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Familiar smiling faces in Alzheimer's disease: Understanding the positivity-related recognition bias

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Abstract

Recent research has revealed a recognition bias favoring positive faces and other stimuli in older compared to younger adults. However, it is yet unclear whether this bias reflects an age-related preference for positive emotional stimuli, or an affirmatory bias used to compensate for episodic memory deficits. To follow up this point, the present study examined recognition of emotional faces and current mood state in patients with mild Alzheimer disease (AD) and healthy controls. Expecting lower overall memory performance, more negative and less positive mood in AD patients, the critical question was whether the positivity-related recognition bias would be increased compared to cognitively unimpaired controls. Eighteen AD patients and 18 healthy controls studied happy, neutral, and angry faces, which in a subsequent recognition task were intermixed with 50% distracter faces. As expected, the patient group showed reduced memory performance, along with a less positive and more negative mood. The recognition bias for positive faces persisted. This pattern supports the view that the positivity-induced recognition bias represents a compensatory, gist-based memory process that is applied when item-based recognition fails.

Keywords

False recognition; Memory; Socioemotional selectivity; Facial emotion; Alzheimer disease

1. Introduction

Emotional information has been shown to induce a recognition bias (Budson et al., 2006; Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004; Grühn, Scheibe, & Baltes, 2007), reflected in enhanced true as well as false memory for positive and negative compared to neutral items (e.g., Johansson, Mecklinger, & Treese, 2004; Leiphart,

Rosenfeld, & Gabrieli, 1993; Maratos, Allan, & Rugg, 2000). Besides an age-independent emotion-induced recognition bias, age differences have been reported with respect to recognition of positive items. Recent research has revealed a larger recognition bias in older compared with younger adults for positive words, scenic pictures, and facial expressions, relying mainly on enhanced false memory (Fernandes, Ross, Wiegand, & Schryer, 2008; Kapucu, Rotello, Ready, & Seidl, 2008; Spaniol, Voss, & Grady, 2008; Werheid et al., 2010).

Two different explanations have been raised for this positivity-induced recognition bias in old age. First, according to Socioemotional Selectivity Theory (SST; Carstensen, 1993), old age is associated with a pronounced striving for emotional balance. Within this framework, the increased positivity-induced recognition bias in the elderly is thought to reflect a general age-related preference for positive stimuli, subserving emotion regulation (Mather, 2006; Spaniol et al., 2008). The bias was associated with higher self-reported positive affect in older compared with younger adults (Carstensen, Gottman, & Levenson, 1995; Mroczek & Kolarz, 1998). In experimental research, this relationship has been addressed by measuring an attentional or memory preference for positive items and relating it to current positive and negative affect (e.g., Fernandes et al., 2008). It was argued that socioemotional selectivity is an active, resource demanding process, which is reduced when cognitive resources are limited (Mather & Knight, 2005). Consequently, within this framework the positivity-related recognition bias should be reduced in cognitively impaired patients compared to age-matched controls.

Second, the positivity-induced recognition bias can be explained as a spontaneous gist-based process in light of general age-associated memory decline. In the case of face recognition, which is a rather difficult discrimination task (Werheid & Clare, 2007), an increased tendency to consider positive faces as previously encountered is thought to reflect a compensatory memory strategy. When being unsure about the correct answer, older participants might infer having previously ‘met’ the face from the fact that it is directly smiling at them. Such a “smiling bias” is in line with everyday experience, and with previous experimental research revealing that nonstudied facial portraits are more likely considered studied if they show a happy facial emotion (Baudouin, Gilibert, Sansone, & Tiberghien, 2000; Dobel et al., 2008), and with electrophysiological evidence showing that facial emotion might affect old/new judgments especially in the late processing stages, immediately prior to the decision (Wild-Wall, Dimigen, & Sommer, 2008). Further, it suggests that the positivity-related recognition bias is not due to aging *per se*, but may arise in the course of declining episodic memory.

In a previous series of experiments (Werheid et al., 2010), we had investigated this point by comparing older adults with normal episodic memory to an age-matched group with reduced episodic memory, as reflected by a diagnosis of amnesic Mild Cognitive Impairment (aMCI). The results showed that the positivity-induced response bias for happy faces persisted in aMCI. This finding was in accordance with the view that the bias reflects a stimulus-driven, compensatory memory process (Petrican, Moscovitch, & Schimmack, 2008). However, two points were left open in this study. First, the bias was preserved but not increased in aMCI, which could be due to the fact that memory deficits were, by definition, very mild. If this hypothesis was true, then patients with more severe memory deficits should display an enhanced bias. Second, self-reported affect was not assessed in this study, so the SST-derived hypothesis, that the positivity-related bias went along with more positive affect, could not be directly tested.

The present study aimed to address these open questions by comparing patients with mild Alzheimer’s disease (AD) and age-matched healthy adults with respect to performance in a

recognition task involving positive, negative, and neutral faces. Going beyond earlier research, positive and negative affects were assessed immediately before and after the experiment. Further, the recognition task used in our previous study was modified in several aspects, to avoid floor or ceiling effects. First, study and test parts were for both groups administered within the same session, instead of two consecutive days. Second, control participants received only one study block, whereas the patient group received three study blocks. This adjustment of difficulty was based on two pilot experiments. Moreover, to obtain standardized parameters of cognitive performance, a neuropsychological test battery including assessment of episodic memory performance, was administered to both groups.

Our hypotheses were as follows. We expected that patients with early AD would, despite additional practice, show reduced general memory performance compared to controls. Within this context, the central question of our study was whether the positivity-induced recognition bias would be increased in the patient group. If this increase were observed, this would support the hypothesis of a compensatory memory strategy. On the other hand, if no increase were observed, this would instead support the hypothesis of socioemotional selectivity.

2. Method

2.1. Participants

Eighteen patients with AD and 18 healthy controls participated in the experiment. The groups were matched for age, AD: $M 76.3$ years, $SD 8.6$, Controls: $M 75.4$ years, $SD 6.5$, $t(35) = .372$, $p = .712$; and education, AD: $M 15.2$ years, $SD 8.6$, Controls: $M 16.8$ years, $SD 2.4$, $t(35) = 1.641$, $p = .110$. There were thirteen women in the AD group, and nine in the control group, all were Caucasians. Patients were recruited from the Boston University Alzheimer's Disease Center. Healthy controls were also recruited from the Boston University Alzheimer's Disease Center, as well as community postings in the Boston area, and spouses of the AD patients who participated in the study.

Inclusion criteria for all participants were absence of past or present clinically significant depression, alcohol or drug use, cerebrovascular disease, or traumatic brain injury. All participants had normal or corrected-to-normal vision and sufficient hearing. Considering the fact that faces are a set of highly complex and perceptually similar stimuli (Werheid & Clare, 2007), prior to their inclusion in the study participants were screened for the ability to correctly perceive and match human faces by means of the Benton Facial Recognition Test (Benton, Sivan, Hamsher, Varney, & Spreen, 1994). All subjects were right-handed, and English was their native language. The study was approved by the human studies ethical committees of the Charité University Clinic, Campus Benjamin Franklin, Berlin, Germany, by the Boston University School of Medicine, Boston, MA, USA, and the Bedford VA Hospital, Bedford, MA, USA. All subjects gave IRB-approved informed consent before participating in the study, and were compensated at the rate of USD 10 per hour.

All subjects completed a neuropsychological battery to examine different aspects of cognitive functioning (see Fig. 1). These tests were administered in the following order in a separate 45 min session prior to the experimental learning paradigm: Mini Mental State Examination (Folstein, Folstein, & McHugh, 1975), the CERAD word list memory test (Morris et al., 1989), Trail Making Test Part B (Adjutant General's Office, 1944), FAS/categories Word Fluency Test (Monsch et al., 1992) and the 15-item Boston Naming Test (Mack, Freed, Williams, & Henderson, 1992).

2.2. Stimulus material

The stimulus material consisted of 192 portraits of Caucasian faces gathered from different databases (Lundqvist, Flykt, & Ohman, 1998; Martinez & Benavente, 1998; Werheid, Schacht, & Sommer, 2007) and selected based on computer-assisted 7-step valence ratings (Werheid et al., 2010). The portraits were edited to a unitary format (10.4 by 8 cm) and converted to 8-bit color scales with a grey background. To enable a comparison of the results with our previous study involving MCI patients and elder adults, the same stimuli were used, except for exchanging 10 faces, which had in the previous study received more than 10% misclassifications in the study part. These stimuli were assigned to two subsets A and B, each containing 32 faces per emotion category (happy, neutral, angry), 96 faces in total. The assignment of old-new status of the subsets to study or test session was counterbalanced across participants.

2.3. Procedure

After giving informed consent and completing the neuropsychological test battery, participants were administered the Geriatric Depression Scale (GDS; Yesavage et al., 1983) and the pre-test Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). Participants were then seated in front of a computer screen and informed that their task was to classify faces as happy, neutral or angry by pressing one of three labeled buttons (arrow left, arrow down, arrow right), or verbally indicating their choice to the experimenter, who pressed the keys. Also, they were instructed to watch the faces carefully because they would be asked to recognize them later on during the experimental session. After six practice items, participants viewed 96 faces of Set A or B in randomized order for 4 s each. To balance task difficulty, the faces were presented three times to the AD group and once to the control group, thus avoiding floor or ceiling effects in either group (Table 1).

Approximately 10 min following the study session, participants viewed 192 facial portraits in random order, half of which had been studied previously, and half of which were novel. The participants' task was to decide whether they had previously seen a portrait of the depicted person, and to indicate their decision by pressing one of two keys labeled 'old' or 'new', respectively. Finally, upon completion of the task, subjects were asked to fill out the post-test PANAS forms.

2.4. Data analysis

Emotion classification during the study session was analyzed by 2 by 2 mixed factor ANOVAs including the within-subjects factor emotion (angry vs. neutral, happy vs. neutral, angry vs. happy) and the between-subjects factor group (AD vs. control). Recognition performance during the test session was analyzed by computing the percentage of correctly recognized faces (hit rates) and erroneously recognized faces (false positives) for angry, neutral, and happy faces. Discrimination accuracy ($Pr = p[\text{hits}] - p[\text{false positives}]$), and recognition bias ($Br = p[\text{false positives}] / p[1 - Pr]$), were calculated for each emotion category according to Snodgrass and Corwin (1988; two-high-threshold model), and analyzed by the 2 by 2 mixed factor ANOVAs described above. Significant group-by-emotion interactions were followed up by *t*-tests. As for measures of affect, the positive and negative affect schedules of the PANAS were analyzed separately by 2 by 2 mixed factor ANOVAs including the within-subjects factor time (pre-test vs. post-test) and the between-subjects factor group (AD vs. control). Analyses involving all three steps of the emotion factor (happy, neutral, angry) had initially been conducted for all dependent variables. All of them revealed significant main effects of emotion and emotion by group interactions, so they are, for brevity's sake, not reported here.

3. Results

3.1. Emotion classification

During the study session, the mean percentage of correct classifications was 74.6% ($SD = 19.2$) in controls, and 66.6% ($SD = 16.0$) in AD patients. The percentage of correctly classified items was higher for angry ($M = 80.7\%$, $SD = 12.2$) than for happy faces ($M = 69.0$, $SD = 26.9$; $F(1,34) = 5.26$, $p = .028$), and for happy compared to neutral faces ($M = 62.00$, $SD = 27.9$; $F(1,34) = 9.45$, $p = .004$). There were no group differences or interactions. The percentage of correctly classified angry, neutral, and happy faces was not correlated with subsequent recognition performance in either of the emotion categories, $r(\text{angry}) = .002$, $p = .993$; $r(\text{neutral}) = .053$, $p = .758$; $r(\text{happy}) = .192$, $p = .252$.

3.2. Recognition performance

Performance during the test session is reported in Table 2. Given that the task was made artificially easier for the AD participants (more study repetitions than controls), direct comparisons between the groups need to be interpreted with more caution (e.g., t -statistics in Table 2), because task difficulty was confounded with group. Instead, the more appropriate comparison seems to be the relative size of the emotional memory effect within each group, i.e., group-by-emotion interactions.

In terms of discrimination accuracy, angry faces were better remembered than neutral faces, $F(1,34) = 9.43$, $p < .004$, and happy faces, $F(1,34) = 14.26$, $p < .001$, but discrimination of happy and neutral faces did not differ. No further interactions or group differences were found. Hit rates did not differ for angry vs. neutral, angry vs. happy, or happy vs. neutral faces (all F s < 2.4 , p s $> .132$). There were no group differences or interactions.

False-positive rates did not differ between angry and neutral faces, but happy faces elicited more false positive responses than angry ones, $F(1,34) = 7.88$, $p < .008$. When comparing happy and neutral faces, the main effect of emotion failed to reach significance $F(1,34) = 3.57$, $p < .067$, but a significant group effect was present, $F(1,34) = 5.89$, $p < .021$, revealing higher false-positive rates for happy and neutral faces in AD patients compared with controls. The group-by-emotion interaction in this comparison trended toward significance, $F(1,34) = 2.91$, $p < .095$. There were no further significances.

Recognition bias scores for happy and neutral faces yielded no main effect of emotion. However, of crucial importance for our research question, a significant group-by-emotion interaction emerged, $F(1,34) = 4.68$, $p < .038$. Subsequent analyses revealed that AD patients showed a larger response bias for happy than for neutral faces, $t(17) = -2.16$, $p < .045$, an effect which was not seen in controls (see Fig. 1). No main effects emerged in this comparison. When comparing angry and happy faces, there was no main effect of emotion ($F < 1$), but there was a main effect of group, $F(1,34) = 4.43$, $p < .043$, revealing a larger bias for angry and happy faces in AD patients compared with controls. The group-by-emotion interaction in this comparison was not significant, $F(1,34) = 2.77$, $p = .105$, and there were no significant effects when comparing bias scores for angry and neutral faces.

As correct emotion classification at study was lower in both groups, particularly in the AD group, than in our previous experiments, we re-analyzed the data of the test session by including only responses to targets that had been correctly classified in the study session by each individual participant. For the AD group, we considered a correct response in two study blocks to be comparable to healthy participants' correct answers in their single study block. The results of the main analysis was unchanged, the ANOVA comparing response bias for happy and neutral faces in both groups revealed a group-by-emotion interaction,

$F(1,34) = 4.20, p < .047$, but no main effects. This result suggests that our central finding was not affected by classification errors at study.

3.3. Positive and negative affect

Measures of affectivity according to group are displayed in Table 1. For positive affect before and after the memory task, there was no main effect of time or group, but a significant group-by-time interaction was present, $F(1,34) = 5.59, p < .024$. Subsidiary analyses revealed that controls reported higher positive affect scores at pre-test than at post-test, $t(17) = 3.09, p < .007$, an effect which was not seen in AD patients. For negative affectivity before and after the memory task, no main effect of time ($F < 1.3$) was observed, but a significant group effect, $F(1,34) = 6.83, p < .013$, revealing higher negative affect rates at both pre- and post-test in AD patients.

As an additional analysis to investigate the relationship of current affect, memory performance, and bias, we calculated correlations between CERAD memory performance and current positive affect on the one hand, and positivity-related response bias on the other hand. The expected negative correlations of the bias with CERAD recall did not reach significance HC: $r = -.286 (p = .250)$, AD: $r = -.188 (p = .454)$. The correlation between current positive affect and bias was calculated by partialling out CERAD memory performance, as performance deficits might affect this relationship. Partial correlations were not significant either, $.411 (p = .101)$ in AD, and $-.075 (p = .775)$ in controls.

4. Discussion

We found that the response bias for happy faces was increased in AD patients compared to controls. In the following, we will discuss the implications of this finding for the positivity-induced response bias and for compensatory memory strategies in early AD.

Bias was enhanced in memory impaired AD patients, suggesting that the positivity related recognition bias is a spontaneous, gist-based process applied when item-specific memory fails. Moreover, the PANAS questionnaires revealed that before and after the experiment, patients with AD reported more negative affect than controls. Prior to the experiment, they also reported less positive affect than controls. Consistent with Fernandes et al. (2008), we found no correlation between the positivity-related recognition bias and positive affect, as would be predicted with socioemotional selectivity. Note, however, we did not find correlations between the bias and memory either, presumably due to small sample sizes.

The enhanced bias found is unlikely due to mood effects, e.g., enhanced holistic processing of positive faces (cf. Bridge, Chiao, & Paller, 2010; Kensinger, Garoff-Eaton, & Schacter, 2007a; Kensinger, Garoff-Eaton, & Schacter, 2007b), as the faces were presented rapidly and randomized, impeding emergence of a pertinent mood state. That the recognition bias may represent an attempt to ameliorate current negative affect, is also unlikely given the finding that the control group rather than the AD group revealed higher positive affect scores at pre-test than at post-test. Moreover, if the bias would, as recent formulations of the SST have argued, demand cognitive resources (Mather & Knight, 2005), it should not be preserved in early AD, due to reduced cognitive capacities in this group.

We found the positivity-induced recognition bias in AD due to enhanced false memory for happy faces, as in Werheid et al. (2010). Although in our study the group-by-emotion interaction in this comparison was not significant, this pattern relates to several prior studies that have shown enhanced emotional false memory in AD in recognition memory tests for pictures (LaBar et al., 2005), and in the Deese-Roediger-McDermott task (Brueckner & Moritz, 2009, but cf. Budson et al., 2006). Gallo, Foster, Wong, and Bennett (2010) also

recently found enhanced false recognition for positively valenced pictures in AD patients and older adults, arguing that although in AD dysfunction of hippocampus and amygdala may impair recollection, it did not disrupt emotion effects on false memory.

The idea of an affirmatory bias shares many similarities with the idea of age-related enhancement of gist-based memory. As item-specific memory fades with age, older participants rely on gist (e.g., Kensinger et al., 2007a, 2007b), due to perceptual similarity (Budson, Desikan, Daffner, & Schacter, 2001), or semantic associations (cf. Balota et al., 1999; Budson et al., 2003; Koutstaal et al., 2003). Associating a smiling face with prior study should not be surprising, as we smile more at known than unknown faces (Baudouin et al., 2000). When perceiving a smiling person looking at us – even if we cannot identify her – we tend to believe we know her.

We note that emotion classification at study was similarly low in both groups, about 25% below our previous experiments. However, as the enhanced bias results remained the same after correction of these errors, this fact did not affect our central findings.

The present results thus confirm and extend our previous findings of an enhanced positivity-related recognition bias in the presence of emotion-induced memory enhancement in aMCI patients (Werheid et al., 2010). We note that prior research on emotion-induced memory effects in AD patients is divided, with some studies reporting memory enhancement (Boller et al., 2002; Kazui, Mori, Hashimoto, & Hirono, 2003; Moayeri, Cahill, Jin, & Potkin, 2000), and others reporting the effect to be diminished (Abrisqueta-Gomez, Bueno, Oliveira, & Bertolucci, 2002; Budson et al., 2004, 2006; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002). Unlike Werheid et al. (2010, experiment 3) in which an enhanced positivity-induced recognition bias was present both in aMCI patients and controls, in the present study enhancement occurred in AD patients only; bias scores for happy and neutral faces did not differ in controls. However in our previous study the retention interval was 24 h, whereas in the present study the retention interval was minutes in order to avoid floor effects in the AD group. This short retention period may have facilitated task performance and prevented enhanced false recognition for happy faces in the control group.

The finding that happy faces increase judgments of prior study is in line with previous findings of a “smiling bias”. The smiling bias is thought to act at the level of the decision process (Baudouin et al., 2000; Döbel et al., 2008; Werheid et al., 2010). Electrophysiological evidence confirmed that facial emotion affects old/new judgments in the late processing stages, immediately prior to the decision (Wild-Wall et al., 2008). In Bruce and Young’s (1986) model, face recognition is independent of analysis of facial expression. However, the face recognition decision is based on two inputs, one about whether the face is known, and another about its expression. Input from facial expression analysis may tip the balance toward making an “old” response even for unknown faces (Baudouin et al., 2000). Although the influence of facial expression is normally weak, it may become observable when a strong expression co-occurs with a weak memory. Importantly, our data suggest that this weighting process is preserved in early AD, despite weakened memory input. The observed positivity induced response bias might, therefore, not be a “conscious” compensatory strategy, but an intuitive decision bias based on relatively preserved analysis of facial expression in the setting of poor memory.

Regarding the neuronal basis of the enhanced bias in AD, neuroimaging research has shown that the hippocampus and the amygdalar complex are activated in concert during processing of facial emotion (Dolcos, LaBar, & Cabeza, 2005; Sharot, Delgado, & Phelps, 2004; Smith, Henson, Dolan, & Rugg, 2004; Smith, Stephan, Rugg, & Dolan, 2006). Thus, we would suggest that when hippocampus-based explicit memory is impaired, the amygdalar complex

takes over at retrieval, resulting in biased old/new judgments that are based on emotion (esp. for positive items), rather than on factual familiarity with the presented face. This interpretation of the enhanced recognition bias as a “smiling bias” is specifically tied to facial stimuli. However, the positivity bias has been reported for other types of stimuli as well (e.g., Kapucu et al., 2008; Spaniol et al., 2008), suggesting that similar processes occur in old/new familiarity decision tasks on other stimuli. The question to what extent this bias is specific to emotional faces should be considered in further research.

The present study suggests that the emotion-based aspect of old/new decisions for faces is preserved in patients with early AD. The pattern of results supports the view that the positivity-induced recognition bias represents a compensatory, gist-based memory process that is applied when item-based recognition fails. This process may represent a compensatory memory strategy or automatic processing in the setting of memory impairment. Other factors may also be important; for example, executive dysfunction might lead to early termination of internal memory search. To specify the relationship between memory impairment and positivity related memory bias would be a valuable topic for future research.

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References

- Abrisqueta-Gomez J, Bueno OFA, Oliveira MGM, Bertolucci PHF. Recognition memory for emotional pictures in Alzheimer's patients. *Acta Neurologica Scandinavica*. 2002; 105:51–54. [PubMed: 11903109]
- Adjutant General's Office (Ed.). Army individual test battery. Manual of directions and scoring. Washington, DC: War Department; 1944.
- Balota DA, Cortese JH, Duchek JM, Adams D, Roediger HL, McDermott KB, et al. Veridical and false memories in healthy older adults and in dementia of the Alzheimer's type. *Cognitive Neuropsychology*. 1999; 16:361–384.
- Baudouin JY, Gilibert D, Sansone S, Tiberghien G. When the smile is a cue to familiarity. *Memory*. 2000; 8:285–292. [PubMed: 11045237]
- Benton, AL.; Sivan, AB.; Hamsher, KS.; Varney, NR.; Spreen, O. Contributions to neuropsychological assessment. 2. New York: Oxford University Press; 1994.
- Boller F, El Massioui F, Devouche E, Traykov L, Pomati S, Starkstein SE. Processing emotional information in Alzheimer's disease: Effects on memory performance and neurophysiological correlates. *Dementia and Geriatric Cognitive Disorders*. 2002; 14:104–112. [PubMed: 12145458]
- Bridge DJ, Chiao JY, Paller KA. Emotional context at learning systematically biases memory for facial information. *Memory & Cognition*. 2010; 38:125–133. [PubMed: 20173185]
- Bruce V, Young A. Understanding face recognition. *British Journal of Psychiatry*. 1986; 77:305–327.
- Brueckner K, Moritz S. Emotional valence and semantic relatedness differentially influence false recognition in Mild Cognitive Impairment, Alzheimer's disease, and healthy elderly. *Journal of the International Neuropsychological Society*. 2009; 15:268–276. [PubMed: 19203441]
- Budson AE, Desikan R, Daffner KR, Schacter DL. Perceptual false recognition in Alzheimer's disease. *Neuropsychology*. 2001; 15:230–243. [PubMed: 11324866]
- Budson AE, Michalska KJ, Sullivan AL, Rentz DM, Daffner KR, Schacter DL. False recognition in Alzheimer disease: Evidence from categorized pictures. *Cognitive and Behavioral Neurology*. 2003; 16:16–27. [PubMed: 14764998]

- Budson AE, Simons JS, Sullivan AL, Beier JS, Solomon PR, Scinto LF, et al. Memory and emotions for the September 11, 2001, terrorist attacks in patients with Alzheimer's disease, patients with mild cognitive impairment, and healthy older adults. *Neuropsychology*. 2004; 18:315–327. [PubMed: 15099154]
- Budson AE, Todman RW, Chong H, Adams EH, Kensinger EA, Krangel TS, et al. False recognition of emotional word lists in aging and Alzheimer disease. *Cognitive and Behavioral Neurology*. 2006; 19:71–78. [PubMed: 16783129]
- Carstensen, LL. Motivation for social contact across the life span: A theory of socioemotional selectivity. In: Jacobs, JE., editor. *Nebraska Symposium on Motivation*. Lincoln: University of Nebraska Press; 1993. p. 209-254.
- Carstensen LL, Gottman JM, Levenson RW. Emotional behavior in long-term marriage. *Psychology and Aging*. 1995; 10:140–149. [PubMed: 7779311]
- Comblain C, D'Argembeau A, Van der Linden M, Aldenhoff L. The effect of ageing on the recollection of emotional and neutral pictures. *Memory*. 2004; 12:673–684. [PubMed: 15724356]
- Dobel C, Geiger L, Bruchmann M, Putsche C, Schweinberger SR, Junghöfer M. On the interplay between familiarity and emotional expression in face perception. *Psychological Research*. 2008; 72:580–586. [PubMed: 18066587]
- Dolcos F, LaBar KS, Cabeza R. Remembering one year later: Role of the amygdala and the medial temporal lobe memory system in retrieving emotional memories. *Proceedings of the National Academy of Sciences*. 2005; 102:2626–2631.
- Fernandes M, Ross M, Wiegand M, Schryer E. Are the memories of older adults positively biased? *Psychology and Aging*. 2008; 23:297–306. [PubMed: 18573004]
- Folstein MF, Folstein SE, McHugh PR. Mini-mental state. A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*. 1975; 12:189–198. [PubMed: 1202204]
- Gallo DA, Foster KT, Wong JT, Bennett DA. False recollection of emotional pictures in Alzheimer's disease. *Neuropsychologia*. 2010; 48:3614–3618. [PubMed: 20727904]
- Grühn D, Scheibe S, Baltes PB. Reduced negativity effect in older adults' memory for emotional pictures: The heterogeneity-homogeneity list paradigm. *Psychology and Aging*. 2007; 22:644–649. [PubMed: 17874962]
- Johansson M, Mecklinger A, Treese AC. Recognition memory for emotional and neutral faces: An event-related potential study. *Journal of Cognitive Neuroscience*. 2004; 16:1840–1853. [PubMed: 15701233]
- Kapucu A, Rotello CM, Ready RE, Seidl KN. Response bias in “remembering” emotional stimuli: A new perspective on age differences. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2008; 34:703–711.
- Kazui H, Mori E, Hashimoto M, Hirono N. Enhancement of declarative memory by emotional arousal and visual memory function in Alzheimer's disease. *Journal of Neuropsychiatry and Clinical Neuroscience*. 2003; 15:221–226.
- Kensinger EA, Brierley B, Medford N, Growdon JH, Corkin S. Effects of normal aging and Alzheimer's disease on emotional memory. *Emotion*. 2002; 2:118–134. [PubMed: 12899186]
- Kensinger EA, Garoff-Eaton RJ, Schacter DL. Effects of emotion on memory specificity in young and older adults. *Journals of Gerontology: Psychological Sciences*. 2007a; 62B:208–215.
- Kensinger EA, Garoff-Eaton RJ, Schacter DL. Effects of emotion on memory specificity in young and older adults. *The Journals of Gerontology Series B, Psychological Sciences and Social Sciences*. 2007b; 62:208–215.
- Koutstaal W, Reddy C, Jackson EM, Prince S, Cendan DL, Schacter DL. False recognition of abstract versus common objects in older and younger adults: Testing the semantic categorization account. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 2003; 29:499–510.
- LaBar KS, Torpey DC, Cook CA, Johnson SR, Warren LH, Burke JR, et al. Emotional enhancement of perceptual priming is preserved in aging and early-stage Alzheimer's disease. *Neuropsychologia*. 2005; 43:1824–1837. [PubMed: 16154458]

- Leiphart J, Rosenfeld JP, Gabrieli JD. Event-related potential correlates of implicit priming and explicit memory tasks. *International Journal of Psychophysiology*. 1993; 15:197–206. [PubMed: 8119838]
- Lundqvist, D.; Flykt, A.; Ohman, A. Karolinska directed emotional faces, KDEF. Stockholm: Karolinska Institutet; 1998.
- Mack WJ, Freed DM, Williams BW, Henderson VW. Boston naming test—Shortened versions for use in Alzheimer's disease. *Journals of Gerontology*. 1992; 47:P154–P158. [PubMed: 1573197]
- Maratos EJ, Allan K, Rugg MD. Recognition memory for emotionally negative and neutral words: An ERP study. *Neuropsychologia*. 2000; 38:1452–1465. [PubMed: 10906371]
- Martinez AM, Benavente R. The AR face database. CVC technical report. 1998; 24
- Mather, M. Why memories may become more positive as people age. In: Uttl, B.; Ohta, N.; Siegenthaler, AL., editors. *Memory and emotion: Interdisciplinary perspectives*. Malden, MA: Blackwell Publishing; 2006.
- Mather M, Knight M. Goal-directed memory: The role of cognitive control in older adults' emotional memory. *Psychology and Aging*. 2005; 20:554–570. [PubMed: 16420131]
- Moayeri SE, Cahill L, Jin Y, Potkin SG. Relative sparing of emotionally influenced memory in Alzheimer's disease. *Neuroreport*. 2000; 11:653–655. [PubMed: 10757495]
- Monsch AU, Bondi MW, Butters N, Salmon DP, Katzman R, Thal LJ. Comparisons of verbal fluency tasks in the detection of dementia of the Alzheimer type. *Archives of Neurology*. 1992; 49:1253–1258. [PubMed: 1449404]
- Morris JC, Heyman A, Mohs RC, Hughes JP, van Belle G, Fillenbaum G, et al. The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology*. 1989; 39:1159–1165. [PubMed: 2771064]
- Mroczek DK, Kolarz CM. The effect of age on positive and negative affect: A developmental perspective on happiness. *Journal of Personality and Social Psychology*. 1998; 75:1333–1349. [PubMed: 9866191]
- Petrican R, Moscovitch M, Schimmack U. Cognitive resources, valence, and memory retrieval of emotional events in older adults. *Psychology and Aging*. 2008; 23:585–594. [PubMed: 18808248]
- Sharot T, Delgado MR, Phelps EA. How emotion enhances the feeling of remembering. *Nature Neuroscience*. 2004; 7:1376–1380.
- Smith AP, Henson RN, Dolan RJ, Rugg MD. fMRI correlates of the episodic retrieval of emotional contexts. *Neuroimage*. 2004; 22:868–878. [PubMed: 15193617]
- Smith AP, Stephan KE, Rugg MD, Dolan RJ. Task and content modulate amygdala-hippocampal connectivity in emotional retrieval. *Neuron*. 2006; 49:631–638. [PubMed: 16476670]
- Snodgrass JG, Corwin J. Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General*. 1988; 117:34–50. [PubMed: 2966230]
- Spaniol J, Voss A, Grady CL. Aging and emotional memory: Cognitive mechanisms underlying the positivity effect. *Psychology and Aging*. 2008; 23:859–872. [PubMed: 19140656]
- Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*. 1988; 54:1063–1070. [PubMed: 3397865]
- Werheid K, Clare L. Are faces special in Alzheimer's disease? Cognitive conceptualisation, neural correlates, and diagnostic relevance of impaired memory for faces and names. *Cortex*. 2007; 43:898–906. [PubMed: 17941348]
- Werheid K, Gruno M, Kathmann N, Fischer H, Almkvist O, Winblad B. Biased recognition of positive faces in aging and amnesic Mild Cognitive Impairment. *Psychology and Aging*. 2010; 25:1–15. [PubMed: 20230123]
- Werheid K, Schacht A, Sommer W. Facial attractiveness modulates early and late event-related brain potentials. *Biological Psychology*. 2007; 76:100–108. [PubMed: 17681418]
- Wild-Wall N, Dimigen O, Sommer W. Interaction of facial expressions and familiarity: ERP evidence. *Biological Psychology*. 2008; 77:138–149. [PubMed: 17997008]

Yesavage J, Brink TL, Rose TS, Lum O, Huang V, Adey MB, et al. Development and validation of a geriatric depression rating scale: A preliminary report. *Journal of Psychiatric Research*. 1983; 17:37–49. [PubMed: 7183759]

Fig. 1. Response bias (means and standard error) for neutral, angry, and happy faces in patients with early Alzheimer disease (AD) and controls.

Table 1

Neuropsychological test battery performance and affectivity of AD patients and controls.

	AD <i>n</i> = 18		Controls <i>n</i> = 18		<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
MMSE	24.6	2.9	29.5	.7	6.948	<.001
CERAD encode	10.7	3.7	22.5	4.3	8.887	<.001
CERAD recall	1.4	1.8	7.4	1.9	9.890	<.001
TMT-B	204.6	83.5	92.2	30.3	-5.366	<.001
CAT	29.1	8.0	48.1	10.6	6.093	<.001
FAS	30.6	11.0	51.7	9.6	6.110	<.001
BNT no cue	12.4	3.2	14.2	.9	2.330	.030
BNT semantic	.1	.2	.1	.3	.589	.560
BNT phonemic	1.7	2.2	.4	.8	-2.460	.023
GDS	8.8	6.1	2.8	2.7	-3.778	.001
PANAS pos pre	29.6	8.1	36.7	7.7	2.693	.011
PANAS neg pre	13.1	3.3	10.9	1.5	-2.588	.016
PANAS pos post	32.8	9.2	34.4	9.1	.526	.602
PANAS neg post	14.4	6.4	11.0	1.2	-2.203	.041

Notes. MMSE: Mini Mental Status Examination (Folstein et al., 1975); CERAD word list memory test (Morris et al., 1989), Subscores 'Encoding' and 'Recall'; TMT: Trail Making Test (Adjutant General's Office, 1944), time in sec to perform version B; CAT/FAS: Word Fluency Test (Monsch et al., 1992), Subscore 'CAT': word fluency to categories (animals, fruits, vegetables), Subscore 'FAS': word fluency to letters (F, A, S); BNT: 15-item short version of Boston Naming Test (Mack et al., 1992), Subscore 'no cue': correct identification without cue, Subscore 'semantic': correct with semantic cue, Subscore 'phonemic': correct with phonemic cue; GDS: Geriatric Depression Scale (Yesavage et al., 1983); PANAS: Positive and Negative Affect Schedule (Watson et al., 1988), pre: administered pre-test, post: administered post-test.

Table 2

Recognition performance of AD patients and controls on average and by emotion category.

	<u>AD</u>		<u>Controls</u>		<u>Group difference</u>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>
All faces						
Hits	.64	.19	.59	.11	-.958	.345
False positives	.31	.15	.21	.08	-2.316	.027
Accuracy [<i>Pr</i>]	.33	.14	.37	.12	.990	.329
Bias [<i>Br</i>]	.48	.23	.35	.11	-2.212	.034
Angry						
Hits	.67	.21	.63	.19	-.575	.569
False positives	.27	.20	.20	.11	-1.472	.152
Accuracy [<i>Pr</i>]	.39	.19	.43	.16	.623	.537
Neutral						
Hits	.61	.21	.59	.13	-.363	.719
False positives	.30	.17	.23	.09	-1.585	.122
Accuracy [<i>Pr</i>]	.32	.16	.37	.13	1.025	.312
Happy						
Hits	.65	.22	.55	.11	-1.560	.131
False positives	.36	.17	.23	.12	-2.813	.008
Accuracy [<i>Pr</i>]	.28	.15	.33	.15	.903	.373