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Alzheimer's disease and memory-monitoring impairment: Alzheimer's patients show a monitoring deficit that is greater than their accuracy deficit☆

Chad S. Dodson[a,*], Maggie Spaniol[b,c,d], Maureen K. O'Connor[b,c,d], Rebecca G. Deason[b,c,d], Brandon A. Ally[e,f,g], Andrew E. Budson[b,c,d]

[a] Department of Psychology, P.O. Box 400400, 102 Gilmer Hall, University of Virginia, Charlottesville, VA 22904-4400, United States
[b] Center for Translational Cognitive Neuroscience, Geriatric Research Education Clinical Center, Bedford VA Hospital, Bedford, MA, United States
[c] VA Boston Healthcare System, Boston, MA, United States
[d] Boston University Alzheimer's Disease Center, Boston University School of Medicine, Boston, MA, United States
[e] Department of Neurology, Vanderbilt University, Nashville, TN, United States
[f] Department of Psychology, Vanderbilt University, Nashville, TN, United States
[g] Department of Psychiatry, Vanderbilt University, Nashville, TN, United States

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ABSTRACT

We assessed the ability of two groups of patients with mild Alzheimer's disease (AD) and two groups of older adults to monitor the likely accuracy of recognition judgments and source identification judgments about who spoke something earlier. Alzheimer's patients showed worse performance on both memory judgments and were less able to monitor with confidence ratings the likely accuracy of both kinds of memory judgments, as compared to a group of older adults who experienced the identical study and test conditions. Critically, however, when memory performance was made comparable between the AD patients and the older adults (e.g., by giving AD patients extra exposures to the study materials), AD patients were still greatly impaired at monitoring the likely accuracy of their recognition and source judgments. This result indicates that the monitoring impairment in AD patients is actually worse than their memory impairment, as otherwise there would have been no differences between the two groups in monitoring performance when there were no differences in accuracy. We discuss the brain correlates of this memory-monitoring deficit and also propose a Remembrance–Evaluation model of memory-monitoring.

Much research has documented the costs to memory from Alzheimer's disease (AD). Individuals with AD are less likely than age- and education-matched controls to recognize or recall previously encountered events (Budson, Wolk, Chong, & Waring, 2006). AD patients also show difficulty remembering source information – specific information about the exact circumstances under which an event was encountered (e.g., Johnson, Hashtroudi, & Lindsay, 1993). They are less able than controls to remember: (a) whether an item was previously seen or imagined (e.g., Dalla Barba, Nedjam, & Dubois, 1999), (b) whether a sentence was completed by oneself or by another (e.g., Multhaup & Balota, 1997), (c) whether words had been previously presented in a red or green color (Tendolkar et al., 1999), (d) whether a fact was said by a man or a woman (Mitchell, Sullivan, Schacter, & Budson, 2006), (e) whether a word was presented during one task or another (Pierce, Sullivan, Schacter, & Budson, 2005; Pierce, Waring, Schacter, & Budson, 2008), (f) whether an item was presented during the study or test session (Budson, Dodson, Daffner, & Schacter, 2005), and (g) source information outside of the laboratory (Budson et al., 2004, 2007; see Souchay & Moulin, 2009, for a review).

Although the memory deficit from AD is increasingly clear, what is not clear is the extent to which AD patients are aware of this memory deficit. In other words, how well can AD patients monitor and judge the likely accuracy of memories? To foreshadow our results, this paper shows that AD patients are strikingly unaware of the accuracy of their memories. Even when their recognition performance is comparable to that of an older control group, AD patients are unable to distinguish between correct and incorrect recognition responses.

Reliably monitoring one's memory is critically important for knowing how much to trust a particular memory. One problem in particular that patients with AD experience is a high percent-

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* Corresponding author.
E-mail address: cdodson@virginia.edu (C.S. Dodson).

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age of false memories, both in the laboratory (Budson, Daffner, Desikan, & Schacter, 2000) and in the real world (Budson et al., 2007). For instance, patients who falsely remember that they have already turned off the stove or have taken their medications when they have not will no longer be able to live independently. However, accurately monitoring memories is a potential mechanism for counteracting the influence of false memories when, for example, individuals are aware that a particular memory is likely to be false. Thus, understanding the extent to which patients with AD can monitor and judge the accuracy of their memories is an important clinical issue in addition to being of great theoretical interest.

The small literature that has examined memory-monitoring on the part of Alzheimer's patients has produced conflicting findings (see Pannu & Kaszniak, 2005; Souchay, 2007 for reviews). On the one hand, patients with mild AD appear no different from healthy controls in using confidence ratings to judge the likely accuracy of answers to general knowledge questions (e.g., Who wrote *Alice in Wonderland*?) that assess well-learned or semantic information (Backman & Lipinska, 1993; Lipinska & Backman, 1996; see also Cosentino, Metcalfe, Butterfield, & Stern, 2007). Similarly, Moulin, James, Perfect, and Jones (2003) observed no differences between AD participants and healthy older controls in monitoring the accuracy of recognition judgments. On the other hand, Souchay, Isingrini, and Gil (2002) showed that AD patients were impaired in monitoring episodic memories. When completing a cued-recall test of recently learned material, AD patients were much less accurate than older controls in providing feeling-of-knowing (FOK) judgments about the likelihood of recognizing an unrecallable item (Souchay et al., 2002). To our knowledge, no one has examined AD patients' ability to monitor the likely accuracy of source judgments.

In general, this pattern of AD patients – when compared to healthy older adults – showing a preserved ability to monitor the accuracy of semantic memories but an impaired ability to monitor the accuracy of episodic memories parallels a similar pattern that exists when healthy older adults are compared to younger adults. Older adults are either no different from or better than younger adults in monitoring the accuracy of responses to general knowledge questions – either with confidence ratings or by providing FOK judgments (e.g., Allen-Burge & Storandt, 2000; Butterfield, Nelson, & Peck, 1988; Dodson, Bawa, & Krueger, 2007; Perlmutter, 1978; Pliske & Mutter, 1996). However, older adults are much worse than younger adults in monitoring the accuracy of recently learned (episodic) material: (a) they provide less accurate FOK judgments on cued-recall tests (Souchay, Isingrini, & Espagnet, 2000); and (b) their confidence ratings are less well calibrated on both cued-recall tests and source memory tests because of the occurrence of high-confidence errors (Dodson, Bawa, & Krueger, 2007; Dodson, Bawa, & Slotnick, 2007; see also Dodson & Krueger, 2006). Dodson, Bawa, and Krueger (2007) and Dodson, Bawa, and Slotnick (2007) proposed a misrecollection account to explain the pattern of older adults' monitoring performance. They suggested that advancing age is associated with an increased susceptibility of miscombining features of different events that in turn produce confidently held misrecollections – memory problems that are likely caused by deterioration of the hippocampus and surrounding tissue (e.g., Shimamura & Wickens, 2009; Squire, Stark, & Clark, 2004; and see Raz et al., 2005 for evidence of accelerated shrinkage of the hippocampus with healthy aging). This account predicts age-related differences in monitoring performance – *because of the occurrence of high confidence errors* – on all tests that require memory for specific details about recently learned past events, such as source memory tests.

The goals of the present study are twofold. First, given the similarity between older adults and AD patients in that both show relatively preserved monitoring of semantic memories and impaired monitoring of episodic memories (when compared to their respective control groups), we sought to test the misrecollection account as an explanation of the monitoring performance on the part of AD patients. Specifically, if AD patients show a more severe version of the same misrecollection impairment that is exhibited by older adults then we should observe that on a source memory test AD patients are more prone than older adults to make high confidence errors.

The second goal is to examine whether the memory-monitoring deficit in AD patients is a byproduct of their overall weaker memory performance or whether this memory-monitoring deficit is a byproduct of a more specific, malfunctioning memory-monitoring mechanism. The answer to this question is unknown because in all extant studies AD patients show worse memory performance than their healthy older counterparts. Thus, worse memory-monitoring by AD patients may be a byproduct of their worse accuracy (see Hertzog, Dunlosky, & Sinclair, 2010 for a similar argument about differences in memory-monitoring between older and younger adults). No study has sought to compare the memory-monitoring abilities of AD patients and healthy older adults when both groups show comparable memory performance.

To address these goals, we used a combination recognition and source identification paradigm that involves collecting confidence ratings for *both* memory judgments (e.g., Dodson, Bawa, & Krueger, 2007; Simons, Peers, Mazuz, Berryhill, & Olson, 2010). At encoding, participants heard sentences that were presented by either a female or a male. At test, participants were presented with sentences and made an initial old–new recognition judgment (i.e., Did you encounter it before or is it new?) and for items receiving a judgment of old, participants made a source judgment about who presented the item earlier (i.e., male or female?). For both the recognition and the source judgments, participants rated the likely accuracy of their responses on a confidence scale from 50 (guessing) to 100 (certain). According to our misrecollection account, we should observe that AD patients make more high confidence errors than healthy older adults on the source judgment. Critically, if the monitoring impairment on the part of AD patients is not merely a byproduct of their worse accuracy then we should observe that even when AD patients and healthy older adults show comparable source identification accuracy, the AD patients still will exhibit a monitoring impairment. In other words, matching the AD patients and the older adults on source memory accuracy avoids a potential confound and so any observed differences in monitoring performance on this judgment cannot be attributed to differences in source accuracy.

1. Methods

1.1. Participants

The participants consisted of twenty-four clinically diagnosed, mild AD patients (age range from 56 to 86) who were assigned to either the AD group or the AD-m group (i.e., 12 in each group). Twenty-four healthy older adults (age range from 62 to 90) were assigned to either the Older group or the Older-m group (i.e., 12 in each group). Each group consisted of 6 females and 6 males, except in the AD-m group where there were 5 females and 7 males. The AD group and the older group experienced the identical study and test conditions. By contrast, the AD-m group received extra repetitions of the encoding material so as to boost their memory performance to that of the older adult group. Likewise, the Older-m group received a longer study list that served to lower and match their memory performance to that of the AD group. We assessed overall cognitive ability with the following neuropsychological tests: the Mini-Mental State Examination (MMSE), the Consortium to Establish a Registry for Alzheimer's disease (CERAD) word list memory test, the Boston Naming Test-Short Form 15 (BNT-15), Word Fluency (FAS/CAT), Trail Making Test-A (TMT-A), and Trail Making Test-B (TMT-B).[1] Inclusion in either

[1] These data were acquired from the AD patients and the healthy older adults within the preceding 6 months and 12 months, respectively, of completing this study. Apart from scores for age, education and the MMSE, the remaining neuropsychological scores are missing for 1 patient in the AD-m group.