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Short title: repetition

Repeated recall on source misattribution in Alzheimer's disease

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We assessed the effect of repeated recall on item memory and source monitoring in Alzheimer's disease (AD). AD patients and controls were instructed to either look at or imagine items. They then had to either retrieve the items without indicating their source in three consecutive free recall tests, or to remember the source of the retrieved items in three consecutive source tests. Results showed a significant increase in item memory across all three free recall tests and all three source monitoring tests in control participants, but not in AD patients. More source misattributions were observed in AD patients and controls in the third source test than in the first and second tests. The absence of beneficial effect of repeated recall on item memory in AD patients may be attributed to compromise in memory consolidation processes, while the increase in source misattributions due to repetitions may be attributed to the inflation effect.

Keywords: Alzheimer's disease; repetition; repeated recall; source memory; source monitoring

Source monitoring refers to the ability to remember the context in which an event took place (e.g., where, when, or how an event was originally encoded) (Glisky, Rubin, & Davidson, 2001; Johnson, Hashtroudi, & Lindsay, 1993). Research has demonstrated compromise of source monitoring in Alzheimer's disease (AD) (El Haj & Kessels, 2013). In a pioneering study (Goldman, Winograd, Goldstein, O'Jile, & Green, 1994), AD patients and controls were asked to remember whether facts were originally self- or experimenter-read. Results showed more difficulties in AD patients than in controls. In another study (Multhaup & Balota, 1997), AD patients and controls were asked to either complete sentences with the first word that came to their mind or watch the experimenter complete other sentences. Participants then had to remember whether words were previously processed by themselves or by the experimenter. Results demonstrated more difficulties in AD patients than in controls to attribute words to the correct source.

Studies on source monitoring have also demonstrated difficulties in AD patients to remember whether an event was originally enacted or imagined. In a study (Dalla Barba, Nedjam, & Dubois, 1999), AD patients and controls viewed or imagined pictures of objects. In a recognition test, they then had to decide whether these pictures had previously been seen or imagined. Results showed compromised source monitoring in AD patients. Similar findings were observed in another study in which AD patients and controls were asked to perform actions (e.g., folding a paper) or imagine performing these actions (Fairfield & Mammarella, 2009). In a subsequent recognition test, AD patients showed difficulties in remembering whether the imagined actions had really been enacted or just imagined. These findings were mirrored in another study, in which AD patients and controls were also asked to perform actions (e.g., holding a pen) or imagine performing these actions (El Haj, Fasotti, & Allain, 2012). In a subsequent recognition test, AD patients showed a

compromised ability to remember whether these actions had actually been enacted or imagined. That difficulty was also observed in a study in which AD patients and controls had to either listen to statements depicting actions (e.g., fill the pillbox), perform actions, or imagine performing these actions (O'Connor et al., 2015). In a subsequent recognition test, participants had to remember whether these actions had been performed or not during the previous session. Results showed compromised source monitoring in AD patients. Altogether, this research demonstrates a difficulty of AD patients to remember whether an event has previously been enacted or imagined.

Considering the compromised source monitoring in AD, our paper investigated whether repeated recall of source was associated with benefits in AD patients. It followed on from a study by Henkel (2008), who asked younger adults and healthy older adults to look at or imagine pictures. Participants then took three successive recall tests in which they either indicated the source of each remembered item (i.e., source recall tests) or recalled the pictures without having to specify their source (i.e., free recall tests). Unlike the first and second free recall tests, the third test required source specification to compare whether source monitoring would be better after the third source monitoring test than after the third free recall test. Results showed that item recall increased systematically across all three free recall tests, as well as across all three source tests. However, the increase was lower for older adults, who recalled fewer items overall. Results also showed that older adults made more source misattributions when the repeated tests did not require specification of the source of retrieved items (i.e., in the third free recall test) than when they did require such specification (i.e., in the third source monitoring test).

Building on the work of Henkel (Henkel, 2008), the aim of this study was to assess the effect of repeated recall on item memory and source monitoring in AD. This issue is of clinical interest since repetition might be found to alleviate memory compromise in AD. To this end, we

asked AD patients and controls to either look at or imagine items (see Figure 1). Half of the participants then had to retrieve the items without indicating their source in two consecutive free recall tests. In the third consecutive free recall test, they had to remember the items as well as their sources. The other half of the participants had to remember the source of the retrieved items in three consecutive source recall tests. Thanks to this experimental design, we first assessed item recall across the three successive free recall and source monitoring tests, to determine whether participants showed improved recall across tests. We also compared source misattributions in the third source recall test with source misattributions in the third free recall test, to determine in what type of tests participants made fewer errors. We then assessed variations of source misattributions across the three source monitoring tests.

INSERT FIGURE 1 HERE

Method

Participants

The study included 26 participants with a clinical diagnosis of probable mild AD (18 women and 8 men; M age = 73.42 years, SD = 6.81; M years of formal education = 8.77, SD = 2.73) and 30 control older adults (23 women and 7 men; M age = 71.40 years, SD = 7.92; M years of formal education = 9.93, SD = 2.96). AD participants were recruited from local retirement homes. They were diagnosed with probable AD dementia by an experienced neurologist or geriatrician based on NINCDS-ADRDA clinical criteria (McKhann et al., 2011). Control participants were often spouses or companions of AD participants. They were independent and living at home. These participants were matched with the AD participants according to gender [X^2 (1, N = 56) = .70, p > .10], age [t (54) = 1.02, p > .10] and educational level [t (54) = 1.52, p > .10].

All participants freely consented to participate and were able to withdraw whenever they wished, in compliance with the declaration of Helsinki. Exclusion criteria were significant neurological or psychiatric illness, history of alcohol or drug use, and major visual or auditory acuity difficulties that could have prevented assessment. Cognitive characteristics of all participants were assessed with a comprehensive battery detailed below.

Procedures

Cognitive assessment

Assessment included tests of general cognitive functioning, episodic memory, working memory, shifting and depression. General cognitive functioning was assessed with the Mini Mental State Exam (MMSE) and the maximum score was 30 points (Folstein, Folstein, & McHugh, 1975). Verbal episodic memory was evaluated with the task of Grober and Buschke (1987), in which participants had to retain 16 words, each of which described an item that belonged to a different semantic category. After immediate cued recall, participants proceeded to a distraction phase, during which they had to count backwards from 374 in 20 seconds. This distraction phase was immediately followed by two minutes of free recall; a score out of 16 provided a measure of episodic recall. In the working memory assessment, participants had to repeat a string of single digits in the same order (i.e., forward spans) or in reverse order (i.e., backward spans). The score referred to the number of correctly repeated digits. Shifting (executive function) was assessed with the Plus–Minus task. The score referred to the difference between the time for List 3 (shifting between additions and subtractions) and the average times for Lists 1 (additions) and 2 (subtractions). For assessment of depression, the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983) was administered. This evaluation consists of seven items assessing depression. The latter were scored by participants on a four-point scale from 0 (not

present) to 3 (considerable) and the cut-off for anxiety and depression was set at $> 10/21$ points (Herrmann, 1997). Scores on clinical and cognitive tasks are summarized in Table 1.

INSERT TABLE 1 HERE

Source monitoring

Our procedures replicated those of Henkel (2008). We used 30 PowerPoint slides: 15 for perception trials and 15 for imagery trials. In the perception trials, each slide depicted a simple colored drawing of an object with its name written beneath. In the imagery trials, the name of the object was presented at the bottom of the slide with no drawing above. Objects were chosen based on their semantic frequency (Content, Mousty, & Radeau, 1990) and on their imaginability. The ease of creating visual images for these objects was controlled in our previous research in healthy older adults and AD patients (El Haj, 2016; El Haj, Caillaud, Verny, Fasotti, & Allain, 2016; El Haj, Fasotti, & Allain, 2015; El Haj, Postal, & Allain, 2013). We preferred using 30 objects rather than 60, as in the study by Henkel (2008), in order to alleviate the cognitive load for AD patients. We also tried to avoid physical similarity (e.g., magnifying glass and lollipop) and conceptual similarity of objects (e.g., banana and apple), as both healthy older adults and AD patients have been found to be vulnerable to similarity-based source confusions (Gilet et al., 2016; Henkel, 2007, 2008; Lyle, Bloise, & Johnson, 2006). The number of objects and their conceptual dissimilarity were also based on the episodic memory task of Grober and Buschke (1987), which includes 16 items belonging to different semantic categories.

Participants were told that they would be shown a series of slides and that they had to either look at the objects or mentally imagine them. Each slide was shown for seven seconds. Participants were explicitly informed that they had to remember the objects as well as their processing modality

(i.e., whether they were seen or imagined). Explicit encoding was chosen to improve performance and avoid any ceiling effect in AD patients (for similar procedures, see (El Haj, Gandolphe, Allain, Fasotti, & Antoine, 2015). Immediately after the slides were shown (see Figure 1), participants were randomly assigned to either three free recall tests or three source recall tests. In the three free recall tests, participants were asked to recall as many items as possible, regardless of whether they had been seen or imagined. In the third test, they also had to decide whether each retrieved item had actually been seen or imagined. In the three source recall tests, they were asked to recall the items and decide whether each recalled item had been seen or imagined. There was no time constraint for retrieval in the free tests or in the source monitoring tests. At the end of the first two free recall and source recall tests, participants were allocated one minute to think about the items from the slide presentation and try to retrieve more.

Results

We first assessed item recall in the three successive free recall and source monitoring tests, to determine whether participants showed gains in recall across tests. We also compared source misattributions in the third source recall test to source misattributions in the third free recall test, to determine in what type of test participants made fewer errors. We finally assessed variations of source misattributions across all three source tests. Analyses were carried out with non-parametric tests, owing to abnormal distribution of data. Between-group comparisons were performed using the Mann-Whitney U test. Within-group comparisons were performed using the Friedman test followed by Wilcoxon signed rank tests. Significant comparisons were reported with effect size: $d = 0.2$ can be considered a small effect size; $d = 0.5$ represents a medium effect size; and $d = 0.8$ refers to a large effect size (Cohen, 1988). Cohen's d was calculated for non-parametric tests

following recommendations by Rosenthal and DiMatteo (2001) and Ellis (2010). For all tests, level of significance was set at $p \leq 0.05$ and p values between 0.051 and 0.099 were considered as trends.

Item memory gains across tests in controls, not in AD patients

Proportions of correct recall of items in the three free recall tests and the three source recall tests are shown in Table 2. In AD patients, analyses revealed similar item recall across all three free recall tests [$X^2(2, N = 26) = 1.80, p > .10, \text{Cohen's } d = .54$]. and across all three source monitoring tests [$X^2(2, N = 26) = 2.13, p > .10$]. However, control participants showed improved item recall across all three free recall tests [$X^2(2, N = 30) = 20.39, p < .001, \text{Cohen's } d = 2.82$]. Post-hoc comparisons showed higher item memory in the third test than in the second one ($Z = 2.65, p < .01, \text{Cohen's } d = .75$) and the first one ($Z = 3.59, p < .01, \text{Cohen's } d = 1.09$), and in the second test than in the first one ($Z = 2.60, p < .01, \text{Cohen's } d = .74$). Control participants also showed improved item recall across all three source recall tests [$X^2(2, N = 30) = 6.49, p < .05, \text{Cohen's } d = 1.05$]. Post-hoc comparisons showed higher item memory in the third test than in the second one ($Z = 2.34, p < .05, \text{Cohen's } d = .65$) and the first one ($Z = 2.87, p < .01, \text{Cohen's } d = .83$), and in the second test than in the first one ($Z = 1.79, p = .075, \text{Cohen's } d = .49$). No significant differences were observed between item recall in the three free recall tests and in the three source recall tests, in both AD patients ($Z = .28, p > .10, \text{Cohen's } d = .11$) and in controls ($Z = .11, p > .10, \text{Cohen's } d = .10$). AD patients showed lower item memory than controls in the first free recall test ($Z = 2.14, p < .05, \text{Cohen's } d = .59$), in the second free recall test ($Z = 2.55, p < .05, \text{Cohen's } d = .72$), in the third free recall test ($Z = 3.01, p < .01, \text{Cohen's } d = .87$), in the first source recall test ($Z = 2.24, p < .05, \text{Cohen's } d = .62$), in the second source recall test ($Z = 3.08, p < .01, \text{Cohen's } d = .87$), and in the third source recall test ($Z = 3.27, p < .01, \text{Cohen's } d = .92$).

INSERT TABLE 2 HERE

Fewer source misattributions in the third source test than in the third free recall test in controls but not in AD patients

Proportion of source misattributions, depicted in Figure 2, referred to: (proportion of seen items that were erroneously considered as imagined + proportion of imagined items that were erroneously considered as seen)/30, i.e., the total number of items. Analyses revealed fewer source misattributions in control participants who took repeated source recall tests than in those who took repeated free recall tests ($Z = 2.09, p < .05$, Cohen's $d = .55$). However, no such effect was observed in AD patients ($Z = .09, p > .10$, Cohen's $d = .03$). Controls thus demonstrated better source monitoring after source recall tests than after free recall tests.

INSERT FIGURE 2 HERE

More source misattributions across source recall tests in AD patients and controls

As depicted in Figure 2, AD patients demonstrated more source misattributions across all three source recall tests [$X^2(2, N = 26) = 10.04, p < .01$, Cohen's $d = 1.58$]. Post-hoc comparisons showed similar source misattributions in the first test and in the second one ($Z = 1.46, p > .10$, Cohen's $d = 1.59$). However, there were more source misattributions in the third test than in the first one ($Z = 2.76, p < .01$, Cohen's $d = .68$) and the second one ($Z = 2.61, p < .01$, Cohen's $d = .66$). Controls also demonstrated more source misattributions across all three source recall tests [$X^2(2, N = 26) = 10.04, p < .01$, Cohen's $d = 1.58$]. Post-hoc comparisons showed similar source misattributions in the first test and in the second one ($Z = .93, p > .10$, Cohen's $d = .34$). However, there were more source misattributions in the third test than in the first one ($Z = 3.31, p < .001$, Cohen's $d = .70$) and the second one ($Z = 2.69, p < .01$, Cohen's $d = .63$). More source misattributions were observed in AD patients than in controls in the first source recall test ($Z =$

3.74, $p < .001$, Cohen's $d = .53$), in the second source recall test ($Z = 3.81$, $p < .001$, Cohen's $d = 1.09$) and in the third source recall test ($Z = 3.01$, $p < .01$, Cohen's $d = .55$). Altogether, more source misattributions were observed in the third source test than in the first and second tests in both AD patients and controls.

Further analysis

For convenience, and because patients with AD demonstrated higher depression scores compared to controls, we assessed potential relationship between depression and item/source memory. Spearman's correlations demonstrated no significant correlations between depression and the mean correct recall of items in the three free recall tests ($r = -.14$, $p > .10$) or the mean source recall in patients with AD ($r = -.11$, $p > .10$). No significant correlations between depression and the mean correct recall of items in the three free recall tests ($r = -.11$, $p > .10$) or the mean source recall ($r = -.09$, $p > .10$) in controls.

Discussion

This study investigated the effect of repetition on item memory and source monitoring in AD patients. Several findings were observed. First, unlike AD patients, controls demonstrated significantly increased item memory across all three free recall tests and across all three source monitoring tests. Second, again unlike AD patients, fewer source misattributions were observed in controls who took repeated source recall tests than in those who took repeated free recall tests. Finally, more source misattributions were observed in both AD patients and controls in the third source test than in the first and second tests.

The absence of item memory improvement in AD patients across both free recall tests and source monitoring tests can be compared with the results of a study assessing effects of rehearsal on memory in AD (Souchay, Moulin, Isingrini, & Conway, 2008). In that study, AD patients, older adults and younger adults were instructed to either overtly rehearse words or read them passively. Unlike younger adults and older adults, AD patients showed modest and non-significant item memory improvement after rehearsal. In our study, the lack of memory benefits across repeated tests may be attributed to the disruption in consolidation processes in AD, since our task involved repetition (i.e., consolidation) of items. Consolidation has previously been found to be compromised in AD as a result of disruption of the hippocampal function and neural consolidation pathways in the disease (Borlikova et al., 2013; Coleman & Yao, 2003; Genon et al., 2013; Moulin, James, Freeman, & Jones, 2004).

Regardless of the effect of repetition on item memory, the originality of our study was the assessment of its effect on source monitoring in AD. Our results demonstrated more source misattributions across the three source recall tests in both AD patients and controls. These findings can be interpreted in light of the Source Monitoring Framework (Johnson et al., 1993), according to which source monitoring decisions are based on the availability of perceptual, contextual and affective information during retrieval, and on the cognitive operations established when the memory was formed (e.g., records of elaborating, organizing and retrieving). Memories of performed actions include more perceptual, contextual and affective information, but fewer cognitive operations than memories of imagined actions (Johnson et al., 1993). In our study, perceptual, contextual and affective characteristics for performed and imagined items may have overlapped owing to repetition, thus leading to source misattributions in both AD patients and controls across the three source recall tests.

Another explanation for increased source misattributions across the three tests may be the imagination inflation effect. This effect refers to the fact that imagining events leads to increased beliefs that these events might have actually happened (Garry, Manning, Loftus, & Sherman, 1996; Mazzoni & Memon, 2003; Pezdek, Blandon-Gitlin, & Gabbay, 2006). The imagination inflation effect has been widely observed in a range of imagery circumstances, with consideration for variables impacting the richness and content of the images, such as age of the memory (Sporer & Sharman, 2006), emotional valence (Barnier, Sharman, McKay, & Sporer, 2005), individual differences (Sharman & Calacouris, 2010), imagery content (Scoboria, Mazzoni, Jarry, & Bernstein, 2012), perspective taken during imagery (Sharman, Garry, & Hunt, 2005) and repeated imagination (Goff & Roediger, 1998; Thomas, Bulevich, & Loftus, 2003). Imagination inflation was reported in AD by O'Connor et al. (2015), who found that imagining performing actions increased the tendency of patients to falsely recall the actions as having actually been performed.

The difficulty of AD patients to remember whether actions have been enacted or imagined may be linked to several clinical and functional consequences. Patients may mistakenly believe they closed the oven or took their medications when, in fact, they only imagined doing these actions. They may also mistakenly believe they only imagined actions when they actually performed them. These distortions may be associated with hallucinations, as some studies found that AD patients may falsely perceive stimuli that are not present (El Haj, Jardri, Laroi, & Antoine, 2016; El Haj & Laroi, 2016; El Haj, Laroi, Gely-Nargeot, & Raffard, 2015; Jost & Grossberg, 1996; Ornstein et al., 2013; Rocca et al., 2010; Ropacki & Jeste, 2005; Scarmeas et al., 2005; Wilson, Gilley, Bennett, Beckett, & Evans, 2000). Interestingly, these imagination distortions (i.e., hallucinations) have been found to be associated with verbal outbursts (Lerner et al., 1994), aggressive behavior (Aarsland, Cummings, Yenner, & Miller, 1996), functional decline (Haupt,

Kurz, & Janner, 2000; Scarmeas et al., 2005), and falls (Bassiony et al., 2000). Evaluating how AD patients respond to deciding about whether an action was actually performed or only imagined is thus crucial for clinical management and understanding source misattributions.

Regarding our control participants, increased item memory across the successive tests mirrors studies that showed that older adults may demonstrate benefits from taking repeated recall tests (Bluck, Levine, & Laulhere, 1999; Finkel, Fox, & McGue, 1995; Henkel, 2007, 2008). These benefits may be attributed to the amount of time spent retrieving additional information that is inherent in successive recall tests, and to the effects of repeated testing itself, such as retrieval practice, organization of remembered items, development of retrieval strategies, and use of recalled items as cues for additional recall (Henkel, 2008; Mulligan, 2001, 2006). Regarding increased source misattributions across source recall tests, they may be attributed to the inflation effect and to inefficient binding processes (Henkel, 2008). Compromised source monitoring in aging has been linked to disrupted binding between contextual information (e.g. how items are processed) and target information (e.g. items) (El Haj & Allain, 2012; Mitchell, Johnson, Raye, Mather, & D'Esposito, 2000). Altogether, our findings suggest that successive recall tests promote imagination processes that later lead to source misattributions, although they may enhance item memory in normal aging.

One limitation of our paper is the absence of an additional source recognition task. After the repeated free and source recall tests in Henkel's study (Henkel, 2008), participants took a source recognition test in which they indicated whether items had been seen, imagined or were new. This test might have been another means to assess source monitoring in AD patients. However, owing to time constraints and patients' fatigability, we were not able to implement such a test. Future research should consider this limitation and implement spaced trials rather than

successive ones, in light of studies demonstrating the positive effect of spaced retrieval on source monitoring (Bahrick & Hall, 2005; El Haj, Kessels, & Allain, 2016; Hawley, Cherry, Boudreaux, & Jackson, 2008; Joltin, Camp, & McMahon, 2003; Schacter, Rich, & Stamp, 1985). Another limitation of our study is the relatively small sample size that could have resulted in low power and a greater likelihood of Type I error, especially regarding the lack of significant differences in patients with AD. This may be especially true regarding the lack of significant differences between source misattributions in the third source test vs the third free recall test in AD patients. The same thing can be said regarding the lack of significant differences between item recall in the three free recall tests and in the three source recall tests in AD patients. However, the lack of significant differences regarding source misattributions between the first test and the second one was characterized by a large effect size and the lack of significant regarding source misattributions between the first test and the second one was characterized by a medium effect size in AD patients.

In conclusion, our study demonstrates the benefits (i.e., item memory gains) and costs (i.e., source misattributions) of repeated recall in normal aging. In AD patients, repeated recall seems to increase source misattributions without benefiting item memory, thus suggesting it might do more harm than good. These findings are therefore relevant for clinicians who treat compromised memory in AD patients.

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Conflict of Interest

The authors declare no conflict of interest.

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Table 1.

Cognitive characteristics of Alzheimer's disease (AD) patients and control participants

Task		AD	Older adults
		<i>n</i> = 26	<i>n</i> = 30
General Cognitive functioning	Mini-Mental State Examination (MMSE)	21.81 (1.47)***	28.23 (1.25)
Episodic memory	Grober and Buschke	6.00 (2.37)***	10.80 (3.37)
Working memory	Forward span	5.27 (1.34)*	6.33 (1.95)
	Backward span	3.65 (1.16)***	5.47 (1.38)
Shifting	Plus-Minus	12.56 (7.27)***	6.83 (4.14)
Depression	HADS	10.59 (3.50)***	6.73 (2.56)

Note. Standard deviations are given between brackets; the maximum score on MMSE was 30 points; episodic performance referred to free recall and the maximum score was 16 points; performances on the forward and backward spans referred to number of correctly repeated digits; the maximum score on the context memory task was 20 points (see, Figure 1); scores on the Plus-Minus task referred to reaction time; the cut-off on the HADS (Hospital Anxiety and Depression Scale) was > 10/21 points; differences between groups were significant at: * $p < .05$, ** $p < .01$; *** $p < .001$

Table 2

Proportion of correct item recall on the three free recall tests and the three source recall tests in Alzheimer's disease (AD) patients and control participants

	AD	Older adults
First free recall	.23 (.08)	.31 (.14)
Second free recall	.24 (.11)	.34 (.14)
Third free recall	.25 (.14)	.37 (.12)
First source recall	.22 (.07)	.31 (.13)
Second source recall	.23 (.11)	.33 (.13)
Third source recall	.24 (.12)	.37 (.10)

Note. Standard deviations are given between brackets.

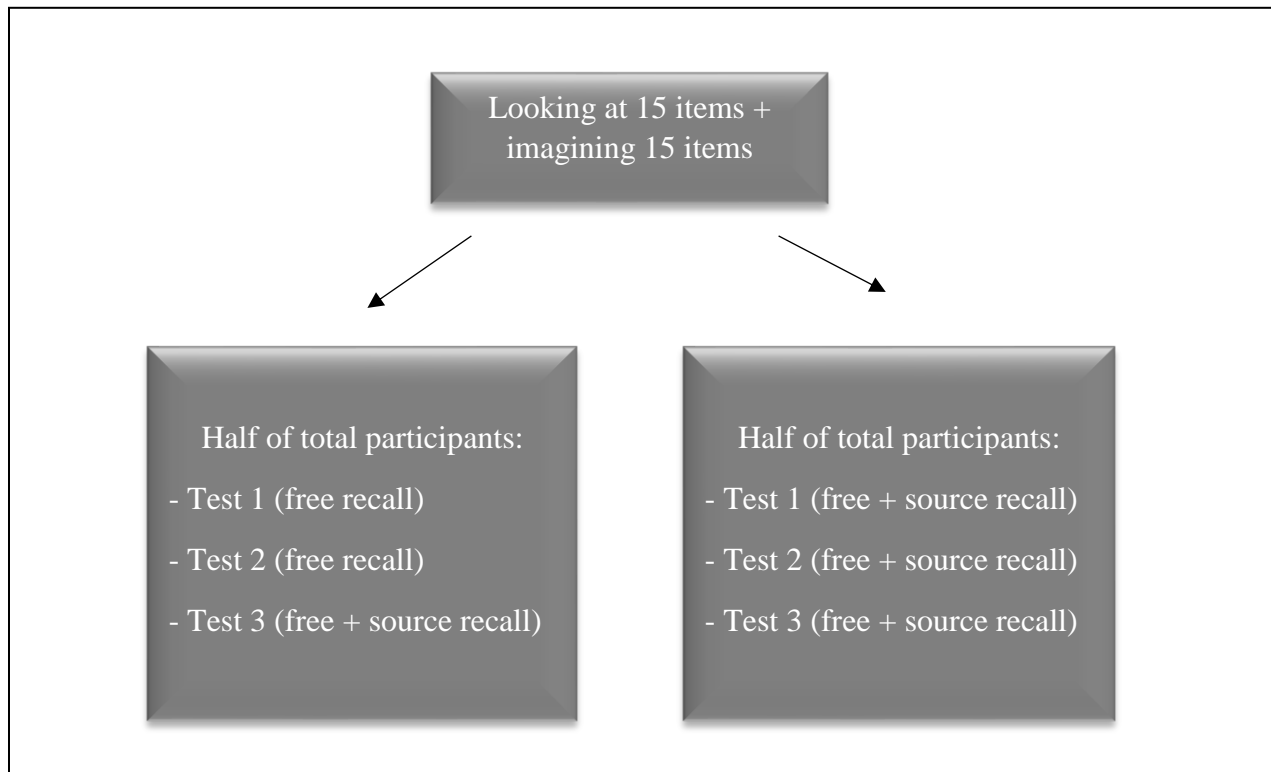


Figure 1

Schematic representation of source monitoring assessment

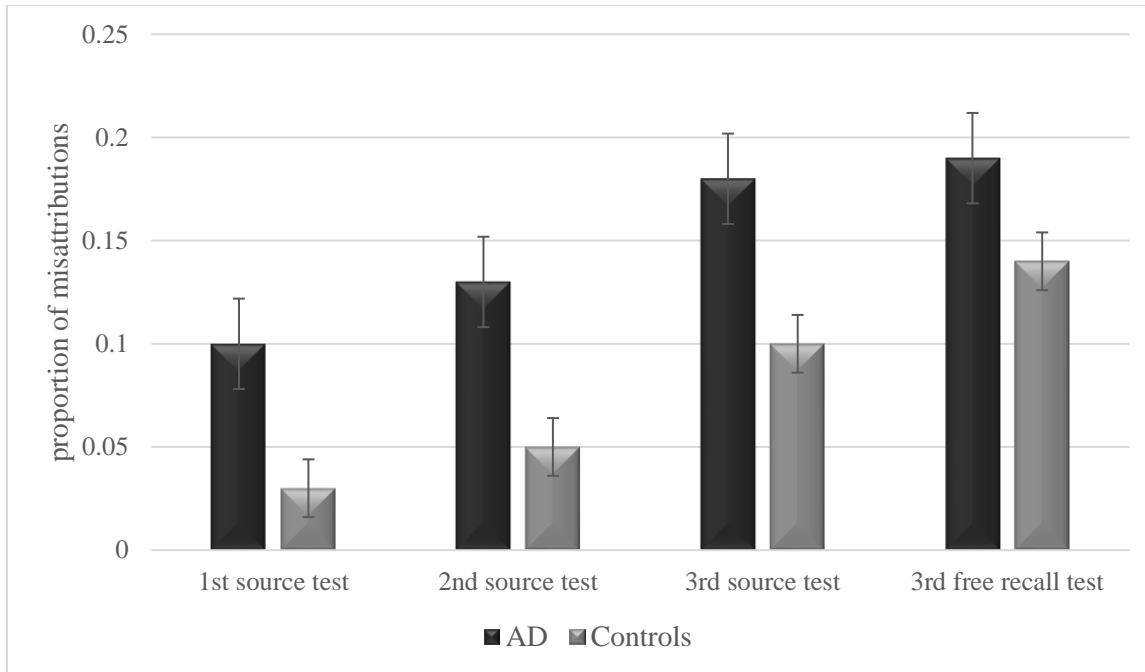


Figure 2

Proportion of source misattributions in Alzheimer's disease (AD) patients and control participants after each source recall test and after third free recall test. Error bars are 95% within-subject confidence intervals.