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Memory for Choices in Alzheimer's Disease

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Key Words

Episodic memory · Alzheimer's disease · Memory for choices · Source memory · False memory

Abstract

Despite their cognitive impairment, patients with mild Alzheimer's disease (AD) often make important life choices. When making choices, people frequently attempt to directly compare the features of different options, rather than evaluating each option separately. Not every feature has an analogous (or alignable) feature in the other option, however. In 2005, Mather's group found that both younger and older adults filled in such gaps when remembering, creating features in the other option to contrast with existing features. In the present study, such effects of alignability on recognition memory were not found in patients with mild AD. This finding suggests that patients with mild AD are less likely to engage in feature-by-feature comparison processes across choice options, a change that may lead them to make qualitatively different choices than healthy older adults.

Introduction

Despite their cognitive impairment, patients in the mild stages of Alzheimer's disease (AD) often make important choices regarding their health care, living arrangements, and financial matters. Several factors contribute to this situation. Most patients with mild AD have no legal guardian. Spouses, children, and siblings cannot be legal guardians without approval by the courts. A health care proxy is active only once the patient has been declared incompetent (or is otherwise unable) to make his or her own health decisions. A power of attorney is relevant only for specific financial issues. Many family members are reluctant to confront a spouse or a parent with AD when they disagree with the decisions that are being made even when the family member has the legal authority to do so.

In this study, we examine memory for choices in patients with AD. Episodic memory and working memory are particularly impaired in patients with AD [1, 2]. Executive function is also impaired in patients with AD [3]. Understanding how these impairments contribute to the problems that patients with AD experience when they make or remember decisions may lead to interventions that can help patients with AD improve their decisions, and also aid our understanding of which decisions are too difficult for them to make. Both decisions with clear rules, such as the Game of Dice Task and decisions without clear rules, such as the Iowa Gambling Task involve executive functions such as categorization and working memory [e.g. 4, 5]. Thus, the declines in both episodic memory and executive function seen in AD are likely to affect decision making processes as well as memory for the decisions. A goal of the present study is to shed light

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on these issues by examining memory for recently made choices in patients with AD compared with older adult controls.

Remembering past decisions accurately is important both to make effective decisions about related information in the future and to effectively manage one's current circumstances. Many decisions involve comparisons among options that have multiple features. For example, a choice about which apartment to rent might involve a comparison between apartment A that is on the first floor, with carpeting, laundry facilities nearby, quiet neighbors, large bedroom, and no dishwasher and apartment B that is on the fifth floor, with hardwood floors, laundry in the apartment, no places to eat out nearby, a fully equipped kitchen, and on a noisy street. Processing all of the option features and deciding out which option is more attractive can be a challenging task. While a small number of features can be kept in mind using working memory, as the number of features increases, the storage of features in episodic memory is required [1, 6, 7]. Researchers have found that in choice, as in other types of comparison processes, people try to put the things to be compared into alignment by linking the features of the two options that can be directly compared [e.g. 8, 9]. As in this example, quite often some features of the options are more easily compared (e.g. quiet neighbors versus noisy street) than other features (large bedroom and a fully equipped kitchen).

The degree to which features can be compared affects episodic memory [9–11]. Features that are directly comparable (alignable) across options are remembered better than features that do not have an analogous feature in the other option. For example, people are more likely to remember that one health plan had brand new facilities if they also learned that the other health plan had rundown facilities than if they did not learn anything about the facilities at the other plan [10]. Thus, being able to put features into alignment with each other seems to help later episodic memory retrieval.

However, alignment processes can also have a cost. Both older and younger adults are more likely to falsely recognize or recall a new feature (e.g. 'The plan is more expensive than average') if the feature is alignable with another feature that was associated with one of the choice options (e.g. 'The plan is a good value' [10]). These findings suggest that people use alignment processes to help guide their episodic memory encoding and retrieval processes, much as they might use schemas or general knowledge in other contexts.

Patients with AD also experience false episodic memories both in the laboratory [12, 13] and for real life events [14]. Several different kinds of false episodic memories have been observed in the laboratory. Patients with AD often falsely remember nonstudied items that are related to the general meaning, idea, or gist of the study items [12, 13]. They exhibit tendencies to falsely remember that a given statement is true when previously informed that it was false [15]. Patients with AD also tend to falsely endorse nonstudied items even when they are completely unrelated to the studied items. Their response bias is liberal compared to healthy older adults; that is, they are more likely to respond 'Yes, I studied that item' than healthy older adult controls [16, 17], when 'yes' responses to all items, studied and nonstudied, are considered.

We thought that the paradigm used by Mather et al. [10] would be helpful for investigating episodic memory and its distortions for choices in patients with AD, as well as providing some information about how they organize comparative information in episodic memory. In this paradigm, participants are given choices between two options, such as between two health plans. Some of the features of the two options are alignable whereas others are not. Participants then complete a recognition memory test for the features from the plan mixed with some unrelated new items as well as some lures that were not associated with either option but are alignable with a feature that was seen. Although patients with AD often show high gist or schema-based false memories, it is not clear whether they will also show a greater susceptibility to false alarms based on the alignability of features. Patients with AD may not use alignment processes to help structure their memories about comparative information, in which case they may actually show less influence of alignability in their correct and incorrect memories of choice option features.

Method

Summary of Experimental Paradigm

In the present study we modified the paradigm of Mather et al. [10] slightly. Participants were given a three-page booklet and asked to make three choices: between two apartments, between two job applicants, and between two restaurants (see table 1 for an example). For each choice, participants read aloud the 8 features that described each of the two options, and were then asked to choose between them by circling which option they would choose at the bottom of the page. After participants returned the choice scenarios to the experimenter, they were informed that we wanted to know what they remembered from the decisions they just made, and were given a three-page test booklet with a list of

features for each of the choice scenarios (table 2). For each feature listed, participants circled the first choice option, the second choice option, or 'new' if the feature was not previously presented in either of the options. These features consisted of (1) studied items that were alignable between the two options, (2) studied items that were nonalignable, (3) nonstudied items that were alignable for one of the options with surface similarity (alignable-similar), (4) nonstudied items that were alignable for one of the options without surface similarity (alignable-different), and (5) nonstudied items that were nonalignable (nonalignable) (see table 3 for examples).

Participants

Twenty-four patients with a clinical diagnosis of probable AD (NINCDS-ADRDA criteria [18]) and MMSE [19] score of 16 or greater were recruited from the Memory Disorders Unit, Brigham and Women's Hospital (BWH), Boston, Mass., and The Memory Clinic, Southwestern Vermont Medical Center, Bennington, Vt. These patients were each assessed by one or more of the neurologists, psychiatrists, and neuropsychologists in these clinics, all of whom are experts in the diagnosis of AD. The neuropsychological tests used for the patients' clinical diagnosis of AD varied by clinician, and included use of the Dementia Scale [20] the Dementia Rating Scale [21], Verbal Fluency to letters and categories [22], the CERAD Word List Memory Test [23], Wechsler Memory Scale III Logical Memory [7], the Frontal Assessment Battery [24], the Boston Naming Test [25], and the Geriatric Depression Scale [26].

Table 1. One of the three choice scenarios

Imagine you are looking for an apartment to rent and need to make a decision as soon as possible. Only two apartments are currently available in the neighborhood you want to live in.
Apartment A: In a large complex
No direct sunlight
Landlord requires a large security deposit
Mildew and mold in shower
Interior has not been painted recently
New wall-to-wall carpet
Large bedroom
Quiet neighbors
No oven or dishwasher
Apartment B: In an older building
No places to eat out nearby
No views from any of the windows
Bright and cheerful during the day
The thermostat works well
On a noisy street
Far from any grocery store
Old shag carpeting
Kitchen is fully equipped
Given this information, which apartment would you choose?
Please circle one: **Apartment A** **Apartment B**

Table 2. One of the three recognition tests

Earlier, you were asked to choose between two apartments. Now please consider each feature below and circle one of the following three options:
Apt. A: For features associated with the apartment in a large complex
Apt. B: For features associated with the apartment in an older building
New: For features that were not associated with either option
Please make a response for every feature, even if you are not sure your response is correct.

Lots of room for storage	Apt. A	Apt. B	New
Bathroom is clean	Apt. A	Apt. B	New
No direct sunlight	Apt. A	Apt. B	New
Poor layout of space	Apt. A	Apt. B	New
Lots of places to eat out nearby	Apt. A	Apt. B	New
Large bedroom	Apt. A	Apt. B	New
Far from any grocery store	Apt. A	Apt. B	New
Has laundry facilities in the building	Apt. A	Apt. B	New
Recently painted interior	Apt. A	Apt. B	New
On a noisy street	Apt. A	Apt. B	New
New wall-to-wall carpet	Apt. A	Apt. B	New
Low ceilings	Apt. A	Apt. B	New
Kitchen is fully equipped	Apt. A	Apt. B	New
No views from any of the windows	Apt. A	Apt. B	New
Landlord requires a large security deposit	Apt. A	Apt. B	New
Heating system is not very effective	Apt. A	Apt. B	New

Table 3. Examples of the different types of pairs of features

1	Studied items that were alignable between the two options Option 1: No oven or dishwasher (not in test list) Option 2: Kitchen is fully equipped
2	Studied items that were nonalignable Option 1: Landlord requires a large security deposit Option 2: Far from any grocery store
3	Nonstudied items that were alignable for one of the options with surface similarity (alignable-similar) New feature: Lots of places to eat out nearby Option 2: No places to eat out nearby (not in test list)
4	Nonstudied items that were alignable for one of the options without surface similarity (alignable-different) New feature: Bathroom is clean Option 1: Mildew and mold in shower (not in test list)
5	Nonstudied items that were nonalignable (nonalignable) New feature: Has laundry facilities in the building

Twenty-two healthy community-dwelling older adults were recruited from participants in a longitudinal study of normal aging at BWH, from spouses and friends of the patients, and by the use of flyers and posters placed in senior centers in and around Boston. Written informed consent was obtained from all participants and their caregivers (where appropriate). The Human Subjects Committees of Southwestern Vermont Medical Center, BWH, and Harvard University approved the study. Participants were paid USD 10/h for their participation. Older adults in the control group were excluded if they scored below 27 on the MMSE [19]. Most patients with AD showed mild impairment on the MMSE (greater than or equal to 20), although 4 of the 24 patients scored in moderate range (below 20; mean = 22.5, range = 16–28). Participants were excluded if they were characterized by clinically significant depression, alcohol or drug use, cerebrovascular disease, or traumatic brain damage. All participants had normal or corrected to normal vision. The patients were matched to the older adults on the basis of age (patient mean = 77.8 years, range = 70–91 years; older adult mean = 76.1 years, range = 65–89 years), and education (patient mean = 13.0 years, range = 6–18 years; older adult mean = 13.7 years, range = 9–18 years). There were 13 female patients and 11 female older adult controls.

Materials

Two three-page stapled choice booklets (versions A and B) were prepared, each with the apartment, job candidate, and restaurant choices in that order (see table 1 for an example). Similarly, two three-page test booklets (versions A and B) were prepared, each with the apartment, job candidate, and restaurant choices in that order (see table 2 for an example). Each choice scenario consisted of two options, each described by eight features. Half of the features associated with each option were alignable with a feature from the other option (e.g. 'Doesn't seem very intelligent' and 'Seems quite smart' for the two job candidates). One feature from each of these alignable old feature pairs was tested on the memory test, yielding four alignable old features on each test. The other four features from each option were not alignable with any features from the other option. Four of these nonalignable features were on each memory test.

The other four of these nonalignable features (the ones not on the memory test) were used to help create the four alignable foil items on each test. Whether these choice features shared surface similarity or not with the test items was varied across participants. For example, all participants saw the test item 'Likes to chat with others' for the job candidates. Half of the participants had previously seen the feature 'Doesn't like to chat with others' and half had instead seen the feature 'Is not very talkative' as part of the choice scenario. Thus, the alignable foil test items were identical for all participants, but what varied was whether they were just alignable with an actual item (alignable-different) or whether they also used mostly the same words to convey the opposing feature (alignable-similar).

Procedure

Participants were randomly assigned to study version A or B, and then given the appropriate choice booklet. They were informed that they would be asked to make a few decisions, and that the first one was to choose between two apartments described on the first page. The experimenter then read the scenario at the top of the page aloud, and followed up to make sure that they understood it. The participant was then asked to read the features of each choice aloud to the experimenter, and to make their choice. Participants were given as much time as they wished to make a choice, which typically took less than 1 min after the features were read aloud. The same procedure was followed for the remaining two scenarios (job candidate and restaurant).

After all three choices were made, the participant returned the choice booklet to the experimenter, who then informed the participant that we were interested in knowing what they remembered from the decisions they just made. The test directions were then read aloud to the participant, and the features and options were identified on the page to avoid any confusion. The participant was instructed to work through the booklet in order (apartment, job candidate, restaurant), and to circle a response for every item, even if he or she was not sure as to the correct response. The test booklet was then returned to the experimenter.

Results

The first set of analyses shown below examined whether participants were able to correctly identify whether items (the features) had been in the choice scenario or not. We therefore treated a circled response for either the first or second option as an 'old' response. The chances of a randomly endorsed 'old' response is therefore 2/3 or 0.66. Figure 1 shows the proportion of 'old' responses to studied and nonstudied items, and table 4 presents recognition accuracy. We also analyzed whether participants were accurate in their attribution of the source of the studied features to the first or second option in each scenario. Table 5 presents the proportion of 'old' respons-

es to studied items for which source identifications were accurate. Normality of the data was determined using Mauchly's Test of Sphericity for each analysis of variance (ANOVA) run; Mauchly's W = 1.000 for all analyses, indicating that normality of the average variance-covariance matrix was present.

Correct Responses (Hits)

An ANOVA examining the proportion of old items that were correctly identified as having been in the choice scenario with alignability (alignable vs. nonalignable old features) as a within-subjects variable and group (patients with AD vs. older adults) as a between-subjects variable yielded a main effect of group, $F(1, 44) = 5.64$, $p = 0.022$, $\eta^2 = 0.11$, indicating that, as expected, patients with AD made fewer old responses to items that had been seen earlier relative to older adults. There was also a main effect of alignability, $F(1, 44) = 4.58$, $p = 0.038$, $\eta^2 = 0.09$, revealing that participants made greater old responses to items that were alignable than items that were nonalignable. Although the interaction between group and alignability did not achieve significance, $F(1, 44) = 1.71$, $p = 0.198$, $\eta^2 = 0.04$, post-hoc tests reveal that the main effect of alignability was significant for the older adult controls, $F(1, 21) = 4.91$, $p = 0.038$, $\eta^2 = 0.19$, but not for the patients with AD, $F(1, 23) < 1$, $\eta^2 = 0.02$.

False Alarms

Old responses to three types of false alarms were analyzed: those that were alignable with items in the choice scenario and showed surface similarity (alignable-similar, e.g. study: 'Friendly waiters and waitresses'; test: 'Unfriendly waiters and waitresses'), those that were alignable with items in the choice scenario and did not show surface similarity (alignable-different, e.g. study: 'Friendly waiters and waitresses'; test: 'Staff can be rude sometimes'), and those that were not alignable (nonalignable, e.g. study: 'Friendly waiters and waitresses'; test: 'Some dishes are bland'). An ANOVA with alignable type (alignable-similar, alignable-different, nonalignable new features) as a within-subjects variable and group (patients with AD vs. older adults) as a between-subjects variable revealed effects of alignable type, $F(2, 88) = 28.50$, $p < 0.0005$, $\eta^2 = 0.39$, and group, $F(1, 44) = 5.47$, $p = 0.024$, $\eta^2 = 0.11$, and a group by alignable type interaction, $F(2, 88) = 17.07$, $p < 0.0005$, $\eta^2 = 0.28$. The effect of group indicates that patients with AD made greater false alarms than older adults. To understand the effect of condition and the interaction, additional analyses were performed.

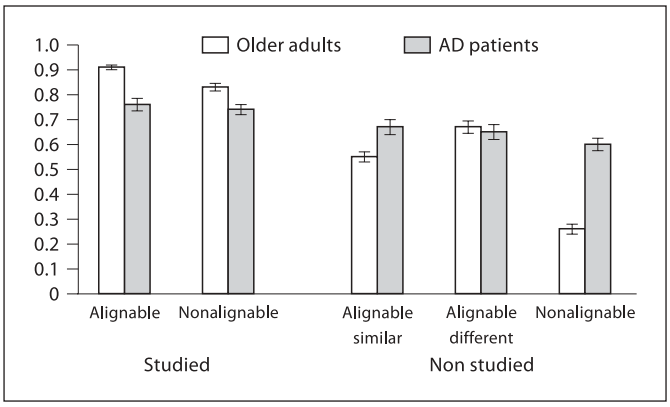

Fig. 1. Proportion of 'old' responses to studied and nonstudied items as a function of alignability and group.

Table 4. Recognition accuracy

	Group	
	older adults	AD patients
Recognition accuracy (studied minus nonstudied items)		
Alignable studied items minus alignable-different non studied items	0.23 (0.06)	0.11 (0.04)
Nonalignable studied items minus non-alignable non studied items	0.58 (0.04)	0.14 (0.03)

Standard error in parentheses.

Table 5. Source identification accuracy

	Group	
	older adults	AD patients
Proportion of hits also correctly attributed to source		
Alignable	0.68 (0.04)	0.48 (0.04)
Nonalignable	0.71 (0.03)	0.59 (0.04)

Standard error in parentheses.

An analysis of condition (alignable-similar, alignable-different, nonalignable) in the patients with AD alone did not reveal any significant differences between these three types of false alarms, $F(2, 46) = 1.26$, $p = 0.293$, $\eta^2 = 0.05$. The same analysis in the older adult controls, however, did reveal very robust differences between these false

alarm types, $F(2, 42) = 39.25$, $p < 0.0005$, $\eta^2 = 0.65$. Paired sample t tests revealed that the older adults made more of both alignable-similar, $t(21) = 6.53$, $p < 0.0005$, and alignable-different, $t(21) = 8.55$, $p < 0.0005$, false alarms than nonalignable false alarms. The older adults also made more alignable-different than alignable-similar false alarms, $t(21) = 2.51$, $p = 0.020$.

Recognition Accuracy

To evaluate recognition accuracy we subtracted alignable-different false alarms from alignable hits and nonalignable false alarms from nonalignable hits. A 2 (alignability: alignable vs. nonalignable) × 2 (group: patients with AD vs. older adults) ANOVA revealed that, as expected, recognition accuracy was lower in the patients with AD than the older adults, $F(1, 44) = 30.36$, $p < 0.0005$, $\eta^2 = 0.41$. In addition, an effect of alignability revealed that recognition accuracy was lower for alignable than nonalignable items, $F(1, 44) = 27.42$, $p < 0.0005$, $\eta^2 = 0.38$. Finally, there was an alignability by group interaction, $F(1, 44) = 20.00$, $p < 0.0005$, $\eta^2 = 0.31$. Post-hoc tests suggest that the interaction is present because recognition accuracy in the older adults was greater in the nonalignable than in the alignable items, $t(21) = 6.38$, $p < 0.0005$, but similar for the patients with AD, $t(23) < 1$.

Source Memory

Lastly, we evaluated whether participants were accurate in their attribution of the source of the studied features to the first or second option in each scenario (table 5). A 2 (alignability: alignable vs. nonalignable old features) × 2 (group: patients with AD vs. older adults) ANOVA revealed a main effect of alignability, $F(1, 44) = 4.10$, $p = 0.049$, $\eta^2 = 0.09$, indicating participants were overall less accurate in their source memory for alignable versus nonalignable studied items. This suggests that when two features are directly comparable, it is harder to remember which option each feature was associated with than when a feature is not comparable with anything in the other option. There was also a main effect of group, $F(1, 44) = 17.19$, $p < 0.0005$, $\eta^2 = 0.28$, revealing that patients with AD were less accurate in their source memory than the older adult controls. There was no group by alignability interaction, $F(1, 44) = 1.03$, $p = 0.316$, $\eta^2 = 0.02$. However, a one-sample t test shows that the patients did demonstrate above chance source memory for nonalignable studied items, $t(23) = 2.21$, $p = 0.038$, though not for alignable studied items, $t(23) < 1$.

Discussion

The present study confirms and expands our understanding of episodic memory for choices in healthy older adults and provides new findings regarding episodic memory for choices in patients with AD. As expected, patients with AD showed overall poorer episodic memory, correctly identifying fewer old features as old and incorrectly identifying more new features as old than controls did. Patients with AD also showed impaired source memory for the features compared with older adults. This poorer memory for the features is consistent with the episodic memory loss that is one of the hallmark symptoms of AD [27].

But of primary interest was the question of whether the alignability of features would influence memory more or less for the patients with AD than for control participants. Our study replicates previous findings [10] that older adults without AD show a large influence of alignability, as they are more likely to both correctly and incorrectly identify alignable features as being associated with the original choice options.

In contrast, we found no effect of alignability on recognition memory among patients with AD. Comparisons of alignable and nonalignable features revealed that the patients did not show any benefit for alignability in their correct recognition and no additional impairment due to alignability in their false recognition. Thus, unlike healthy older adults, patients with AD do not remember choice options as being more easily compared than they actually were. If this difference among controls and patients with AD extends to comparison processes during choice, it would suggest that patients with AD are less likely to compare features across options in a systematic way. Such changes could contribute to less effective decision making.

Furthermore, because the alignable nonstudied features are familiar due to the underlying similarity of their meaning, the finding that the patients' false alarms to alignable and nonalignable features were the same suggests that patients with AD show impaired familiarity – in fact, in this analysis they showed little or no evidence of this type of familiarity. Previous studies of patients with AD have also found that patients with AD show impaired familiarity in addition to recollection [13, 15, 28–30]. It is worth noting that although no evidence of the use of familiarity was found in the patients with AD in our study, the patients clearly demonstrated above chance episodic memory performance, as shown by a 2 (studied vs. nonstudied) × 2 (alignable-different vs. nonalign-

able) ANOVA for the patients' recognition of old items which showed a significant and robust effect of study status, $F(1, 23) = 14.98$, $p = 0.001$, $\eta^2 = 0.39$.

In this study, we manipulated whether the alignable new features used the same words as the old features they could be contrasted with (alignable-similar) or used different language to convey the contrast (alignable-different). Thus, for example, all participants were given the new feature 'recently painted interior' as part of the apartment choice memory test. Half the participants had seen 'Interior has not been painted recently' and the other half had seen 'Walls look grimy' associated with one of the apartment choice options. We included the alignable-different new features in order to rule out the possibility that false alarms to alignable features were due to the surface similarity of the features. We expected, however, that surface similarity would lead to additional episodic memory errors and therefore false alarms would be higher for the alignable-similar than for the alignable-different features, and for both types of false alarms to be higher than those to nonalignable new features.

As expected, older control participants made fewer false alarms to nonalignable new features (e.g. 'Lots of room for storage') than to alignable new features. However, to our surprise, older adult controls were less likely to falsely call a feature like 'Recently painted interior' old when they had seen a feature that shared surface similarity with it (e.g. 'Interior has not been painted recently') than when they had just seen a feature that was alignable with it (e.g. 'Walls look grimy'). Thus, instead of increasing their false alarm rate, surface similarity decreased it. This surprising finding may be due to a recall-to-reject process [28, 31], in which the alignable-similar features provided more specific cues to recall their alignable match than alignable-different features did. Having recalled the feature that was seen, people might have been able to remember that they did not see a comparable feature to contrast with that feature.

Patients with AD did not show any difference in their false alarm rate for any of the new features, indicating that how easily the new feature can be compared with old features makes little difference for them. That the patients showed very high levels of false alarms of all types of nonstudied features (from 0.60 to 0.67) suggests that decisions of this level of complexity (i.e. with eight features per option) simply overwhelm their episodic memory-encoding capabilities. They would not, therefore, be able to make such decisions accurately if they had to make them based on their episodic memory for the option features, rather than having the features available for reference throughout the decision. This finding was somewhat surprising because these decisions appear, at least at first glance, to be relatively simple and straightforward – similar to the kinds of decisions that are frequently made in everyday life. Presumably the decisions presented in this study are of equal or lesser complexity than many decisions outside of the laboratory regarding where they should live, how they should spend their money, whether they should undergo major surgery, and whether they should enter into a clinical trial of an experimental medication.

Frontal/executive dysfunction in the patients with AD may provide another explanation of their poor performance on this task. Frontal lobe functioning is required for many kinds of decision making tasks. Patients with ventromedial prefrontal cortex lesions were found to be impaired on the Iowa Gambling Task [32]. On the Game of Dice Task, Brand et al. [4] found that not only were Korsakoff patients impaired, but that their impairment correlated with disturbances of specific executive functions including errors on the Modified Wisconsin Card Sorting Test [33]. And using almost the same task as that of the present study, Mather et al. [10] found that healthy older adults with high scores on tasks requiring strategic processing associated with prefrontal brain region functioning showed a larger advantage for remembering alignable relative to nonalignable studied features. Patients with AD show pathologic changes in the frontal lobes at autopsy [34], and neuropsychological and neuroimaging studies of patients with AD have demonstrated frontal lobe dysfunction [3, 35, 36]. Thus, frontal/executive dysfunction may help explain why patients with AD perform poorly on this decision making task.

In addition to being critical for decision making, the frontal lobes (and in particular ventrolateral frontal cortices) are also important for updating and maintaining information in working memory so that it can be further processed by other brain systems [37]. Because of their frontal lobe dysfunction, patients with AD are also impaired in tasks requiring working memory tasks [1, 2, 38]. Thus, working memory deficits may also contribute to the poor performance that patients with AD show in the present study.

We believe that the present study provides a valuable contribution toward understanding decision making in patients with AD, an important but little explored area. It should be noted, however, that there were a number of limitations of the present study that could be improved in future studies. The patients showed a relatively wide range of impairments as measured by the MMSE, making the population studied somewhat heterogeneous. Be-

cause the patients were not given a standard neuropsychological test battery, correlational analyses with standard cognitive tests could not be performed. Future studies may be able to improve on these limitations, and also provide new insights into decision making in AD. For example, if a series of choices were given to the patients, starting with those that had very few features and systematically increasing the number of features, we would be able to better ascertain which choices are reasonable for them and which are too difficult.

In summary, our study reveals two main findings. The first is the dramatic impairment that patients with AD have in remembering features from choices they just made. This may lead to serious difficulties in making decisions that involve maintaining features from various options in either episodic or working memory as one works through the choice. There is, of course, an obvious way to circumvent their difficulty in remembering the different options and features of such decisions. If the different options and their features are presented to the patient at the same time, such as on separate sheets of paper laid out on a table, then the patient might be more likely to be able to accurately compare the options despite their memory deficits. Although one would presume that such a strategy is frequently used when patients with mild AD are involved in making decisions, the experience of one of us (A.E.B.) in clinical practice suggests that such strategies are hardly, if ever, used. We hope that the results of our study will highlight the need for such approaches to be used whenever patients with mild AD are involved in making important life decisions.

The second central finding from our study is that, unlike control participants, the patients do not show any influence of alignability in their recognition memory for the option features. This lack of organization in patients' memory for the choice options suggests that they are less likely than controls to engage in systematic comparison processes during the choice. In particular, the patients may be less likely to put the two options into alignment by trying to compare each feature from an option to a corresponding feature from the other option. In addition, the lack of effect of alignability on the patients' false alarms to new items suggests that they are not attempting to use features from one option to help them remember corresponding features from the other option. Failing to compare options in a feature-by-feature fashion may lead to different choices among patients with AD. Further work is needed to see whether these changes in the comparison processes lead to worse choices, and if so, how effective decision making might be maintained for as long as possible among patients with AD.

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