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The Imagination Inflation Effect in Healthy Older Adults and Patients With Mild Alzheimer's Disease

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Objective: The imagination inflation effect is a type of memory distortion defined as an increased tendency to falsely remember that an item has been seen, or an action has been performed, when it has only been imagined. For patients with very mild Alzheimer's disease (AD), susceptibility to the imagination inflation effect could have significant functional consequences in daily life. ***Method:*** We assessed whether patients with very mild AD were more or less susceptible to the imagination inflation effect when compared with healthy older adults. In the first session, participants were read an action statement such as "fill the pillbox" and engaged in 1 of 3 activities: listened to the statement being read, performed the action, or imagined performing the action. During the second session, participants imagined action statements from the first session, as well as new action statements. During the recognition test, participants were asked to determine whether action statements were or were not performed during the first session. ***Results:*** We found that imagining performing actions increased the tendency of patients with very mild AD to falsely recall the action as having been performed to an extent similar to that of healthy older adults. ***Conclusion:*** We concluded that, similar to healthy older adults, patients with very mild AD were susceptible to the imagination inflation effect, which we attributed to difficulties with source monitoring and reliance on familiarity.

Keywords: Alzheimer's disease, imagination inflation, source monitoring, familiarity, visual imagery, false memory

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Patients with Alzheimer's disease (AD) are more susceptible to certain kinds of memory distortions compared with healthy older adults (Budson et al., 2003; Budson et al., 2007; Budson & Solomon, 2011; MacDuffie, Atkins, Flegal, Clark, & Reuter-Lorenz, 2012). The imagination inflation effect, a term initially coined by Garry, Manning, Loftus, and Sherman (1996), is a particular type of memory distortion that refers to the finding that people are more likely to falsely remember that an item has been seen or an action has been performed when it has only been imagined. For patients with AD, susceptibility to the imagination inflation effect for performed actions versus imagined actions could have significant functional consequences. For example, patients with AD may mistakenly believe they took their medications, shut off the stove, or locked the door when they have only imagined doing these actions, raising significant safety concerns related to the home and medical health. Understanding how patients with AD respond when faced with a decision about whether an action was performed or imagined is important for understanding the clinically relevant memory errors that patients with AD commonly experience.

Goff and Roediger (1998) examined the imagination inflation effect for actions in healthy young adults by presenting them with action statements such as "put the match in the box" and asking them to either perform the action, imagine performing the action, or simply listen to the action being read. In a second session, participants were again presented with the action statements and were asked to imagine performing the action zero, one, three, or five times. At test, participants were asked whether they had heard the action before and, if so, whether they had performed, imagined, or listened to the action in the first session. Findings revealed that participants were more likely to falsely believe they had performed an action after repeatedly imagining performing that action. The more times the action was imagined, the more robust the effect. In addition, participants became more confident in the accuracy of their false memories as the number of imaginings increased.

Source memory failures have been used to explain the imagination inflation effect (Dalla Barba, Nedjam, & Dubois, 1999; Goff & Roediger, 1998; Mammarella et al., 2009). Source memory broadly refers to the ability to identify the source, or origin, of information retrieved from memory (Johnson, Hashtroudi, & Lindsay, 1993), such as the speaker and location of information. A particular type of source memory is the ability to differentiate information that has been imagined from information that has been heard, seen, or performed. Characteristics of a memory that can help individuals make this distinction include perceptual information (sound and color), contextual information (time and space), affective information (emotional reaction), and the cognitive operations established when the memory was formed (records of organizing, elaborating, retrieving, and identifying; Hashtroudi, Johnson, & Chrosniak, 1990; Norman & Schacter, 1997). For example, memories for performed actions, such as "fill the pillbox," should include more information about perceptual detail (the color of the pillbox), contextual detail (the location of the pillbox on the table), and affective experience (delight at finishing the task) than memories for imagined actions and less information on the cognitive operations that would be needed to generate the mental image of filling the pillbox. When memory characteristics for performed versus imagined actions overlap there is an increased chance that the two will be confused. In support of this notion, events that actually occurred and falsely remembered imagined events have shown activation of many of the same brain regions during both encoding and retrieval (Goldmann et al., 2003; Gonsalves & Paller, 2000; Gonsalves et al., 2004). It is well known that patients with AD have impairments in source memory (Dodson et al., 2011) linked to frontal lobe dysfunction (Budson et al., 2002), which might make them more susceptible to the imagination inflation effect than healthy older adults.

Three prior studies have examined the impact that imagining has for patients with AD. Dalla Barba, Nedjam, and Dubois (1999) examined the imagination inflation effect in patients with AD and healthy older adults. At study, participants viewed pictures of objects and read other object names aloud that they then imagined. At test, participants had to say whether a word presented on the screen had been previously seen or just imagined. Findings revealed that patients with AD were more likely than healthy older adults to incorrectly indicate that imagined objects had been seen. Two additional studies have investigated source memory in patients with AD using imagined versus performed actions. Mammarella and Fairfield (2006) asked patients with AD and healthy older adults to either imagine or perform actions. Participants were interrupted at unpredictable intervals during the task to engage in a recognition memory test. Source accuracy was defined as the percentage of time performed or imagined actions were attributed to their correct source. Performed actions tended to be better recognized than imagined actions, and source accuracy was greater for healthy older adults compared with patients with AD. However, Mammarella and Fairfield (2006) examined source memory by combining source memory errors for imagined and performed actions, with no information provided about source memory errors involving only imagined items incorrectly recalled as performed. Therefore, the imagination inflation effect was not able to be examined. In a second study by Fairfield and Mammarella (2009), source accuracy was evaluated in young adults, older adults, and a smaller group of patients with AD who were asked to either perform actions, imagine performing actions, watch another performing actions, or imagine another performing actions. This study found that healthy older adults and patients with AD had impairments in source memory for both performed and imagined actions, which were greatest in patients with AD. Again, in this study no distinctions were made between source memory errors for imagined versus performed actions, preventing any conclusions about the imagination inflation effect specifically. In summary, although both of these latter studies demonstrated greater failure in source memory for patients with AD compared with healthy older adults under conditions of imagining versus performing, neither study presented data on only imagined actions and therefore, neither addressed the imagination inflation effect specifically. In addition, all three studies used mutually exclusive sources, meaning that items that were "seen" or "performed" could not also have been "imagined." This experimental design might have allowed participants to use a recall-to-reject strategy, where the recall of one source helped subjects infer that the item could not have been presented in the other source. Patients with AD have been shown to have impairments in the use of the recall-to-reject strategy (Gallo, Sullivan, Daffner, Schacter, & Budson, 2004), and the differences in false alarms in the previous studies could be because of a greater use of a recall-to-reject strategy in healthy older adults, rather than the imagination inflation effect.

Regarding our current experiment, it is unclear whether the imagination inflation effect in patients in very mild AD would be *increased* because of impairments in source monitoring, or *decreased* because of patients' impairments in the ability to engage in more complex mental imagery (Borg, Thomas-Antérion, Bogey, Davier, & Laurent, 2010). A prior investigation into mental imagery in patients with mild AD revealed that although the ability to form basic mental images remained intact, consistent with other accounts (Grossi, Becker, & Trojano, 1994), the ability to perform more complex mental imagery—such as that involved in imagining performing an action— was impaired (Hussey, Smolinsky, Pirytinsky, Budson, & Ally, 2012). In addition, individuals who are able to form more vivid mental images tend to have more difficulty with source discrimination than "poor" or "low" imagers (Dobson & Markham, 1993; Johnson, Raye, Wang, & Taylor, 1979; Markham & Hynes, 1993). Therefore, if patients with AD are impaired in their ability to engage in complex mental imagery, then the imagination inflation effect might be reduced or absent. Furthermore, even if the patients are able to imagine the actions they might not be able to remember them. Although patients with AD are generally more susceptible to memory distortions compared with healthy older adults, under certain conditions false recognition may be reduced, such as when details or the gist of the studied items are important for the generation of memory errors because of the fact that patients with AD have memory impairment that interferes with their ability to recall details and gist (Budson, Daffner, Desikan, & Schacter, 2000; Budson, Desikan, Daffner, & Schacter, 2001; Budson, Todman, & Schacter, 2006). Although patients with AD might show a decrease in the imagination inflation effect related to their poor ability to engage in mental imagery, the prior research examining memory for imagined versus performed items still suggests that the imagination inflation effect may be increased in these patients because of their impairment in source monitoring (Dalla Barba et al., 1999; Fairfield & Mammarella, 2009; Mammarella & Fairfield, 2006). Thus, our study sets out to directly examine the imagination inflation effect in patients with AD compared with healthy older adults.

The current study uses methods similar to those of Goff and Roediger (1998). In an initial session, participants were read an action statement such as "put the pills in the pillbox" and either listened to the statement being read (listen only), performed the action, or imagined performing the action. During a second session participants imagined action statements from the first session as well as new action statements one or three times. One advantage of this paradigm is that the inclusion of a listen only condition and single or multiple imaginings more closely parallels real life. For example, patients with AD might falsely recall that an action was performed one or more times simply because they heard the action mentioned, as is often the case with the question, "Did you take your medication?" Another advantage of this paradigm is that the actions presented were not mutually exclusive; actions that were imagined in Session 2 would also have been listened to, performed, or imagined in Session 1, controlling for the use of a recall-to-reject strategy that may assist healthy older adults more than patients with AD. Last, and in contrast to Goff and Roediger (1998), to specifically address the imagination inflation effect for action statements and more closely approximate the decision patients would have to make in a real world setting, our critical question at test was, "Did you perform this action?". If the answer was "no," subjects were then asked whether the action was heard only, imagined, or new.

The goal of the present study was to investigate whether the imagination inflation effect was more or less prominent for patients with very mild AD compared with healthy older adults. We were also interested in examining the effect of imagining on correct recognition. We hypothesized that healthy older adults would be more likely to endorse actions as having been performed when those actions were subsequently imagined, thereby increasing true recognition of actually performed actions and increasing false recognition/source memory errors of actions that were not performed and were either new, listened to, or imagined only. We also hypothesized that patients with very mild AD would show a larger imagination inflation effect than that observed in healthy older adults, because of the patients' greater source memory impairment.

Materials and Methods

Participants

Sixteen healthy older adults and 17 patients with a clinical diagnosis of very mild AD were recruited for this study. One participant was excluded from data analysis because of missing data, leaving a total of 15 healthy older adults and 17 patients with very mild AD. All subjects completed a brief neuropsychological battery to evaluate their cognitive functioning, administered in a separate 45-min session. Subjects were administered the Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), the Consortium to Establish a Registry for Alzheimer's Disease word list memory test (Morris et al., 1989), Trail Making Test Part B (Army Individual Test Battery, 1944), Verbal Fluency (Monsch et al., 1992), and the 15-item Boston Naming Test (Mack, Freed, William, & Henderson, 1992).

Patients with probable AD met criteria described by the National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association (McKhann et al., 1984) and were in the very mild range of the disease based on MMSE scores ranging from 25 to 30. Healthy older adults scored 27 or better on the MMSE, did not display evidence of cognitive impairment on any neuropsychological measures, and had no first-degree relatives with Alzheimer's disease or other neurodegenerative diseases. The participants with very mild AD were recruited from The Memory Clinic in Bennington, Vermont, and the Boston University Alzheimer's Disease Center, in Boston, Massachusetts. Healthy older adults were recruited from online and community postings in the Boston area or were spouses and friends of the patients with AD who participated in the study. The human subjects committees of the Bedford VA Hospital, VA Boston Health care System, and Boston University School of Medicine approved the study. Participants were paid $10/hr for their participation.

Participants were excluded if they were characterized by clinically significant depression, alcohol or drug use, cerebrovascular disease, traumatic brain damage, other neurological or psychological disease that could affect cognitive function, or if English was not their primary language.

Demographic and neuropsychological test data can be seen in Table 1.

Materials

Ninety-six action statements were used as critical items. A subset of these statements were taken from Goff and Roediger (1998). The remaining items were generated specifically for use in the current experiment. Half of the items were intended to reflect functional actions that might be encountered in everyday life, such as "fill the pillbox." The other half of the items were nonfunctional items, such as "put the duck on the plate." For the analyses reported, we collapsed across functional and nonfunctional items because our initial analyses yielded no effects or interactions of this variable. All items involved the presentation of actual objects followed by an action statement. Items were divided into 12 blocks of 8 action statements, for counterbalancing purposes. These 12 blocks of action statements were rotated through encoding conditions and number of imaginings across subjects so that each action statement served in every condition an equal number of times.

In the first session, 72 action statements were presented in a predetermined pseudorandom order. Subjects were instructed to perform the action (24 action statements), imagine performing the action (24 action statements), or simply listen to the action being read (24 action statements). When instructed to listen only, subjects were given a number and told to count backward from that number until they were told to stop, in order to equate the time that the action statement was presented and to prevent them from rehearsing or imagining the action. In the second session, 24 old action statements (8 perform actions, 8 imagine actions, 8 listen actions) were imagined one time, 24 old action statements (8 perform actions, 8 imagine actions, 8 listen actions) were imagined three times, 8 new action statements were imagined one time, and 8 new action statements were imagined three times. Twenty-four old action statements (8 perform actions, 8 imagine actions, 8 listen actions) were not presented in the second session. If an action was imagined more than once, the occasions were spaced out with at least five items between presentations. The test materials, given 24 hr later, included all 96 of the critical action statements along with 40 filler action statements.

Table 1
Demographic and Neuropsychological Test Data by Group

Test	*M* (*SD*)	
	Healthy older adults	Patients with AD[a]
Age	78.1 (10.0)	78.6 (5.4)
Years of education	16.0 (2.8)	15.1 (3.2)
MMSE	29.4 (0.8)	27.1 (1.5)*
CERAD		
Immediate	19.7 (4.0)	12.5 (3.9)*
Delayed	7.5 (1.7)	1.6 (1.6)*
Recognition	9.8 (0.6)	6.7 (2.8)*
Trails-B	85.9 (38.0)	133.6 (79.7)*
FAS	46.3 (9.7)	37.9 (10.4)*
CAT	44.3 (8.4)	31.9 (12.4)*
BNT-15	14.6 (0.6)	12.8 (3.1)*

Note. AD = Alzheimer's disease; MMSE = Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975); CERAD = Consortium to Establish a Registry for Alzheimer's Disease Word List Memory Test (Morris et al., 1989); Trails-B = Trail Making Test Part B (Adjutant General's Office, 1944); FAS and CAT = Verbal Fluency to letters and categories (Monsch et al., 1992); BNT-15 = 15-item Boston Naming Test (Mack, Freed, Williams, & Henderson, 1992).
[a] One patient with very mild AD was given different standard neuropsychological tests and not included in this table.
* Significant difference ($p < .05$) between the healthy older adults and the patients with AD.

Procedure

Each subject participated in three sessions described below in turn. Each subject was tested individually for a total of approximately 4 hr over 2 days. An overview of the experiment is presented in Figure 1.

Session 1: Encoding. The procedures were briefly explained to each subject and any questions were answered. Subjects sat facing a table, half of which was hidden from the subjects' view by a black plastic divider that blocked the subjects' view of the objects to be presented. Subjects were informed that they would hear action statements that involved simple requests. For some action statements, they would be asked to perform the action, for others they would imagine the action, and for others they would simply listen to the action being read, after which they would be provided with a number and asked to count backward from that number until they were told to stop. Before reading each action statement, the experimenter placed a 9 × 5 card printed with the word *perform*, *imagine*, or *listen* in black letters to keep subjects oriented to the condition about to be presented and to help subjects remember the condition during the task. The 72 action statements (24 performed, 24 imagined, and 24 only read) were read aloud by the experimenter and the objects needed to perform the action were presented simultaneously. Objects were presented even if subjects were only imagining or listening to the action statement. Subjects were given 15 s to perform the action, imagine performing the action, or count backward after the action was read. The objects were replaced behind the plastic divider after the 15 s had expired. After the 72 action statements were presented subjects were told that Session 1 was over and that Session 2 was about to begin.

Session 2: Imagining. The imagination session (Session 2) immediately followed Session 1. Subjects were told that they were beginning Session 2 and informed that all action statements in this session would only be imagined. The 9 × 5 card printed with the word *imagine* was placed on the table to keep subjects oriented to the task. In this session, action statements were read by the examiner with simultaneous presentation of the referenced objects. All action statements presented were only imagined and never performed. Twelve seconds were given for each action statement to be imagined. Twenty-four old action statements from Session 1 (8 perform, 8 listen, and 8 imagine), and 8 new action statements were not presented in the second session. Twenty-four old action statements from Session 1 (8 perform, 8 listen, and 8 imagine) and 8 new action statements were imagined once in the second session. Twenty-four old action statements from Session 1 (8 perform, 8 listen, and 8 imagine) and 8 new action statements were imagined three times in the second session. After all action statements were presented, subjects were reminded of their Session 3 appointment and dismissed.

Session 3: Testing. Twenty-four hours later, subjects returned and were given a recognition and source monitoring test. All of the 96 critical action statements (including the 72 encoded in Session 1) plus 40 filler action statements were presented in a fixed, pseudorandom order. Subjects were given explicit instructions to

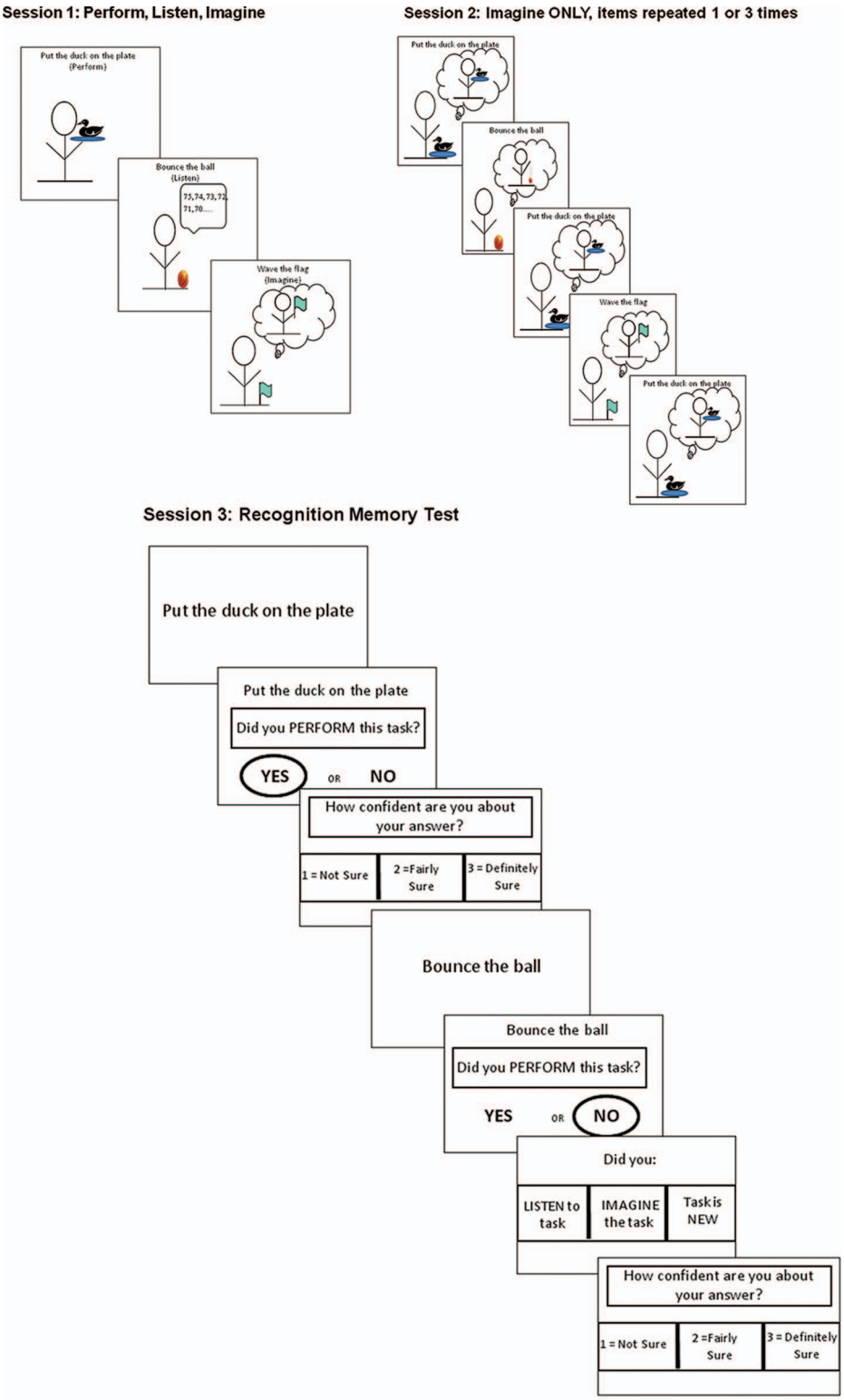

Figure 1. Visual depiction of the experimental method. In Session 1, participants either perform an action, listen to an action being read, or imagine performing an action. In Session 2 participants only imagine performing actions. At test (Session 3), participants decide whether they performed the action during Session 1 and, if not, whether the action was listened to, read, or new, and then made confidence judgments. See the online article for the color version of this figure.

answer the recognition and source monitoring questions based only on what they remembered from Session 1. They were told that what they did during Session 2 was not relevant for this test. Subjects first answered the question, "Did you perform this action?" with a "yes" or "no." If the subject answered "yes," a confidence judgment was made (1 = *not sure*, 2 = *fairly sure*, 3 = *definitely sure*). If the subject answered "no," he or she made a source judgment as to whether the action statement had been imagined, only heard, or was new. The subject also made a confidence rating on each source monitoring judgment using the same scale described above. An 8x11 sheet with the recognition question and response options, as well as the source and confidence ratings, were placed in front of subjects to help keep them oriented to the task. Subjects were debriefed as to the purpose of the study at the end of Session 3.

Results

We were interested in analyzing our data with the purpose of examining the following questions. First, compared with healthy older adults, are patients with very mild AD more or less susceptible to the imagination inflation effect, defined as an increased tendency to incorrectly identify actions that were imagined as having been performed (a false alarm)? Second, does imagining an action after it has been performed differentially effect the tendency to correctly recall that the action has been performed (a hit) for patients with very mild AD compared with healthy older adults? Last, do patients with very mild AD differ from healthy older adults in their ability to recall the source of actions that were heard, imagined, or are new in the face of imagining?

Imagination Inflation Effect

Figure 2 presents the mean proportion of actions that were incorrectly identified as being performed as a function of number of imaginings (imagination inflation effect). Table 2 presents the mean proportion of actions that were incorrectly identified as being performed as a function of number of imaginings for each Session 1 condition. Again, we were primarily interested in the question of whether imaginings could become confused with actions (the imagination inflation effect) and whether this effect was different for patients with very mild AD compared with healthy older adults.

To examine the imagination inflation effect, a 2 (Group: healthy older adults, patients with very mild AD) × 3 (Session 2 imaginings: 0, 1, 3) × 3 (Session 1 condition: imagine, listen, new) mixed-factor analysis of variance (ANOVA) was performed on false alarm rates. As expected, healthy older adults were less likely to incorrectly identify an action statement that was never performed as having been performed compared with patients with AD, main effect of group: $F(1, 30) = 7.52$, $p = .010$, $\eta^2 = .20$, 95% confidence interval (CI) [.12, .42], and the performances of both groups were influenced by the number of times the action statements were imagined in Session 2, main effect of imagining: $F(2, 60) = 9.95$, $p < .001$, $\eta^2 = .25$, 95% CI [.07, .40]. The Session 1 imagine condition produced more false alarms compared with the listen condition, main effect of condition: $F(2, 60) = 4.61$, $p = .014$, $\eta^2 = .13$, 95% CI [.01, .28]; imagine versus listen condition: $t(31) = 3.56$, $p = .001$, 95% CI [.24, 1.01], $d = .62$.

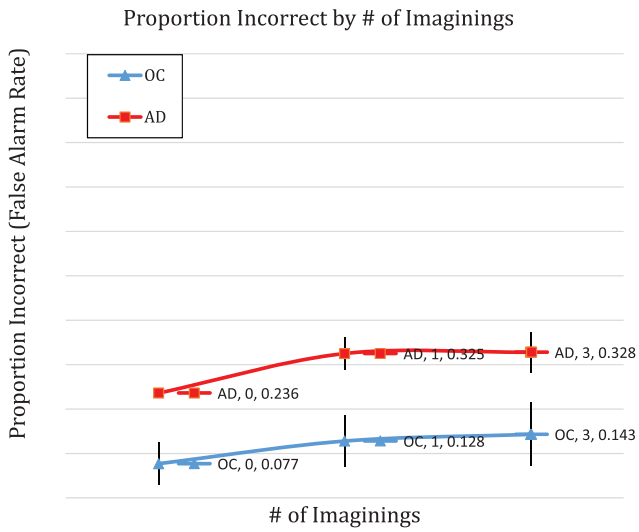

Figure 2. Mean proportion of items incorrectly identified as being performed (imagination inflation; collapsed across Session 1 condition) by of Session 2 imaginings (0, 1, 3) as a function of group (healthy older adult [OC], Alzheimer's disease [AD]). Error bars represent *SE*s. See the online article for the color version of this figure.

False alarm rates did not differ between listen and new conditions, $t(31) = -.781$, $p = .441$, 95% CI [−.48, .21], $d = -.13$, nor did they differ between imagine and new conditions, $t(31) = 1.79$, $p = .082$, 95% CI [−.04, .66], $d = .31$. Patients with AD were not more or less susceptible to the imagination inflation effect compared with healthy older adults, Group × Imaginings: $F < 1$]. There was no significant Session 1 condition × Session 2 imaginings interaction nor was there a significant Session 1 condition × Group interaction (both Fs < 1).

In summary, the imagination inflation effect was present for both healthy older adults and patients with very mild AD, and this effect did not differ between the groups. There were no significant main effects or interactions found when looking at confidence ratings for items that were incorrectly identified as being performed as a function of number of imaginings (all Fs < 1).

Recognition

A response was counted as a hit if the action statement was performed during Session 1 and the participant correctly identified the action statement as having been performed at test. Figure 3 presents the mean proportion of items that were correctly identified as being performed, a hit, as a function of number of imaginings.

To examine the effect of imagining on memory for old items, a 2 (Group) × 3 (Session 2 imaginings) × 3 (Session 1 condition) mixed-factor ANOVA was performed on hit rates. As expected, healthy older adults successfully identified performed actions more often than patients with AD, main effect of group: $F(1, 30) = 9.01$, $p = .005$, $\eta^2 = .23$, 95% CI [.02, .45], and the performances of both groups were influenced by the number of times the action statements were imagined in Session 2, main effect of Imagining: $F(2, 60) = 5.03$, $p = .010$, $\eta^2 = .14$, 95% CI [.01, .30]. Patients with AD were not more or less susceptible to the effect of imag-

Table 2
Means for Incorrect "Perform" False Alarms by Session 1 Condition (Listen, Imagine, and New) and Session 2 Imaginings (0, 1, 3) as a Function of Group (Healthy Older Adult [OC], Alzheimer's Disease [AD])

	M (*SD*)	
Session 1 condition	OC	AD
Listen		
0 imaginings	0.05 (0.06)	0.16 (0.16)
1 imagining	0.11 (0.16)	0.28 (0.24)
3 imaginings	0.13 (0.19)	0.32 (0.33)
Imagine		
0 imaginings	0.12 (0.11)	0.21 (0.22)
1 imagining	0.15 (0.21)	0.34 (0.34)
3 imaginings	0.17 (0.19)	0.41 (0.32)
New		
0 imaginings	0.01 (0.03)	0.22 (0.26)
1 imagining	0.10 (0.15)	0.31 (0.33)
3 imaginings	0.17 (0.19)	0.32 (0.29)

ination on hit rate compared with healthy older adults, significant interaction effect of Group × Imaginings: $F(2, 60) = 1.00$, $p = .373$, $\eta^2 = .03$, 95% CI [0, .36].

In summary, both healthy older adults and patients with very mild AD were more likely to endorse actions they performed when the performance was followed by subsequent imaginings. Both healthy older adults and patients with very mild AD were equally susceptible to the effect of imaginings on subsequent correct recognition.

Mean confidence ratings for hits are presented in Figure 4. A 2 (Group) × 3 (Session 2 imaginings) × 3 (Session 1 condition) mixed-factor ANOVA was also conducted on confidence ratings to hits, to examine the effect of imagining on confidence ratings for hits. Overall, healthy older adults were more confident than patients with AD when they correctly identified a performed action statement as having been performed, main effect of group: $F(1, 27) = 10.10$, $p = .004$, $\eta^2 = .27$, 95% CI [.02, .50]. Although not statistically significant, there was a trend toward enhancement of confidence ratings for performed action statements that were subsequently imagined in both healthy older adults and patients with AD, main effect of imagining: $F(2, 54) = 2.95$, $p = .061$, $\eta^2 = .10$, 95% CI [0, .24]. Imagining did not differentially affect confidence ratings for patients with AD compared with healthy older adults, Group × Imaginings: $F(2, 54) = 1.37$, $p = .264$, $\eta^2 = .05$, 95% CI [0, .17].

In summary, healthy older adults were more confident than patients with very mild AD when correctly identifying performed actions and imagining action statements three times may have contributed to slight increases in confidence.

Source Memory

We were interested in examining the impact of imagining on source memory for action statements that were listened to, imagined, or never presented in Session 1. All participants made source judgments when they responded "no" to the initial recognition question, "Did you perform this action?" by subsequently indicating whether the action statement had been imagined, only heard, or was new. The subject also made a confidence rating on each source monitoring judgment. Correct source judgments were defined as correct identification of the modality of the presentation of action statements during Session 1 (imagined, listened to, new). Table 3 presents the means and *SD*s of correct source judgments by Session 1 condition (listen, imagine, new).

To examine the effect of imagining on correct source judgments, a 2 (Group) × 3 (Session 2 imaginings) × 3 (Session 1 condition) mixed-factor ANOVA was performed on the proportion of correct

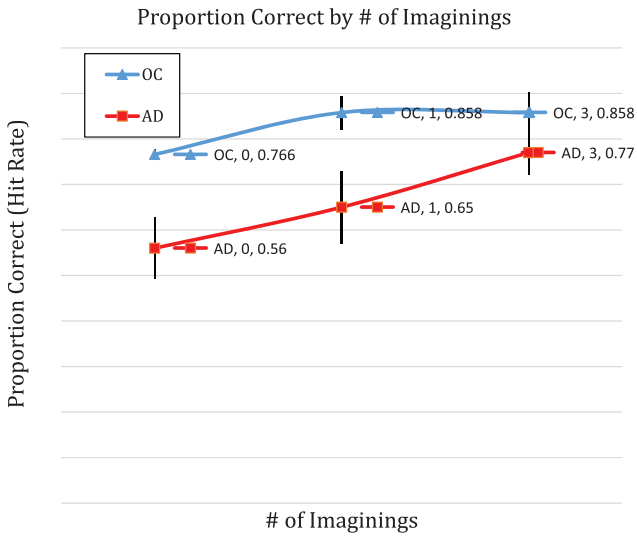

Figure 3. Mean proportion of items that were correctly identified as being performed (hits; collapsed across Session 1 condition) by Session 2 imaginings (0, 1, 3) as a function of group (healthy older adult [OC]; Alzheimer's disease [AD]). Error bars represent *SE*s. See the online article for the color version of this figure. See the online article for the color version of this figure.

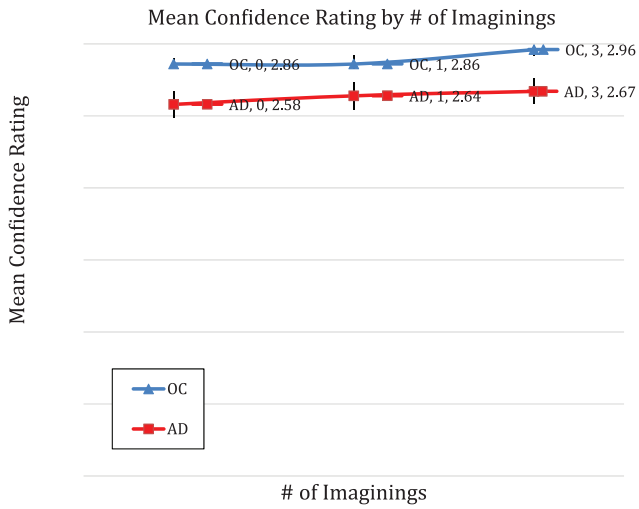

Figure 4. Mean confidence ratings for items that were correctly identified as being performed (hits; collapsed across Session 1 condition) by Session 2 condition (0, 1, 3) as a function of group (healthy older adult [OC]; Alzheimer's disease [AD]). Error bars represent *SE*s. See the online article for the color version of this figure.

source identification. As expected, healthy older adults made more correct source judgments compared with patients with AD, main effect of group: $F(1, 30) = 30.99$, $p = < .001$, $\eta^2 = 0.51$, 95% CI [.08, .53]. In addition, both healthy older adults and patients with AD were more likely overall to make a correct source judgment when action statements were subsequently imagined compared with when they were not imagined, main effect of imagining: $F(2, 60) = 7.24$, $p = .002$, $\eta^2 = 0.19$, 95% CI [.03, .34]. Both healthy older adults and patients with very mild AD were more likely to make a correct source judgment when action statements were never presented in Session 1 (identification of new action statements) compared with action statements that were listened to or imagined in Session 1, main effect of Session 1 condition: $F(2, 60) = 10.85$, $p < .001$, $\eta^2 = 0.27$, 95% CI [.08, .41]; new versus listen: $t(31) = 5.04$, $p < .001$, 95% CI [.47, 1.29], $d = .89$; new versus imagine: $t(31) = 3.70$, $p = .001$, 95% CI [.26, 1.03], $d = .65$. There was no difference in correct source judgments for items in the listen versus the imagine conditions, $t(31) = 0.73$, $p = .47$, 95% CI [−.21, .47], $d = .12$. Overall, for healthy older adults and patients with very mild AD, source accuracy was greater for new action statements (those never presented in Session 1) compared with action statements that were presented, regardless of the mode of presentation.

We also found that imagining action statements in Session 2 had differing effects on subsequent source accuracy, significant interaction effect of Session 1 condition × Session 2 imaginings: $F(4, 120) = 28.28$, $p < .001$, $\eta^2 = 0.49$, 95% CI [.34, .57], depending on the presence (listen and imagine conditions) or absence (new condition) of presentation in Session 1. No other significant interactions were observed, Group × Session 1 condition: $F(2, 60) = .089$, $p = .915$, $\eta^2 = .003$, 95% CI [.00, .04], Group × Session 2 imaginings: $F(2, 60) = .293$, $p = .747$, $\eta^2 = .01$, 95% CI [.00, .08]. In general, the Session 1 condition × Session 2 imaginings interaction showed that imagining action statements three times after initial presentation improved source accuracy regardless of whether action statements were initially listened to or imagined, while imagining action statements one or three times for new items (those never presented in Session 1) had the opposite effect, resulting in decreased source accuracy.

Table 3
Means for Correct Source Judgments by Session 1 Condition (Listen, Imagine, and New) and Session 2 Imaginings (0, 1, 3) as a Function of Group (Healthy Older Adult [OC], Alzheimer's Disease [AD])

	M (*SD*)	
Session 1 condition	OC	AD
Listen		
0 imaginings	0.20 (0.18)	0.13 (0.17)
1 imagining	0.25 (0.28)	0.13 (0.17)
3 imaginings	0.40 (0.31)	0.22 (0.28)
Imagine		
0 imaginings	0.23 (0.24)	0.20 (0.23)
1 imagining	0.36 (0.28)	0.18 (0.20)
3 imaginings	0.39 (0.28)	0.24 (0.23)
New		
0 imaginings	0.87 (0.22)	0.59 (0.32)
1 imagining	0.45 (0.20)	0.41 (0.32)
3 imaginings	0.18 (0.25)	0.25 (0.22)

When considering whether imagining action statements had a different impact on source accuracy when considering the mode of presentation (listen, imagine) and presence versus absence of presentation (new) in Session 1 depending on group (healthy older adult compared with patients with AD), we found that imagining action statements in Session 2 did affect source accuracy differently for healthy older adults compared with patients with AD, significant interaction effect of Group × Session 1 condition × Session 2 imaginings: $F(4, 120) = 4.19$, $p = .003$, $\eta^2 = 0.12$, 95% CI[.02, .21]. To explore this interaction further, three ANOVAs were conducted for each condition (listen, imagine, new). Findings revealed greater overall source accuracy for action statements in the new condition for healthy older adults compared with patients with AD, interaction effect for new condition of imagining by group: $F(2, 60) = 5.74$, $p = .023$, $\eta^2 = 0.16$, 95% CI [.02, .31]; follow-up analysis for new condition 0 imaginings: $t(30) = 8.10$, $p = .008$, 95% CI [1.85, 3.85], $d = 2.86$, which was driven by the Session 2 zero imaginings condition, Session 2 imaginings × Group: $F(2, 60) = 5.74$, $p = .023$, $\eta^2 = 0.16$, 95% CI [.02, .31]; as these differences disappeared after one and three imaginings (both ts < 1. There were no statistically significant group differences in the impact of imagining on source accuracy in the imagine condition and the listen condition. In summary, for new action statements (those never presented during Session 1) healthy older adults displayed greater source accuracy compared with patients with very mild AD, as expected. However, for these same action statements, after one and three imaginings healthy older adults were no longer at an advantage and, instead, had source accuracy levels that are equivalent to patients with very mild AD. There were also no group differences in source accuracy for listened to or imagined action statements presented in Session 1 regardless of whether they were never subsequently imagined or imagined once or three times.

Discussion

The goal of the current study was to investigate the imagination inflation effect (the increased tendency to incorrectly identify actions that were imagined in Session 2 as having been performed; a false alarm) for action statements in patients with very mild AD compared with healthy older adults. For these patients—and for healthy older adults as well—susceptibility to the imagination inflation effect for performed versus imagined actions could have significant functional consequences.

In the current experiment, as expected, patients with very mild AD showed a lower overall hit rate and higher overall false alarm rate compared with healthy older adults. However, in contrast to our hypothesis, patients with very mild AD did not display a differential impact of imagination compared with healthy older adults. Both patients with very mild AD and healthy older adults incorrectly recalled performing more actions they had not performed when they subsequently imagined the action compared with having never imagined the action (the imagination inflation effect). Patients with very mild AD did not display any differential impact of imagination compared with healthy older adults.

Although prior studies have found that patients with AD are more susceptible to source memory errors under conditions of imagining (Dalla Barba et al., 1999; Fairfield & Mammarella, 2009; Mammarella & Fairfield, 2006), these studies relied on

mutually exclusive stimuli, raising the possibility that differences between patients with AD and healthy older adults were because of the increased ability of healthy older adults to use a recall-to-reject strategy (Gallo et al., 2004). The current paradigm prevented healthy older adults from capitalizing on this potential advantage and may be one explanation for the discrepancy between our results and those of prior studies. In addition, these prior studies used patients at slightly later stages of disease severity, as characterized by MMSE performance, and it is possible that the current findings are because of variations in disease severity, with our very mild patients performing in a similar manner to healthy older adults. For example, some studies have suggested that the ability to engage in mental imagery might be impaired in patients with mild AD (Hussey et al., 2012) and other studies have noted that patients with mild AD might have difficulty recalling information such as the imagined action. Either of these factors could reduce or eliminate susceptibility to the imagination inflation effect, and the potential contribution of these factors may vary by disease severity.

Regarding source accuracy for new action statements (those never presented in Session 1), imagining led to source memory confusion, with a higher number of false positive errors for both healthy older adults and patients with very mild AD. In fact, healthy older adults made more correct source judgments when new items were never imagined in Session 2 compared with the patients, but after new items were imagined once or three times the source accuracy of the groups did not differ. It is interesting that we also found that correct source judgments increased for both groups when items were imagined in Session 2 after being performed, listened to, or imagined in Session 1.

In addition to source memory failures, the imagination inflation effect might also be explained by failures in the memorial processes used at test (Goff & Roediger, 1998; McDaniel, Lyle, Butler, & Dornburg, 2008). That is, it may not be just the specific characteristics of memory, such as perceptual details, that were responsible for the imagination inflation effect, but rather general aspects of memory, such as feelings of familiarity, that underlie the effect. The dual process model of memory holds that remembering is composed of both familiarity, an acontexual sense that a stimulus has been previously encountered, and recollection, the ability to recall the specific contextual details of a memory (Yonelinas, 2002). Using recollection enables the correct source of action statements to be identified. However, when individuals base their recognition memory judgments on familiarity, which helps them know that the item has been presented but not in what context, they may falsely believe that they have actually performed an action that has been repeatedly presented in other contexts. In imagination inflation paradigms, actions are imagined one or more times and when an action is incorrectly remembered as having been performed when it has only been imagined, this memory distortion may be because of an increase in overall familiarity with the action based on the number of repeat exposures, in this case, the number of imaginings. Note that this increase in familiarity could occur even if the item was not imagined, but was simply repeated. Furthermore, the source monitoring framework and familiarity misattribution theories of the imagination inflation effect are not mutually exclusive. Both mechanisms might have been operating to create the effect (for an example, see Thomas, Bulevich, & Loftus, 2003).

It is also possible that the mechanism underlying the imagination inflation effect differed for the two groups. That the imaginings in Session 1 and Session 2 led patients with very mild AD to endorse that they had actually performed actions when they had not suggests that patients with very mild AD can engage in at least some mental imagery. However, it is possible that there would be a similar effect of increased false alarms if there were repetitions of the actions simply being read instead of imagined in Session 2 (as in the Thomas et al., 2003, study). Because recollection is severely impaired in patients with AD (Ally, Gold, & Budson, 2009; Budson, Daffner, Desikan, & Schacter, 2000; Smith & Knight, 2002; Gallo et al., 2004), these patients are often overly reliant on familiarity, which increases their tendency to respond "old" on recognition memory tests (Budson, Wolk, Chong, & Waring, 2006; Deason, Hussey, Ally, & Budson, 2012; Gallo et al., 2006; Gold, Marchant, Koutstaal, Schacter, & Budson, 2007; Wolk, Dickerson, & the Alzheimer's Disease Neuroimaging Initiative, 2011; Wolk, Dunfee, Dickerson, Aizenstein, & DeKosky, 2011). Future research can examine whether the inclusion of a listen only condition in Session 2 produces similar results in patients with very mild AD compared with healthy older adults, which might help further our understanding of memorial mechanisms of the imagination inflation effect in these patients. In addition, inclusion of vividness ratings would help to further explore potential differences in the quality of mental images formed by patients with very mild AD compared with healthy older adults.

Despite the negative consequences of imagining action statements, there were also benefits that resulted from imagining. As mentioned previously, both groups were more likely to correctly recognize an action as having been performed, listened to, or imagined in Session 1 if it was subsequently imagined in Session 2 than if it was not. Research has found that a using a technique called self-imagination (a specific type of visual imagery technique that involves imagining an event from a personal perspective) can improve memory in healthy and neurologically impaired adults (Grilli & Glisky, 2010; Grilli & McFarland, 2011; Potvin, Rouleau, Sénéchal, & Giguère, 2011). Unlike pure rehearsal (mentally repeating information after it is no longer available), self-imagination includes visual imagery and self-referential processing. Although participants in our study were not specifically instructed to imagine themselves performing the action statements and did not describe their visual images, it may be assumed that when imagining action statements in Session 2 that they had previously performed in Session 1, the visual image formed was similar to self-imagination; that is, the participant was likely imagining themselves performing the action. The improved hit rate for action statements that were performed and then subsequently imagined may be the result of self-imagination rather than rehearsal. This result is consistent with Souchay, Moulin, Isingrini, and Conway (2008), who found that although simple rehearsal was beneficial in older adults, it did not help patients with AD. Therefore, it is possible that when patients with AD actually do perform an action, they might benefit from imagination to help them remember the performance later. However, when imagination is encouraged before the performance of an action, such as is done when using the technique of forming implementation intentions to remember to perform future activities (Gollwitzer, 1999), this may lead to unexpected false memories of completing the action. Future

work investigating the use of self-imagination in patients with AD may determine whether it could be one method of rehabilitating memory and improving day-to-day functioning for this population.

From a clinical standpoint, this study suggests that the imagination inflation effect may underlie many functionally related errors that patients with very mild AD—and healthy older adults—make in day-to-day life. As AD progresses, imagination can also lead to confabulation, a more elaborate false memory in which individuals believe they have had an experience that they did not (Mazzoni & Memon, 2003). Functionally, both healthy older adults and patients with very mild AD may be more prone to believing they have completed relevant tasks such as taking their medication when they have only imagined taking their medication. Exploring methods to reduce susceptibility to the imagination inflation effect may be the first step toward creating effective interventions to reduce the impact of false memories of this type in daily life.

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