Published in final edited form as:
Psychol Aging. 2006 December ; 21(4): 821–825.

The Influence of Emotional Valence on Age Differences in Early Processing and Memory

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Abstract

This study examined young and older adults' attentional biases and subsequent incidental recognition memory for distracting positive, negative, and neutral words. Younger adults were more distracted by negative stimuli than by positive or neutral stimuli and they correctly recognized more negative than positive words. Older adults, however, attended equally to all stimuli yet showed reliable recognition only for positive words. Thus, although an attentional bias towards negative words carries over into recognition performance for younger adults, older adults' bias appears to be limited to remembering positive information.

Keywords

Aging; emotion; emotional memory; attention; positivity effect

The Influence of Emotional Valence on Age Differences in Early Processing and Memory

Much research in the field of cognitive aging is rooted in the information processing approach of experimental psychology wherein participants engage in basic cognitive tasks that attempt to isolate particular processes and control for additional factors that could influence performance. However, recent research suggests that there may be a number of factors that are at least partially independent of cognitive ability that influence age differences in memory performance (see Hess, 2005, for a review). For example, time of testing (e.g., Hasher, Zacks, & May, 1999; May, Hasher, & Stoltzfus, 1993; May, 1999), the presence of stereotype threat (e.g., Chasteen, Bhattacharyya, Horhota, Tam, & Hasher, 2005; Hess, Auman, Colcombe, & Rahhal, 2003), and emotional engagement with stimulus materials (e.g., Charles, Mather, & Carstensen, 2003; Rahhal, May, & Hasher, 2002) all influence the magnitude of age differences in memory performance. As well, motivational changes across the lifespan may also influence cognitive functioning (e.g., Charles et al.; Mather & Carstensen, 2003; Mather et al., 2004). In particular, there appears to be an age-related motivational shift towards emotionally meaningful goals (e.g., Carstensen, Fung & Charles, 2003) that helps older adults to optimize their generally positive affective states (Blanchard-Fields, Stein, & Watson, 2004; Carstensen,

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The study is supported by a grant from the National Institute on Aging (R37 4306).We thank Ji-A Min and Ursula Wiprzycka for their assistance. Portions of this study were presented at the 2005 meeting of the Midwestern Psychological Association, Chicago, Illinois, and at the 2005 meeting of the Canadian Psychological Association, Montréal, Québec. The experiment was conducted in partial fulfillment of R. T.'s master's degree at the University of Toronto.

Pasupathi, Mayr, & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001; Gross et al., 1997; Mroczek & Kolarz, 1998). This shift in goals may result in older adults' tendency to focus on positive information moreso than negative or neutral information (Carstensen et al., 2003).

Evidence for a bias towards positive information can be seen in a number of studies that test memory for affectively valenced information (e.g., Charles et al., 2003; Hashtroudi, Johnson & Chrosniak, 1990; Mather & Carstensen, 2003). For example, Charles et al. examined incidental free recall of verbal labels of pictures as well as recognition of negative, positive, and neutral pictures in young, middle-aged, and older adults. The proportion of recall consisting of negative pictures decreased across the lifespan, whereas the proportion of recall consisting of positive pictures increased. Similarly, there was an age-related decrease in recognition accuracy for negative emotional pictures while recognition accuracy for positive emotional pictures remained stable across the lifespan. Similar findings have been reported for memory of facial expression in a study comparing young and older adults (Mather & Carstensen, 2003; but see Grady, Hongwanishkul, Keightley, Lee, & Hasher, 2006).

Although there is compelling evidence for an age-related memory bias for emotionally gratifying stimuli, the source of this memory effect is unclear. One possibility is that older adults' enhanced memory for positive emotional stimuli is tied to attentional biases that support the encoding of positive emotional information but not negative emotional information. Several studies directly address the existence of age differences in attentional biases to valenced stimuli. Although some studies show the expected bias of older adults toward positive stimuli and, in some cases, a bias of younger adults toward negative stimuli (Mather & Carstensen, 2003, Experiment 1; Mather et al., 2004), others do not (Charles et al., 2003, Experiment 2; Mather & Carstensen, Experiment 2).

For example, the expected pattern of attentional biases is observed in Mather and Carstensen (2003) using a dot-probe procedure to investigate whether young and older adults tend to direct their attention toward a face with either a negative or positive expression instead of a face with a neutral expression. Although younger adults did not demonstrate an attentional bias for valenced stimuli, older adults biased their attention away from negative stimuli and, in some cases, toward positive stimuli. Likewise, Mather et al. (2004) found that young and older adults' expected attentional bias is reflected in changes in amygdala activity while viewing positive, negative, and neutral images. The amygdala is widely thought to play an important role in processing emotional information (e.g., Anderson & Phelps, 2001). By contrast, in another study using looking time as a measure of attentional bias, Charles et al. (2003) found that both young and older adults spent more time viewing negative images than neutral or positive images when they were not expecting a memory test in the future. There is thus some conflicting evidence regarding the existence of early processing biases for emotional stimuli.

Here we report a study using a new methodology to assess the existence of an early processing bias and its consequences for remembering. Participants in the present study made decisions about numbers in the face of distracting words that were to be ignored. The target task was to make a parity decision about two numbers ('yes' they are both odd or even, 'no' one is a mismatch; Harris & Pashler, 2004; Wolford & Morrison, 1980). Irrelevant words occurred between the two digits on each trial and these were positive, negative or neutral in valence. Each display of digits plus word appeared for a brief and fixed duration (200 ms). As a result, the time to respond is affected by parity processing plus any additional item processing. Our assumption is that any differences in response times across the distraction conditions should reflect variation in processing valence. Thus, the speed of parity decisions was used to assess the existence of attentional biases in both younger and older adults.

The present study also included an incidental recognition memory test for the positive, negative, and neutral distractors presented during the digit parity task. Based on previous research (e.g., Charles et al., 2003; Mather & Carstensen, 2003) and on predictions of the socioemotional selectivity theory (Carstensen et al., 2003), we expected older adults to demonstrate enhanced recognition for positive emotional words relative to negative and neutral words. We also expected young adults to recognize more negative words than positive or neutral words. If the source of these memory effects occurs during initial presentation of the stimuli, older adults should slow down when the distractor is a positive word, relative to when the distractor is a negative or neutral word and younger adults should slow down on negative relative to neutral and positive distractors. Thus, the current study examined the central hypothesis that the age-related bias for emotionally gratifying information influences the initial processing of and subsequent incidental memory for positive, negative, and neutral stimuli.

Method

Participants

Forty-eight younger (18-28) and 48 older (60-75) adults participated in this study. Younger adults were students at the University of Toronto and received either course credit or monetary compensation; older adults were volunteers and received monetary compensation. All participants were either native English speakers or learned English before the age of 5. Younger adults (*M*= 21.4, *SD*= 2.44) had an average of 15.0 (*SD* = 1.9) years of education, and a mean score of 32.67 (*SD* = 3.9) on the Shipley Vocabulary Test. Older adults (*M*= 67.6, *SD*= 4.40) had significantly more years of education *(M* = 16.4, *SD* = 2.7), *F* (1, 95) = 8.942, *MSE* = 48.39, and a significantly higher score on the Shipley Vocabulary Test *(M* = 35.9, *SD* = 3.3), *F* (1, 95) = 19.046. Data from three younger adults and seven older adults were replaced due to either computer problems (one young and one older adult) or low accuracy on the digit parity task (incorrect responses on more that one-third of the trials; two young and six older adults).

Design

The design was a 2 (age) X 3 (distractor valence) mixed factorial with age (young, old) between subjects and valence (neutral, positive, negative) within subjects. The dependent measures were reaction time in the digit parity task and corrected recognition.

Materials

Digit parity task.—The distracting words were drawn from Bradley and Lang’s (1999) set of Affective Norms for English Words (ANEW). A total of 240 words were selected, divided into two sets of 120 each composed of 40 neutral, 40 positive, and 40 negative words. All words were between four and seven letters and were matched for frequency (*M* = 32.75, *SD*= 3.50) and length (*M* = 5.58, *SD* = 0.98) between the two sets of words and across the three valence conditions. The ANEW emotional valence scores of the positive (*M* = 7.66, *SD*= 0.41), neutral (*M* = 5.45, *SD*= 0.28), and negative (*M* = 2.42, *SD*= 0.50) words differed significantly from each other *F* (2, 237) = 3397.48, *MSE*= 554.07. The arousal level for negative (*M* = 5.99, *SD*= 0.72) and positive words (*M*= 5.95, *SD*= 0.65) did not vary significantly from each other, *t* (158) = 0.36. However, neutral words, as is common, were less arousing than both positive, *t* (158) = 19.65, and negative words, *t* (158) = 18.97. Although ANEW norms are based on data collected with younger adults only, Wurm, Labouvie-Vief, Aycock, Reucal, & Koch (2004) found extremely high correlations among the original ANEW ratings on valence and arousal and their own samples of young and older adults. Furthermore, valence and arousal ratings did not differ between young and older adults (Wurm et al.).

The digit parity task consisted of 120 experimental trials, including 40 trials each with neutral, positive and negative words. There were 40 unique digit pairs presented throughout the experiment; each pair was presented with a single word in the middle. Half of the pairs matched in parity and half did not. The distance between the two digits ranged from 9 to 13 cm based on the length of the distracting word. The different types of distracting words were presented in blocks; the order of the blocks was counterbalanced across participants such that each type of distracting word appeared equally often in each position (i.e., first, second, or third in the digit parity task) and the sequence of blocks varied to minimize potential carryover effects. With two sets of words, there were a total of 12 unique conditions, with four young and four older participants in each materials condition.

Recognition task.—All participants saw the same set of 72 words in an old/new recognition test. The words were randomly selected from the two sets used in the digit parity task; accordingly, there were 36 words from set A (12 positive, 12 negative, and 12 neutral) and 36 words from set B (12 positive, 12 negative, and 12 neutral).Thus, the words that served as old and new were counterbalanced across participants. The two sets of words were matched on valence, arousal, frequency, and length.

Mood measure.—The Brief Mood Introspection Scale (BMIS; Mayer & Gaschke, 1988) consists of ten adjectives describing different emotions (e.g., sad, annoyed, content, gloomy, happy). Participants were instructed to indicate if the adjectives describe their current feelings based on a scale from 1 (definitely do not feel) to 5 (definitely feel).

Procedure

All participants were tested individually, with each providing informed consent. Participants first completed the BMIS followed 80 practice trials, 40 without a distracting item and 40 with symbols (e.g., #####) inserted between the two digits. This was followed by 120 experimental trials. Each triplet of digits and words was presented, centered on a computer monitor, for 200 ms, followed by a blank screen until the participant responded. The next triplet appeared after 500 ms.

After completing the digit parity task, participants were given two nonverbal filler tasks for 10 minutes. Participants were then given instructions for the unexpected recognition task. Each word appeared in the center of the screen and remained on the screen until participants responded. At the end of each session, participants completed the Shipley Vocabulary Test (Shipley, 1946) and the Short Blessed Test (older adults only; Katzman et al., 1983).

Results

For each dependent variable of interest, a 2 (Age: young, old) X 3 (Valence: positive, negative, neutral) Analysis of Variance (ANOVA) with repeated measures on the second factor was followed by planned comparisons of all conditions (unless otherwise noted). The significance level for all statistical tests was $p < .05$.

Digit Parity Task[1]

Median reaction times and accuracy for positive, negative, and neutral distracting words are presented in Table 1. Accuracy scores did not differ across different valence types, F (2, 188) = 2.07, $p > .10$, or age, $F < 1$. The Age x Valence interaction was not significant, $F < 1$. Overall older adults ($M = 928.30$, $SD = 253.20$) responded more slowly than younger adults ($M = 689.21$, $SD = 199.59$), F (1, 94) = 26.40, $MSE = 155922.12$. Response times differed across distractor valence, F (2, 188) = 4.92, $MSE = 6811.41$. Although the Age x Valence interaction was not significant, $F > 1$, the pattern of reaction times across valence warranted a more liberal

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[1] No conclusion is altered by including the data from replaced participants.

test of age differences in reaction time as a function of valence. As such, main effects of valence were examined separately for young and older adults. Young adults' response time differed across positive, negative, and neutral words, F (2, 94) = 6.31, MSE= 5159.30, in that they responded more slowly when negative words were distractors than when either neutral, t(47) = 3.28, or positive words, t(47) = 2.60, were distractors. However, older adults responded at the same speed across items of different valences, $F < 1$[2].

Recognition memory

Hit rates, false alarm rates, and corrected recognition (hits minus false alarms) scores are reported in Table 2. Figure 1 displays the corrected recognition scores for positive, negative, and neutral words by age group. Overall younger adults recognized more words than older adults, F (1, 94) = 4.90, MSE = 0.13. The main effect of valence was not significant, $F < 1$; however, there was a significant Age x Valence interaction, F (2, 188) = 5.88, MSE = 0.14. For younger adults, the means suggest best recognition for negative and least for positive words and this difference was reliable, t (47) = 2.14. Although the mean recognition score for negative items was greater than that for neutral items, this difference did not reach traditional levels of significance, t (47) = 1.74, p = .09.

The recognition pattern of older adults' was quite different from that of younger adults, with older adults showing best recognition of positive words. Recognition of both neutral and negative words was actually very poor, indeed did not differ from chance, (t (47) = 1.65 for neutral words, and, t (47) = 0.67 for negative words). Recognition of positive words, however, was well above chance, t (47) = 4.91.

Additional analysis of hit and false alarm rates revealed age differences in the pattern of hits and false alarms across positive, negative, and neutral words. Overall, younger adults had higher hit rates, F (1, 94) = 11.23, MSE = 171.13, and higher false alarm rates, F (1, 94) = 5.20, MSE = 77.09, compared to older adults. Specifically, younger adults had similar hit rates for positive and negative words, t (47) = 0.59, but they had more difficulty discriminating between old and new words when they were positively valenced (i.e., more false alarms for positive compared to negative, t (47) = 3.72, and neutral words, t (47) = 2.45). Older adults, on the other hand, had stable false alarm rates across differently valenced words, $F < 1$, but they correctly identified more positive than negative, t (47) = 3.46, or neutral words, t (47) = 4.13. Thus, young adults showed a response bias in their false alarm rates, a bias not observed in older adults.

To control for response bias in the old/new recognition task used here, an unbiased measure of discriminability, A' (MacMillan & Creelman, 1990), was calculated. The pattern of results observed using corrected recognition performance did not change when A' scores were used as the dependent measure, with the sole exception being that young adults were unable to discriminate between positively valenced old and new words, t (47) = 1.64.

Mood ratings

Mood ratings were obtained by subtracting the scores for negative mood from those of positive mood from the BMIS. A one-way ANOVA was conducted on the average mood ratings with age (young, old) as a between-subjects factor. In replication of earlier findings (e.g., Carstensen et al., 2000; Charles et al., 2001; Gross et al., 1997; Mroczek & Kolarz, 1998), older adults

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[2] The response time data are based on 40 words of each valence. All analyses were also calculated on the 12 words of each valence included in the subsequent recognition test. The statistical outcomes were identical to those reported for all items. We thank an anonymous reviewer for suggesting this analysis.

ratings showed a more positive mood overall (*M*= 2.49, *SD*= 1.46) compared to younger adults (*M*= 1.72, *SD*= 1.43), *F* (1, 95) = 6.87, *MSE* = 13.35.

Given that young and older adults differed significantly in their mood ratings, we repeated the analyses on corrected recognition memory with the average mood ratings included as a covariate. The covariate was not significant and the pattern of results did not change. Thus, this analysis suggests that mood did not contribute to the different pattern of corrected recognition performance for young and older adults.

Discussion

The present study investigated the early processing of and subsequent incidental memory for positive, negative, and neutral stimuli in young and older adults. A growing literature (e.g., Charles et al., 2003; Mather & Carstensen, 2003) suggests that older adults tend to remember positive emotional stimuli better than negative or neutral stimuli. We anticipated a replication of this age-related memory bias and we assessed the degree to which the source of the memory bias is tied to attentional or encoding processes. To this end, participants completed a task in which they were instructed to ignore emotional and neutral distractors while making a simple parity judgment as well as a surprise recognition task to assess the extent to which encoding of the stimuli influences subsequent memory for the positive, negative, and neutral words.

The recognition findings are consistent with the previously reported positivity bias of older adults (Charles et al., 2003; Mather & Carstensen, 2003). In fact, we actually found reliable recognition for positive words only; older adults were unable to discriminate between old and new words that were either negative or neutral. Furthermore, we also expected and found that younger adults correctly recognized a greater proportion of negative stimuli compared to positive stimuli; and they tended towards better recognition of negative than neutral words. Thus, results of the present study provide corroborating evidence of an age-related difference in memory biases that occurs even when participants do not expect a memory test. Younger adults preferentially recognized negative words and older adults preferentially recognized positive words.

We expected that early processing - or attention regulation - might be a major source of these recognition differences. Indeed young adults took longer to respond in the digit parity task when the distractors were negative even when stimuli were exposed for only 200 ms. However, for older adults, there was no evidence of an encoding bias - valence did not influence performance in the digit parity task. Given that the speed of processing was approximately equal across various distractor types, the recognition data are especially surprising - equal encoding time did not even ensure that negative and neutral items were recognized above chance. Only positive items were reliably recognized by older adults.

Although these findings are inconsistent with work by Mather and colleagues (Mather & Carstensen, 2003; Mather et al., 2004), there is other evidence that increased attention to positive stimuli is not necessary for the memory enhancement of these items in older adults. Specifically, Mather and Carstensen (Experiment 2) failed to replicate older adults' attentional bias for positive stimuli observed in their first experiment; however, older adults still correctly recognized more positive stimuli than negative and neutral stimuli. Furthermore, Charles et al. (2003) demonstrated that both young and older adults spent more time viewing negative images than neutral or positive, but there was an age-related decrease in recognition memory for negative stimuli but not positive or neutral stimuli. Results of the current study suggest that older adults' attentional bias for positive stimuli is not consistently observed, even in the very early processing of stimuli.

Early processing biases do not appear to fully explain age differences in memory for valenced words. The absence of early processing biases in older adults, along with evidence that mood alone does not play a role in the differential recognition of positive items suggests that post encoding processes are responsible for the memory patterns observed here and elsewhere. These processes might occur in the interval between the end of the presentation of the list and the time the unexpected test occurred - or they might begin as early as the reflective stages proposed by Johnson (1992). For example, older adults may deliberately - or spontaneously - rehearse or dwell on positive stimuli immediately after they occur and not engage such reflection for negative stimuli even when a memory test is unanticipated. If so, reflective operations, when devoted to emotionally gratifying information, may help to increase positive affect by maintaining activation of the positive stimuli as well as by enhancing their subsequent retrievability.

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Table 1

Mean Percent Correct and Means of Median Reaction Times in the Digit Parity Task for Age Group and Valence of Distracting Word

	Word Valence							
	Accuracy				Median Response Time			
Age Group	**Neutral**	**Positive**	**Negative**	**Overall**	**Neutral**	**Positive**	**Negative**	**Overall**
Young (n = 48)								
M	89.5	88.5	88.1	88.7	672	677	719	689
SD	6.56	7.20	6.28	5.38	201	193	228	200
Older (n = 48)								
M	89.4	89.3	87.7	88.8	927	917	942	928
SD	7.99	7.41	8.59	6.52	284	252	255	253

Table 2

Hit Rates, False Alarm Rates (FA), and Corrected Recognition (CR) by Valence and Age

	Word Valence								
	Neutral			**Positive**			**Negative**		
Age Group	**Hits**	**FA**	**CR**	**Hits**	**FA**	**CR**	**Hits**	**FA**	**CR**
Young (*n* = 48)									
M	0.26	0.19	0.07	0.41	0.35	0.06	0.39	0.26	0.13
SD	0.19	0.18	0.15	0.22	0.23	0.20	0.19	0.18	0.20
Older (n = 48)									
M	0.20	0.17	0.03	0.28	0.19	0.09	0.19	0.18	0.01
SD	0.23	0.24	0.13	0.26	0.22	0.12	0.23	0.21	0.13