False Recognition of Emotional Word Lists in Aging and Alzheimer Disease

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Objective: To examine 3 different aspects of the emotional memory effect in aging and Alzheimer disease (AD): item-specific recollection, gist memory, and recognition response bias.

Method: Younger adults, older adults, and patients with AD performed a false recognition memory test in which participants were tested on "lure" items that were not seen at study, but were semantically related to the study items. Participants were tested on 5 emotional and 5 non-emotional lists.

Results: In addition to finding an increase in true recognition for emotional versus non-emotional items in healthy younger and older adults but not in patients with AD, and confirming that emotional items led younger adults to shift their response bias to a more liberal one, 3 novel findings were observed. First, the emotional effect on response bias was also observed in healthy older adults. Second, the opposite emotional effect on response bias was observed in patients with AD. Third, emotional items did not lead to an improvement in item-specific recollection or gist memory.

Conclusions: Although healthy older adults show the normal amygdala-modulated criterion shift for emotional items—influencing their subjective feeling that information has been previously encountered, the amygdala pathology present in early AD may disrupt this influence.

Key Words: false memory, emotional memory, aging, Alzheimer disease, response bias

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Although memory is often accurate, memory distortions and false memories frequently occur.[1] False recognition, one type of memory distortion that has been studied in the laboratory, occurs when people incorrectly claim to have previously encountered a novel word or event. Experiments using a paradigm originally developed by Deese[2] and revived and modified by Roediger and McDermott[3] have demonstrated robust levels of false recognition. After studying lists of semantic associates (eg, candy, sour, sugar, bitter, good, taste, and so forth) that all converge on a nonpresented "theme word" or "related lure" (eg, sweet), participants frequently intruded the related lure on free recall tests,[2] and made very high levels of false alarms to these words on recognition tests.[3] Subsequently, experiments using a number of variations of this paradigm have been conducted, including those using words that are related phonologically[4–6] and orthographically,[7] rather than semantically.

In their article, "Are emotionally charged lures immune to false memory?," Pesta et al[8] examined the false recognition of emotional lures (eg, rape) that were orthographic associates of non-emotional words (eg, cape, tape, ripe, nape, rope, rake, rare, raze) in young adults. In 4 experiments, the repeated finding was that emotional lures showed lower rates of false recognition compared with non-emotional lures. They found that the distinctiveness of the emotional lures was the key factor; when they reduced the distinctiveness of the emotional lures by including several emotional words on the study list, rates of emotional false recognition increased. Nonetheless, these latter rates did not approach those of the non-emotional false recognition.

We were interested in whether false recognition of emotional lures would also be lower than that of non-emotional lures if study lists were related to the lures semantically rather than orthographically. Emotional stimuli are frequently better remembered than neutral stimuli.[9,10] Thus, participants would presumably show higher levels of true recognition for semantically related emotional words versus semantically related non-emotional words. We hypothesized that whether levels of false

recognition of emotional lures would be higher or lower than that of non-emotional lures would depend on the particular kind of memory that emotionality enhanced. Note that we did not expect to replicate the results of Pesta et al[8] as their study used orthographic associates of emotional lures (eg, for the lure rape, associates were cape, tape, ripe, nape, rope, rake, rare, raze), and our study used semantic associates of emotional lures (eg, for the lure rape, associates were sex, man, violate, blame, struggle, date, force, shame) (see Appendix for the complete word lists used).

True and false recognition in the Deese/Roediger-McDermott paradigm may be understood as depending upon memory for 2 different kinds of information: specific details of the prior encounter with a particular item (item-specific recollection), and the general meaning, idea, or gist conveyed by a collection of items (gist memory[11]). As the study list is presented in the Deese/Roediger-McDermott paradigm, a gist representation is developed, which may result in an experience of either recollection or familiarity when either a studied item or a related lure is presented on a later recognition test.[12] Thus, accurate recognition of previously studied items depends on both item specific and gist information, whereas false recognition of related lure words depends on remembering gist but not item-specific information.[13–15] If the emotionality of the semantically related words enhanced memory for the particular items that were studied (ie, item-specific recollection), we would expect that false recognition of emotional lures would be less than that of non-emotional lures. On the other hand, if emotional memory enhanced only the gist of the study list, then we would expect that false recognition of emotional lures would actually be greater than that of non-emotional lures.

We were also interested in subjects' memorial response bias for emotional items, that is, their tendency toward endorsing emotional items as "old" relative to non-emotional items. Several prior studies examined response bias in this setting and found that young adults showed a more liberal response bias (ie, they were more likely to respond old) for emotional compared with non-emotional items in recognition memory tests.[16,17] Windman and Kutas[17] referred to this finding as the "emotion-induced recognition bias effect." Because in their study the effects of emotion were associated with relatively early event-related potential effects (from 300 to 500 ms), Windman and Kutas suggested that the emotion-induced recognition bias effect altered participants' recognition memory at an unconscious and automatic stage of processing.

While examining response bias may seem to be an esoteric issue of academic interest only, we believe that its examination is absolutely essential to understanding memory. For example, in the clinic, 2 patients may each receive a score of 6 on the recognition portion of a memory test in which there are 10 studied and 10 unstudied words. The first patient correctly endorses only 6 of the 10 studied words and none of the unstudied words. The second patient correctly endorses all 10 studied words but also incorrectly endorses 4 of the unstudied words. Do these 2 patients have the same problems with their memory? The answer is likely no. The first patient shows a *conservative response bias*, that is, they responded old less than 50% of the time, whereas the second patient has a *liberal response bias* because they responded old greater than 50% of the time. Despite having the same recognition score, these 2 patients probably have different memory problems, which may be attributable to different anatomical and neurochemical dysfunction. Focusing on discrimination as the sole measure of memory performance would overlook such differences.

In addition to understanding the effects of emotion on false recognition and response bias in young adults, we were also interested in determining the effects of aging and Alzheimer disease (AD) on emotional false recognition and response bias. Most studies have shown that the emotional enhancement of memory is intact for healthy older adults,[18–20] although one study found that relative to younger adults, older adults showed intact enhancement of memory for emotional items but impaired enhancement of memory for items embedded in an emotional context,[21] and another study suggested that older adults may show memory enhancement for positive but not negative information.[22] We predicted that the emotional memory effect observed for true and false recognition and recognition response bias would be similar in healthy younger and older adults.

Several studies have suggested that the emotional memory effect is impaired in patients with AD. For example, Hamann et al[23] studied emotional responses and emotional memory in patients with AD compared with older adults. Patients with AD demonstrated normal emotional responses to picture stimuli as measured by arousal ratings and skin-conductance responses. On a recognition test, patients with AD did not show the emotional memory effect for negative pictures observed in older adults. Thus, Hamann et al[23] demonstrated dissociation between the intact emotional responses and impaired emotional memory effect for negative stimuli in patients with AD. Similarly, Kensinger and others found that patients with AD did not show the improved memory for emotional versus neutral pictures, words, and brief narratives observed in younger and older adults.[21,24,25]

Other studies, however, found that patients with AD showed a normal emotional memory effect. Kazui and colleagues[26,27] found that patients with AD and older adults both remembered an emotionally arousing story better than a neutral one; the extent of memory improvement was similar in patients and controls. Similarly, Boller and colleagues[28] also found that patients with AD remembered emotional better than neutral stories, and Moayeri and colleagues[29] found that patients with AD remembered more emotionally negative parts of an audio-visual story compared with the emotionally neutral parts.

One possible reason for the discrepancy between the results of these different studies examining emotional enhancement of memory in patients with AD may be related to the differences between gist memory and item-specific recollection. That is, the studies of Kazui et al,[26,27] Boller et al,[28] and Moayeri et al[29] may have facilitated memory for the gist of the stories, whereas item-specific recollection may have been more important for remembering the unrelated stimuli in the studies of Hamann et al,[23] Kensinger et al,[21,24] and Abrisqueta-Gomez et al.[25] Given this possibility, we suspected that patients with AD might show an enhancement of gist memory—but not item-specific recollection—for emotional relative to neutral word lists. If the patients' enhanced gist memory caused them to be more likely to experience familiarity for any emotional item (those related and those unrelated to the study list) then this would lead them to endorse more emotional than non-emotional items, giving them a more liberal response bias for the emotional versus non-emotional items.

In brief, using a paradigm consisting of words that were semantically related to emotional lure words, we were interested in determining: (1) the false recognition of emotional lure words, (2) the response bias for emotional words, (3) the effects of aging on false recognition of emotional lure words, (4) the effects of aging on response bias for emotional words, (5) the effects of AD on false recognition of emotional lure words, and (6) the effects of AD on response bias for emotional words.

METHODS

Participants

Nineteen patients with a clinical diagnosis of probable AD (NINCDS-ADRDA criteria[30]) were recruited from the Memory Disorders Unit, Brigham and Women's Hospital (BWH), Boston, MA. Nineteen 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 flyer and posters placed in senior centers in and around Boston. Twenty healthy young adults (mean age = 20.0 y, range = 18 to 23 y; mean education = 14.3 y, range = 13 to 16 y) were recruited from Harvard University. Written informed consent was obtained from all participants and their caregivers (where appropriate). The study was approved by the Human Subjects Committee of BWH and Harvard University. Participants were paid $10/h for their participation. Older adults were excluded if they scored below 27 on the Mini-mental Status Examination.[31] Most patients with AD showed mild to moderate impairment on the Mini-mental Status Examination (mean = 23.0, range = 16 to 29). Participants were excluded if they were characterized by clinically significant depression, alcohol or drug use, cerebrovascular disease or traumatic brain damage, or if English was not their primary language. All participants had normal or corrected to normal vision and hearing. The patients were matched to the older adults on the basis of gender (10 female patients, 12 female older adults), age (patient mean = 76.6 y, range = 60 to 91 y; older adult mean = 73.8 y, range = 63 to 90 y), and education (patient mean = 14.3 y, range = 9 to 19 y; older adult mean = 15.0 y, range = 12 to 23 y).

Materials and Procedure

Ten lists of non-emotional words and 10 lists of emotional words were either adapted from Roediger and McDermott,[3] Cassiday et al[32] Wilhelm et al[33] or were constructed and extensively piloted. Emotional and non-emotional lists were equivalent for word length (non-emotional mean = 5.3 letters; emotional mean = 5.5 letters) and Kucera-Francis written frequency (non-emotional mean = 65.2; emotional mean = 52.7). (See Appendix for the word lists used.) Each word list consisted of 8 words semantically related to a critical lure word. Participants studied 5 non-emotional and 5 emotional lists in pseudorandom order. Studied and nonstudied word lists were counterbalanced across participants. Lists were presented from highest to lowest semantic associate on an Apple Macintosh G3 Powerbook computer, one word at a time for 2600 ms each, in the center of the screen, which was placed a comfortable viewing distance from the participant. Subjects were instructed to read the words out loud and remember them for a subsequent memory test. There was a 400-ms interval between words. The 10 study lists were presented successively without interruptions. There was a 5-minute retention interval while participants performed simple puzzles. Each test list was composed of 30 studied items (from positions 1, 3, and 6 of each of the 10 studied lists), 10 nonstudied non-emotional control items (selected from the 15 possible words at positions 1, 3, and 6 of the 5 nonstudied non-emotional lists), 10 nonstudied critical lure items (1 from each studied list), and 10 nonstudied unrelated lure control items (1 from each nonstudied list). (Note that nonstudied emotional control items were not used because of the concern that they would engender false alarms because of their semantic similarity to studied emotional items. This asymmetry of the study design represents a limitation of this paper.) Test items were presented visually in the same font and size as in the study session in a different random order for each participant, and were present on the screen until the participant responded verbally with an ''old'' or ''new'' response. The experimenter then entered the appropriate response on the keyboard.

RESULTS

Table 1 shows the results for old responses to the 7 different item types: emotional and non-emotional studied items, nonstudied non-emotional control items, related emotional and non-emotional lure items, and unrelated emotional and non-emotional lure control items. Table 1 also shows one measure of item-specific recollection: subtracting related lure items from studied items. Analyses of true recognition are presented first, followed by false recognition, item-specific recollection,

TABLE 1. Proportion of ''Old'' Responses to Studied Items (True Recognition), Lure Items (False Recognition), and Item-specific Recollection by Emotion and Group

	Group		
	Younger Adults	**Older Adults Mean (SD)**	**AD**
True recognition			
Emotional studied items	0.84 (0.11)	0.75 (0.19)	0.71 (0.24)
Non-emotional studied items	0.78 (0.13)	0.67 (0.19)	0.73 (0.21)
Nonstudied non-emotional control items	0.06 (0.08)	0.04 (0.06)	0.37 (0.27)
False recognition			
Emotional related lure items	0.37 (0.25)	0.49 (0.28)	0.63 (0.25)
Non-emotional related lure items	0.39 (0.28)	0.46 (0.25)	0.68 (0.31)
Emotional unrelated lure control items	0.13 (0.15)	0.14 (0.18)	0.42 (0.30)
Non-emotional unrelated lure control items	0.02 (0.06)	0.07 (0.12)	0.50 (0.35)
Item-specific recollection (studied minus related lure items)			
Emotional	0.47 (0.27)	0.26 (0.23)	0.08 (0.25)
Non-emotional	0.39 (0.32)	0.20 (0.25)	0.05 (0.24)

and finally response bias. Comparisons between older and younger adults are always presented first, followed by comparisons between patients with AD and older adults.

True Recognition

Older versus younger adults. An analysis of variance (ANOVA) of old responses to studied items with the within-subjects factor of emotion (emotional vs. non-emotional) and the between-subjects factor of group (younger vs. older adults) yielded an effect of emotion [$F(1,37) = 9.39$, $P = 0.004$, $\eta^2 = 0.20$], an effect of group [$F(1,37) = 5.07$, $P = 0.030$, $\eta^2 = 0.12$], and no interaction [$F(1,37) < 1$]. Younger and older adults made similar numbers of false alarms to the nonstudied control items [$F(1,37) = 1.12$, $P = 0.296$]. The effect of emotion shows, as predicted, that younger and older adults were more likely to correctly recognize studied emotional versus non-emotional words, consistent with previous studies[9,10,19,20] (Table 1). The effect of group is present because younger adults were more likely to respond old to studied items than were older adults. Importantly, the lack of an Emotion × Group interaction indicates that emotional content boosted the proportion of old responses similarly for both age groups.

Patients with AD versus older adults. Similar analyses comparing older adults and patients with AD showed a somewhat different pattern of results. Analysis of old responses to studied items yielded no effects of emotion [$F(1,36) = 1.57$, $P = 0.218$, $\eta^2 = 0.04$] or group [$F(1,36) < 0.1$], but did show a near significant Emotion × Group interaction [$F(1,36) = 3.67$, $P = 0.064$, $\eta^2 = 0.09$]. Post hoc *t* tests show that this near significant interaction is present because an effect of emotion was present for older adults [$t(18) = 2.41$, $P = 0.027$] but not for patients with AD [$t(18) < 1$] (Table 1). Patients AD made more false alarms to the unstudied non-emotional control items than older adults [$F(1,36) = 27.31$, $P < 0.0005$. $\eta^2 = 0.43$]. Thus, consistent with the previous studies of Hamann et al[23] and Kensinger et al,[21] we found an enhancing effect of

emotion on memory for studied items in healthy older adults but not in patients with AD.

False Recognition

Older versus younger adults. An ANOVA of false recognition of lure items with within-subjects factors of emotion (emotional vs. non-emotional) and relatedness (related vs. unrelated to study lists) and the between-subjects factor of group (younger vs. older adults) yielded an effect of relatedness [$F(1,37) = 94.01$, $P < 0.0005$, $\eta^2 = 0.72$], but no reliable effects of emotion [$F(1,37) = 3.22$, $P = 0.081$, $\eta^2 = 0.08$] or group [$F(1,37) = 1.97$, $P = 0.169$, $\eta^2 = 0.05$], and no reliable interactions [Emotion × Relatedness interaction: $F(1,37) = 3.13$, $P = 0.085$, $\eta^2 = 0.08$; other $Fs(1,37) < 1.2$]. The large effect of relatedness is present because participants were much more likely to false alarm to lures that were related to the study list than to those that were unrelated (Table 1).

Patients with AD versus older adults. The analysis of false recognition of lure items for patients with AD and older adults showed effects of relatedness [$F(1,36) = 97.74$, $P < 0.0005$, $\eta^2 = 0.73$] and group [$F(1,36) = 16.00$, $P < 0.0005$, $\eta^2 = 0.31$] and an Relatedness × Group interaction [$F(1,36) = 9.39$, $P = 0.004$, $\eta^2 = 0.21$]. There was no effect of emotion [$F(1,36) < 1$], and no other interactions [Emotion × Group: $F(1,36) = 2.78$, $P = 0.104$, $\eta^2 = 0.07$; other $Fs(1,36) < 1$]. The effect of relatedness is again present because participants made more false alarms to related compared with unrelated lure items. The Relatedness × Group interaction is present because the effect of relatedness was greater for older adults than for patients with AD. The effect of group is present because patients with AD made more false alarms to lure items than did healthy older adults (Table 1).

Item-specific Recollection

There are different ways in which others and we have estimated the item-specific recollection used by

TABLE 2. Signal Detection Analyses for True Recognition, False Recognition, and Item-specific Recollection by Emotion and Group

	Group					
	Younger Adults		**Older Adults**		**AD**	
	d′	**C**	**d′**	**C**	**d′**	**C**
True recognition (studied vs. nonstudied non-emotional control items)						
Emotional	2.35	0.20	2.21	0.38	1.03	− 0.16
Non-emotional	2.17	0.29	1.96	0.50	1.07	− 0.18
False recognition (related lure vs. unrelated lure control items)						
Emotional lures	0.62	0.65	0.94	0.48	0.53	− 0.05
Non-emotional lures	1.01	0.81	1.05	0.61	0.44	− 0.26
Item-specific recollection (studied vs. related lure items)						
Emotional	1.32	− 0.32	0.74	− 0.36	0.36	− 0.49
Non-emotional	1.10	− 0.25	0.56	− 0.20	0.23	− 0.60

participants. In the present study we used the subtraction method, which is based upon the following logic: true recognition of studied items can be thought of as a combination of gist memory plus item-specific recollection, whereas false recognition of related lures is likely a measure of gist memory minus any item-specific recollection that is available to counteract the effect of gist. Thus, subtracting false recognition from true recognition should provide a measure of the item-specific recollection used by the groups.

Older versus younger adults. Older adults showed lower levels of item-specific recollection than younger adults as indicated by an effect of group [$F_{(1,37)} = 7.01$, $P = 0.012$, $\eta^2 = 0.16$]. There was no effect of emotion [$F_{(1,37)} = 2.11$, $P = 0.155$, $\eta^2 = 0.05$] and no interaction [$F_{(1,37)} < 1$].

Patients with AD versus older adults. Patients with AD showed lower levels of item-specific recollection than older adults as indicated by an effect of group [$F_{(1,36)} = 6.50$, $P = 0.015$, $\eta^2 = 0.15$]. There was no effect of emotion [$F_{(1,36)} < 1.5$] and no interaction [$F_{(1,36)} < 1$].
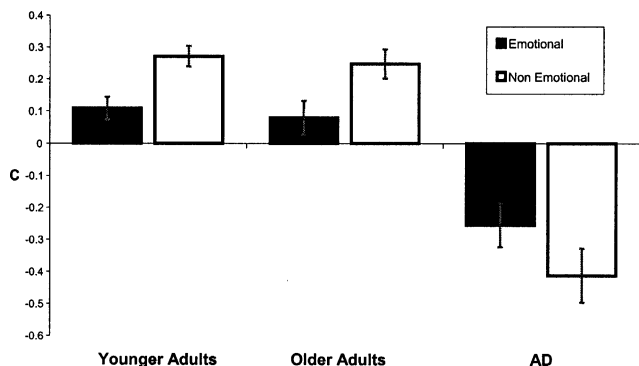

FIGURE 1. Values of the bias measure C collapsed across studied items, related lures, and unrelated lures in younger adults, older adults, and patients with AD for emotional and non-emotional items. Error bars show standard error.

Response Bias (C)

We used C as our response bias variable, computed as described in Snodgrass and Corwin.[34] Negative values of C indicate a liberal response bias (more likely to call an item old), and positive values of C indicate a conservative response bias (more likely to call an item new). Table 2 shows the complete signal detection analyses. (Analyses of d′ are not presented because d′ is mathematically similar to our calculation of item-specific recollection and yielded similar results.)

Older versus younger adults. An ANOVA investigating the effect of emotion on the bias measure C across all items types revealed a significant effect of emotion [$F_{(1,37)} = 8.55$, $P = 0.006$, $\eta^2 = 0.19$], no effect of group and no interaction [$Fs_{(1,37)} < 1$], indicating that younger and older adults were more liberal in their responses to emotional compared with non-emotional items (Fig. 1).

Patients with AD versus older adults. An ANOVA comparing patients with AD to older adults found an effect of group [$F_{(1,36)} = 9.22$, $P = 0.004$, $\eta^2 = 0.20$], no effect of emotion [$F_{(1,36)} < 1$], and a Group × Emotion interaction [$F_{(1,36)} = 4.53$, $P = 0.040$, $\eta^2 = 0.11$]. The effect of group is present because the response bias of patients with AD was more liberal compared with that of older adults (Fig. 1). The interaction is present because, compared with non-emotional items, emotional items caused older adults to be more liberal and patients with AD to be more conservative (Fig. 1). Note that although the interaction was significant—indicating that emotion influenced response bias differently in patients with AD and older adults, the post hoc tests for the individual groups were not significant, likely due to the number of subjects in the study [older adults: $t_{(18)} = 1.72$, $P = 0.102$; AD: $t_{(18)} = 1.34$, $P = 0.198$].

DISCUSSION

Effects of Emotion on True and False Recognition and Recognition Response Bias

In the present study we found that healthy younger and older adults showed greater true recognition of

emotional versus non-emotional words, consistent with previous research.[9,10,20] This effect, however, did not seem to stem from enhancements in memory per se: emotion had little impact on false recognition (our measure of gist memory) and no effect on item-specific recollection (true minus false recognition).

Instead we found that the increases in true recognition arose from changes in response bias: healthy adults showed a more liberal response bias for emotional versus non-emotional items (Fig. 1). In other words, younger and older adults made more old responses to emotional items than non-emotional items regardless of whether they were studied or nonstudied, and if nonstudied, regardless of whether they were related to the studied items or not. These results suggest that studying emotionally charged items may shift healthy participants' response bias to a more liberal one for all emotional items at test—not just the ones related to the study lists. This finding is consistent with prior studies of young adults.[16,17,35]

One possible explanation for this effect of emotion on recognition bias is related to the gist formed by participants. If the gist representation of emotional word lists is more robust and/or broader than that of non-emotional word lists, participants may be more likely to experience familiarity or recollection on the recognition test for emotional than non-emotional related and unrelated lures. However, because false recognition (our measure of gist memory) was not increased for emotional items, this explanation is unlikely to be correct.

Instead, we agree with Windmann and Kutas[17] who suggested that emotion biased subjects' recognition memory at an unconscious and automatic stage of processing. Presumably, this bias serves to facilitate processing of potentially threatening stimuli relative to neutral ones. This facilitation in processing may lead to enhanced fluency, which produces a sense of familiarity in subjects, leading to an old response regardless of whether the items were studied.

A remaining issue is why healthy participants' response bias was more liberal for emotional versus non-emotional studied and unrelated lure items but not for related lure items. Many different factors contribute to false recognition of related lure items. One possible explanation for the present results is that any greater bias toward responding old to emotional versus non-emotional related lures may have been mitigated by the emotional lures being somewhat more distinctive than the non-emotional lures, as participants are less likely to false alarm to distinctive items.

Effects of Aging and AD on Emotional True Recognition, False Recognition, and Recognition Response Bias

We were also interested in understanding the effects of aging and AD on emotional true recognition, false recognition, and recognition response bias. Regarding aging, the lack of Emotion × Group interactions in the analyses of older versus younger adults suggests that

emotion impacted older and younger adults in a similar manner in our study.

By contrast, the analyses comparing patients with AD to older adults demonstrated differential effects of emotion on these groups. For the true recognition analyses, patients with AD did not show the greater endorsement of emotional relative to non-emotional studied items that the older adults did, consistent with several previous studies.[21,23–25] Most notably, emotional items produced the opposite effect on response bias in these groups: emotional items caused older adults to be more liberal and patients with AD to be more conservative (Fig. 1). Our study, therefore, is the first to report the typical emotion-induced recognition bias effect in older adults, and the opposite effect in patients with AD.

These results are important in demonstrating that AD disrupts multiple effects of emotion on memory: patients with AD do not show an emotion-related boost in how much information is remembered,[21,23,25] and they also do not show emotion-induced changes with regard to where the criterion for a memory is set. We speculate that these abnormal effects of emotion in patients with AD is attributable to AD pathology in the amygdala.[36,37] This hypothesis is consistent with recent claims that amygdala activity during retrieval may not always enhance memory accuracy, but rather may serve to inflate one's confidence in a memory.[38] The results of the present study suggest that healthy adults show the amygdala-modulated criterion shift in response bias, whereas the amygdala pathology present even early in AD may disrupt the influence of emotion on a person's subjective feeling that information has been previously encountered.

By examining whether emotion increases item-specific recollection, gist memory, and/or alters response bias, the present study has investigated three different aspects of the emotional memory effect in aging and AD. In addition to confirming that emotional items led younger adults to shift their response bias to a more liberal one, and finding an increase in true recognition for emotional versus non-emotional items in healthy younger and older adults but not in patients with AD, 3 novel findings were observed. First, the normal emotional effect on response bias was not affected by healthy aging (Fig. 1). Second, the opposite emotional effect on response bias was observed in patients with AD. Third, emotional items did not lead to an improvement in either item-specific recollection or gist memory. We suggest that examination of response bias is necessary when evaluating the effect of emotion on memory in healthy and impaired populations.

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APPENDIX

Non-emotional Word Lists				
Slow	Sleep	Fruit	Foot	Soft
Fast	Bed	Apple	Shoe	Fur
Time	Nap	Vegetable	Hand	Touch
Boring	Dream	Orange	Toe	Feather
Stay	Snore	Kiwi	Kick	Satin
Wait	Awake	Citrus	Sock	Fleece
Steady	Doze	Ripe	Arch	Cotton
Turtle	Pillow	Pear	Heel	Smooth
Stop	Yawn	Banana	Ankle	Gentle
Window	Girl	Sweet	Teacher	Chair
Door	Boy	Candy	School	Table
Glass	Dolls	Sugar	Classroom	Sit
Pane	Female	Bitter	Student	Desk
Shade	Young	Sour	Learn	Seat
Ledge	Dress	Treat	Quiz	Couch
Sill	Pretty	Pastry	Test	Sofa
House	Caring	Taste	Grade	Wood
Open	Pink	Salty	Lecture	Cushion
Emotional Word Lists				
Rape	Sick	Hungry	Hell	Alone
Sex	Cough	Food	Devil	Single
Man	Fever	Starve	Satan	Isolated
Violate	Ill	Famine	Evil	Solitary
Blame	Flu	Empty	Damned	Apart
Struggle	Vomit	Stomach	Sin	Separate
Date	Doctor	Poor	Demon	Quiet
Force	Health	Eat	Heaven	Detached
Shame	Dizzy	Pangs	Judgment	Self
Danger	Thief	Cry	Lie	Anger
Fear	Steal	Tears	Fib	Mad
Caution	Robber	Sad	Cheat	Rage
Trouble	Crook	Tissue	Truth	Annoyed
Warning	Burglar	Sorrow	False	Furious
Risk	Money	Eyes	Mislead	Bothered
Hazard	Cop	Weep	Trick	Wrath
Alarm	Purse	Sob	Fake	Hate
Help	Mugger	Unhappy	Betray	Mood

Note: The non-emotional word lists (with the exception of the "Teacher" list) plus the emotional lists for "Sick," "Thief," and "Anger" were adapted and modified from Roediger and McDermott Experiment 2 Appendix.[3] The "Rape" list was adapted and modified from Cassiday et al.[32] The lists for "Alone" and "Danger" were adapted and modified from Wilhelm et al.[33] The other lists were created as described in the Methods.