropsychology, 16,* 385–398.

Dalla Barba, G., Parlato, V., Iavarone, A., & Boller, F. (1995). Anosognosia, intrusions, and "frontal" functions in Alzheimer's disease and depression. *Neuropsychologia, 33,* 247–259.

Dalla Barba, G., & Wong, C. (1995). Encoding specificity and intrusion in Alzheimer's disease. *Brain and Cognition, 27,* 1–16.

Derouesné, C., Thibault, S., Lagha-Pierucci, S., Baudouin-Madec, V., Ancri, D., & Lacomblez, L. (1999). Decreased awareness of cognitive deficits in patients with mild dementia of the Alzheimer type. *International Journal of Geriatric Psychiatry, 14,* 1019–1030.

Dockree, P. M., O'Keeffe, F. M., Moloney, P., Bishara, A. J., Carton, S., Jacoby, L. L., & Robertson, I. H. (2006). Capture by misleading information and its false acceptance in patients with traumatic brain injury. *Brain: A Journal of Neurology, 129,* 128–140.

Dodson, C. S., & Schacter, D. L. (2002). Aging and strategic retrieval processes: Reducing false memories with a distinctiveness heuristic. *Psychology and Aging, 17,* 405–415.

Dubois, B., Slachevsky, A., Litvan, I., & Pillon, B. (2000). The FAB: A frontal assessment battery at bedside. *Neurology, 55,* 1621–1626.

Feher, E. P., Mahurin, R. K., Inbody, S. B., Crook, T. H., & Pirozzolo, F. J. (1991). Anosognosia in Alzheimer's disease. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 4,* 136–146.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-Mental State," a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198.

Gallo, D. A., Cotel, S. C., Moore, C. D., & Schacter, D. L. (2007). Aging can spare recollection-based retrieval monitoring: The importance of event distinctiveness. *Psychology and Aging, 22,* 209–213.

Gallo, D. A., Kensinger, E. A., & Schacter, D. L. (2006). Prefrontal activity and diagnostic monitoring of memory retrieval: FMRI of the criterial recollection task. *Journal of Cognitive Neuroscience, 19,* 135–148.

Gallo, D. A., Sullivan, A. L., Daffner, K. R., Schacter, D. L., & Budson, A. E. (2004). Associative recognition in Alzheimer's disease: Evidence for impaired recall-to-reject. *Neuropsychology, 18,* 556–563.

Gallo, D. A., Weiss, J. A., & Schacter, D. L. (2004). Reducing false recognition with criterial recollection tests: Distinctiveness heuristic versus criterion shifts. *Journal of Memory and Language, 51,* 473–493.

Gilewski, M. J., Zelinski, E. M., & Schaie, K. W. (1990). The Memory Functioning Questionnaire for assessment of memory complaints in adulthood and old age. *Psychology and Aging, 5,* 482–490.

Jacoby, L. L., Bishara, A. J., Hessels, S., & Toth, J. P. (2005). Aging, subjective experience, and cognitive control: Dramatic false remembering by older adults. *Journal of Experimental Psychology: General, 134,* 131–148.

Kalbe, E., et al. (2005). Anosognosia in very mild Alzheimer's disease but not in mild cognitive impairment. *Dementia and Geriatric Cognitive Disorders, 19,* 349–356.

Kaszniak, A. W., & Zak, M. G. (1996). On the neuropsychology of metamemory: Contributions from the study of amnesia and dementia. *Learning and Individual Differences, 8,* 355–381.

Knight, R. G. (1998). Controlled and automatic memory processes in Alzheimer's disease. *Cortex, 34,* 427–435.

McGlynn, S. M., & Kaszniak, A. W. (1991). When metacognition fails: Impaired awareness of deficit in Alzheimer's disease. *Journal of Cognitive Neuroscience, 3,* 183–189.

McGlynn, S. M., & Schacter, D. L. (1989). Unawareness of deficits in neuropsychological syndromes. *Journal of Clinical and Experimental Neuropsychology, 11,* 143–205.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology, 34,* 939–944.

Michon, A., Deweer, B., Pillon, B., Agid, Y., & Dubois, B. (1994). Relation of anosognosia to frontal lobe dysfunction in Alzheimer's disease. *Journal of Neurology, Neurosurgery & Psychiatry, 57,* 805–809.

Migliorelli, R., Tesón, A., Sabe, L., Petracca, G., Petracchi, M., Leiguarda, R., & Starkstein, S. E. (1995). Anosognosia in Alzheimer's disease: A study of associated factors. *Journal of Neuropsychiatry and Clinical Neurosciences, 7,* 338–344.

Morris, J. C., et al. (1989). The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology, 39,* 1159–1165.

Multhaup, K. S., & Balota, D. A. (1997). Generation effects and source memory in healthy older adults and in adults with dementia of the Alzheimer's type. *Neuropsychology, 11,* 382–391.

Pannu, J. K., & Kaszniak, A. W. (2005). Metamemory experiments in neurological populations: A review. *Neuropsychology Review, 15,* 105–130.

Pierce, B. P., Sullivan, A. L., Schacter, D. L., & Budson, A. E. (2005). Comparing source-based and gist-based false recognition in aging and Alzheimer's disease. *Neuropsychology, 19,* 411–419.

Price, J. L., & Morris, J. C. (1999). Tangles and plaques in nondemented aging and "preclinical" Alzheimer's disease. *Annals of Neurology, 45,* 358–368.

Reed, B. R., Jagust, W. J., & Coulter, L. (1993). Anosognosia in Alzheimer's disease: Relationships to depression, cognitive function, and cerebral perfusion. *Journal of Clinical and Experimental Neuropsychology, 15,* 231–244.

Reisberg, B., Gordon, B., McCarthy, M., Ferris, S. H., & deLeon, M. J. (1985). Insight and denial accompanying progressive cognitive decline in normal aging and Alzheimer's disease. In B. Stanley (Ed.), *Geriatric psychiatry: Clinical, ethical, and legal issues* (pp. 19–39). Washington, DC: American Psychiatric Press.

Rizzo, M., Anderson, S. W., Dawson, J., & Nawrot, M. (2000). Vision and cognition in Alzheimer's disease. *Neuropsychologia, 38,* 1157–1169.

Rugg, M. D. (2004). Retrieval processing in human memory: Electrophysiological and MRI evidence. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (3rd ed., pp. 727–738). Cambridge: MIT Press.

Schacter, D. L., Israel, L., & Racine, C. (1999). Suppressing false recognition in younger and older adults: The distinctiveness heuristic. *Journal of Memory & Language, 40,* 1–24.

Schacter, D. L., & Wiseman, A. L. (2006). Reducing memory errors: The distinctiveness heuristic. In R. R. Hunt and J. Worthen (Eds.), *Distinctiveness and memory* (pp. 89–107). New York: Oxford University Press.

Smith, C. A., Henderson, V. W., McCleary, C. A., Murdock, G. A., & Buckwalter, J. G. (2000). Anosognosia and Alzheimer's disease: The role of depressive symptoms in mediating impaired insight. *Journal of Clinical and Experimental Neuropsychology, 22,* 437–444.

Starkstein, S. E., Chemerinski, E., Sabe, L., Kuzis, G., Petracca, G., Teson, A., & Leiguarda, R. (1997). Prospective longitudinal study of depression and anosognosia in Alzheimer's disease. *British Journal of Psychiatry, 171,* 47–52.

Starkstein, S. E., Vazquez, S., Migliorelli, R., Teson, A., Sabe, L., & Leiguarda, R. (1995). A single-photon emission computed tomographic study of anosognosia in Alzheimer's disease. *Archives of Neurology, 52,* 415–420.

Vogel, A., Hasselbalch, S. G., Gade, A., Ziebell, M., & Waldemar, G. (2005). Cognitive and functional neuroimaging correlates for anosognosia in mild cognitive impairment and Alzehiemer's disease. *International Journal of Geriatric Psychiatry, 20,* 238–246.

Vogel, A., Stokholm, J., Gade, A., Andersen, B. B., Hejl, A-M., & Waldemar, G. (2004). Awareness of deficits in mild cognitive impairment and Alzheimer's disease: Do MCI patients have impaired insight? *Dementia and Geriatric Cognitive Disorders, 17,* 181–187.

Received July 12, 2006
Revision received March 5, 2007
Accepted March 12, 2007 ■