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

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This study examined older and younger 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 toward negative words carried over into recognition performance for younger adults, older adults' bias appeared to be limited to remembering positive information.

Keywords: aging, emotion, emotional memory, attention, positivity effect

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 are intended to isolate particular processes and to 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, 1999; May, Hasher, & Stoltzfus, 1993), 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 life span may influence cognitive functioning (e.g., Charles et al., 2003; Mather et al., 2004; Mather & Carstensen, 2003). In particular, there appears to be an age-related motivational shift toward 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, 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 more than on negative or neutral information (Carstensen et al., 2003).

Evidence for a bias toward positive information can be seen in a number of studies that tested memory for affectively valenced information (e.g., Charles et al., 2003; Hashtroudi, Johnson, & Chrosniak, 1990; Mather & Carstensen, 2003). For example, Charles et al. (2003) 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 life span, whereas the proportion of recall consisting of positive pictures increased. Similarly, there was an age-related decrease in recognition accuracy for negative emotional pictures, whereas recognition accuracy for positive emotional pictures remained stable across the life span. Similar findings were 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 have directly addressed the existence of age differences in attentional biases to valenced stimuli. Although some studies have shown the expected bias of older adults toward positive stimuli and, in some cases, a bias of younger adults toward negative stimuli (Mather et al., 2004; Mather & Carstensen, 2003, Experiment 1), others have not (Charles et al., 2003, Experiment 2; Mather & Carstensen, 2003, Experiment 2).

For example, Mather and Carstensen (2003) observed the expected pattern of attentional biases using a dot-probe procedure to investigate whether young and older adults tended to direct their attention toward a face with either a negative or a 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 was reflected in changes in amygdala activity when the adults

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viewed 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.

In the present article, 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 (i.e., to indicate whether they were both odd or even or whether one was a mismatch; Harris & Pashler, 2004; Wolford & Morrison, 1980). Irrelevant words appeared between the two digits on each trial, and these were positive, negative, or neutral in valence. Each display of digits plus word was presented for a brief and fixed duration (200 ms). As a result, the time to respond was 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, we used the speed of parity decisions to assess the existence of attentional biases in both younger and older adults.

The present study also includes an incidental recognition memory test for the positive, negative, and neutral distractors presented during the digit parity task. On the basis of previous research (e.g., Charles et al., 2003; Mather & Carstensen, 2003) and 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 examines 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 years old) and 48 older (60–75 years old) 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 either were native English speakers or had learned English before the age of 5 years. Younger adults (M = 21.4, SD = 2.44) had an average of 15.00 (SD = 1.9) years of education and a mean score of 32.67 (SD = 3.90) on the Shipley Vocabulary Test (Shipley, 1946). Older adults (M = 67.6, SD = 4.40) had significantly more years of education (M = 16.40, 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), $F(1, 95) = 19.046$, MSE = 13.14. Data from 3 younger adults and 7 older adults were replaced as a result of either computer problems (1 young and 1 older adult) or low accuracy on the digit parity task (incorrect responses on more that one third of the trials; 2 young and 6 older adults).

Design

The design was a 2 (age) × 3 (distractor valence) mixed factorial with age (young, older) as a between-subjects factor and valence (neutral, positive, negative) as a within-subject factor. 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) Affective Norms for English Words (ANEW) set. A total of 240 words were selected and 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 words 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, $F(2, 237) = 3{,}397.48$, MSE = 554.07. The arousal levels 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 from younger adults only, Wurm, Labouvie-Vief, Aycock, Rebucal, and 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., 2004).

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 on the basis of 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 was varied to minimize potential carryover effects. With two sets of words, there were a total of 12 unique conditions, with 4 young and 4 older participants in each.

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 10 adjectives describing different emotions (e.g., *sad, annoyed, content, gloomy, happy*). Participants were instructed to indicate whether the adjectives described their current feelings on a scale from 1 *(definitely do not feel)* to 5 *(definitely feel).*

Procedure

All participants were tested individually, and each provided informed consent. Participants first completed the BMIS, followed by 80 practice trials, 40 without a distracting item and 40 with symbols (e.g., #####) inserted between the two digits. Next, participants completed 120 experi-

Table 1
Mean Percentage 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

mental 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 min. 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, all participants completed the Shipley Vocabulary Test (Shipley, 1946), and older adults completed the Short Blessed Test (Katzman et al., 1983).

Results

For each dependent variable of interest, a 2 (age: young, older) × 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 (unless otherwise noted).

Digit Parity Task

Median reaction times and accuracy for positive, negative, and neutral distracting words are presented in Table 1.[1] Accuracy scores did not differ across valence types, $F(2, 188) = 2.07$, $MSE = 0.74$, $p > .10$, or age ($F < 1$). The Age × Valence interaction was not significant ($F < 1$). Overall, older adults ($M = 928.30$, $SD = 253.20$) responded more slowly than younger adults ($M = 689.21$, $SD = 199.59$), $F(1, 94) = 26.40$, $MSE = 155{,}922.12$. Response times differed across distractor valence, $F(2, 188) = 4.92$, $MSE = 6{,}811.41$. Although the Age × Valence interaction was not significant ($F < 1$), the pattern of reaction times across valence warranted a more liberal test of age differences in reaction time as a function of valence. Accordingly, we examined the main effects of valence separately for young and older adults. Young adults' response times differed across positive, negative, and neutral words, $F(2, 94) = 6.31$, $MSE = 5{,}159.30$, in that the participants 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 scores (hits minus false alarms) are reported in Table 2. Table 2 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 × Valence interaction, $F(2, 188) = 5.88$, $MSE = 0.14$. For younger adults, the means suggest that the best recognition was for negative words and the worst recognition was for positive words, and this difference was reliable, $t(47) = 2.14$. Although the mean recognition score for negative items was greater than the mean score 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; older adults showed the best recognition for positive words. Their recognition of both neutral and negative words was actually very poor—indeed, it did not differ from chance, $t(47) = 1.65$ for neutral words, and $t(47) = 0.67$ for negative words. Older adults' 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, $F(1, 94) = 11.229$, $MSE = 171.125$, and higher false alarm rates, $F(1, 94) = 5.199$, $MSE = 77.087$, compared with older adults. In particular, younger adults had similar hit rates for positive and negative words, $t(47) = 0.586$, but they had more difficulty discriminating between old and new words when they were positively valenced—that is, more false alarms for positive than for negative words, $t(47) = 3.721$, and neutral words, $t(47) = 2.454$. Older adults, conversely, had stable false alarm rates across differently valenced words ($F < 1$), but they correctly identified more positive than negative, $t(47) = 3.455$, or neutral words, $t(47) = 4.127$. Thus, young adults showed a response bias in their false alarm rates, but older adults did not.

To control for response bias in the old/new recognition task, we calculated an unbiased measure of discriminability, A′ (MacMillan

[1] No conclusion was altered when we included the data from replaced participants.

[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.

Table 2
Hit Rates, False Alarm Rates (FAs), 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

& Creelman, 1990). The pattern of results that we observed with corrected recognition performance did not change when we used A′ scores 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

We obtained mood ratings by subtracting the scores for negative mood from the scores for positive mood from the BMIS. We conducted a one-way ANOVA on the average mood ratings with age (young, older) 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 ratings showed a more positive mood overall ($M = 2.49$, $SD = 1.46$) compared with 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 investigates 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 was 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 completing a surprise recognition task so that we could assess the extent to which encoding of the stimuli influenced 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, in keeping with our expectations, we also found that younger adults correctly recognized a greater proportion of negative stimuli compared with positive stimuli, and they tended toward better recognition of negative than of 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 better than chance. Only positive items were reliably recognized by older adults.

Although these findings are inconsistent with work by Mather et al. (2004; Mather & Carstensen, 2003), there is other evidence that increased attention to positive stimuli is not necessary for the memory enhancement of these items in older adults. In particular, Mather and Carstensen (2003, 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 images, 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 postencoding processes are responsible for the memory patterns observed in this study 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 the stimuli 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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