

Effects of Emotion on Memory Specificity in Young and Older Adults

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To examine how emotional content affects the amount of visual detail remembered, we had young and older adults study neutral, negative, and positive objects. At retrieval, they distinguished same (identical) from similar (same verbal label, different visual details) and new (nonstudied) objects. A *same* response to a same item indicated memory for visual details (specific recognition), whereas a *same* or *similar* response to a same or similar item signified memory for the general sort of object (general recognition). Both age groups showed enhanced specific recognition for negative (not positive) objects. Young adults' general recognition advantage also was restricted to negative objects, whereas older adults showed enhanced general recognition for positive and negative objects. Negative (not positive) content enhanced the visual specificity of memory in both ages, but positive content conferred a general memory advantage only for older adults.

NOT all memories are equally detailed. We might remember seeing a coffee cup on our desk but fail to recall its color, size, or shape, or we might remember seeing a large, blue mug with a logo. Although at some level both of these memories are accurate, the latter memory contains more visual detail than the former. In the present study we investigated whether the amount of visual detail that young and older adults remember about an object is influenced by the item's emotional valence (whether it is positive or negative).

Although we have previously shown that young adults remember visual details for negative objects more often than they do for neutral objects (Kensinger, Garoff-Eaton, & Schacter, 2006), we had reason to believe that they might not show a similar enhancement in memory for the visual details of positive objects. The memory boost for negative items often results from enhancements in the memory's vividness or level of detail (Dewhurst & Parry, 2000; Kensinger & Corkin, 2003; Kensinger & Schacter, 2006; Ochsner, 2000). By contrast, when there are memory enhancements for positive information, they are more likely to result from an increased feeling of familiarity, or from memory for general (nonspecific) information (Bless & Schwartz, 1999; Clore et al., 2001; Fiedler, 2001; Gasper & Clore, 2002; Ochsner). Thus, individuals often claim they "know" a positive item was presented but do not "remember" the details of its presentation (Dewhurst & Parry; Ochsner). Participants can also be more likely to falsely or inconsistently remember positive information compared with negative information (Kensinger & Schacter, 2006; Levine & Bluck, 2004), likely because of their increased reliance on schematic information when processing positive information (Storbeck & Clore, 2005). Given this prior research, we hypothesized that, in young adults, negative (but not positive) emotional content would lead to enhancement in memory for visual details.

It was less clear whether these divergent effects of positive and negative emotion would occur in older adults. In general, older adults have less access to information about the specific details of an item's presentation than do young adults (Kensinger & Schacter, 1999; Koutstaal, 2003; Schacter,

Koutstaal, & Norman, 1997). Thus, we expected that there would be an overall effect of age on the specificity of a memory. The critical question, however, was whether valence would differentially affect memory for visual detail in young and older adults. Recent evidence has suggested that older adults are more likely than young adults to focus attention on emotional information (Fung, Carstensen, & Lutz, 1999; Hashtroudi, Johnson, & Chrosniak, 1990; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; May, Rahhal, Berry, & Leighton, 2005), and perhaps specifically on positive information (see Mather & Carstensen, 2005; Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005). Although it is likely that enhanced attention toward emotional information would result in a memory benefit for that information (see D'Argembeau & van der Linden, 2004), it is less clear whether it would lead to enhancements primarily in memory for the general theme of an item, or also would boost older adults' memory for visual detail. On the one hand, if positive and negative stimuli are processed in fundamentally different ways from one another by both young and older adults (i.e., with positive stimuli processed in a heuristic way and negative stimuli processed in a detail-oriented fashion), then both ages may show enhancements in memory for detail only for negative items and not for positive items. On the other hand, if negative content enhances the specificity of young adults' memories because their attention is drawn toward negative stimuli (Dolan & Vuilleumier, 2003; LeDoux, 2000; Mather & Carstensen, 2003), then the effect could be reversed in older adults, who tend to focus more attention, and more elaborative encoding processes, on positive than on negative information (Isaacowitz et al., 2006; Mather & Knight, 2005).

Despite increased interest in understanding the effects of advancing age on memory for emotional information (reviewed by Kensinger, 2006; Mather & Carstensen, 2005), to our knowledge only one prior study has used retrieval tasks that can tease apart visually specific from more general memories. In this prior study, Denburg, Buchanan, Tranel, and Adolphs (2003) assessed participants' memories for the general theme and specific visual details of complex visual scenes (e.g., a dead

body in a forest). Their results suggested that, throughout the adult life span, positive and negative emotional content can be associated with enhancements in memory for “gist” but with impairments in memory for visual details. They did not, however, distinguish memory for details of the emotional item in the scene (e.g., the dead body) from memory for details of the nonemotional context (e.g., the forest). An extensive literature has demonstrated that the emotional elements of an event often are remembered well, whereas nonemotional elements often are forgotten (reviewed by Reisburg & Heuer, 2004). Thus, it is plausible that the results of this prior study would have been different had the authors assessed memory for the visual details of the emotional elements only, rather than also requiring memory for details peripheral to the emotional content of the scenes. In fact, a few studies have demonstrated that, at least in young adults, memory for both the specific visual details as well as the general theme of information can be enhanced for emotional items (Burke, Heuer, & Reisberg, 1992; Kensinger, Garoff-Eaton, & Schacter, 2006, 2007). For example, when presented with a scene depicting a snake in a forest, young adults remember the visual details of the snake, as well as the fact that there was a snake. By contrast, they fail to remember the visual details of the forest – details not linked to the emotional element (Kensinger et al., 2007).

In the present study, we examined young and older adults’ abilities to remember the visual details of positive, negative, or neutral objects that were presented in isolation against a blank background. We previously showed that young adults are more likely to remember the visual details of negative objects than of neutral ones (Kensinger, Garoff-Eaton, & Schacter, 2006). Our goals of the present study were to investigate whether young adults also would show enhanced memory specificity for positive items and to examine whether the effects of emotion on memory for visual detail would change between young adulthood and old age.

EXPERIMENT 1

In Experiment 1, we addressed our goals within an experiment in which young and older adults were tested after different delays (30 min for the older adults and 2 days for the young adults) in order to roughly numerically equate the memory performance of the two groups. We reasoned that if the two groups did not have similar memory performance for the neutral items, then it could be difficult to interpret age differences in emotional memory enhancements. For example, if older adults’ performance was worse than younger adults’, and if older adults also showed a greater emotional memory enhancement than did young adults, then that additional enhancement could simply reflect the fact that there was more room for improvement in the older adults than in the young adults.

At study, participants viewed positive, negative, and neutral objects. At test, they distinguished “same” objects (identical to those studied) from “similar” (same verbal label, different visual details) or “new” ones. Consistent with previous studies using variants of this paradigm (Garoff et al., 2005; Kensinger, Garoff-Eaton, & Schacter, 2006), we considered a *same* response to a same item to reflect memory for specific visual details, or “specific recognition.” Collectively, same or similar

items given either a *same* or a *similar* response were considered to reflect memory for at least the general sort of object, or “general recognition.” (All results remained qualitatively the same when we computed general recognition as *same* or *similar* responses to same items, i.e., when we did not include responses to similar items in the general recognition score.)

Thus, we assessed the effects of negative and positive content on young and older adults’ memories for (a) specific visual details (specific recognition) and (b) general object information (general recognition).

It is worth noting that although our measurement of general recognition shares many similarities with the conceptualization of so-called gist memory, the two also differ in a couple of important ways. First, gist memory often has been used to refer to memory for the general theme of previously presented information in the absence of memory for specific details (e.g., Brainerd & Reyna, 2005). In the present study, we conceptualized general recognition as memory for *at least* the gist information, regardless of whether individuals also remembered the specific visual details. Second, gist memory often refers to the extraction of commonalities among a series of items or to inferences regarding presented information (e.g., Adams, Labouvie-Vief, Hobart, & Dorosz, 1990; Adams, Smith, Nyquist, & Perlmutter, 1997; Gould, Trevithick, & Dixon, 1991). In the present study, general recognition reflected memory for the general theme of a single item, not for a common theme shared among multiple items.

METHODS

Participants

Participants were 32 young and 32 older adults (see Table 1 for demographic information). Young adults were Harvard or Boston College students. Older adults were recruited from a database maintained at Harvard University or through the Harvard Cooperative Program on Aging. All participants were native English speakers with normal or corrected-to-normal vision and with no history of a neuropsychological or psychiatric disorder. No participant listed taking medications that affected the central nervous system. We obtained informed consent in a method approved by the Harvard University and Boston College Institutional Review Boards.

Materials and Procedure

Materials.—Materials comprised 180 pairs of photo objects (from Kensinger, Garoff-Eaton, & Schacter, 2006 and supplemented with additional positive objects). Pairs shared the same verbal label (e.g., were both umbrellas) but differed in other perceptual features (e.g., color, shape, size, orientation). We selected the final images from a larger set that had been rated by a separate group of 6 young and 6 older adults for their valence and arousal, using 9-point Likert-type scales (with low numbers indicating low valence and low arousal, respectively). One third of the selected objects were negative and arousing (i.e., valence < 3.5, arousal ratings \geq 5), one third were positive and arousing (i.e., valence > 5.5, arousal \geq 5), and one third were neutral (i.e., valence = 3–6, arousal < 5). The positive and negative objects did not differ from one another in arousal or in

Table 1. Demographic Information and Mean (SE) Test Scores for Participants in Experiments 1 and 2

Age Group	Gender	Age	Education	MMSE	Digit Span		WAIS-III Digit Symbol		WAIS-III Vocabulary	
					Forward	Backward	No. completed*	AASS	% Correct*	AASS
Experiment 1										
Young adults	10 men	20.1 (.63)	15.1 (.38)		7.09 (.18)	4.69 (.27)	73.1 (2.6)	9.7 (.51)	87.1 (1.0)	16.3 (.37)
	22 women	Range = 18–30	Range = 13–20;							
Older adults	10 men	73.4 (1.2)	16.5 (.32)	29.3 (.13)	6.88 (.19)	4.19 (.28)	48.3 (2.3)	10.0 (.49)	90.6 (1.3)	16.7 (.42)
	22 women	Range = 65–80	Range = 14–22							
Experiment 2										
Young adults	11 men	20.8 (.57)	14.7 (.34)		7.06 (.27)	5.56 (.30)	66.5 (2.6)	9.8 (.42)	84.6 (2.7)	15.8 (.53)
	21 women	Range = 19–28	Range = 13–19;							
Older adults	8 men	70.3 (1.1)	16.8	29.0 (.20)	6.56 (.29)	4.88 (.29)	48.4 (2.9)	10.5 (.63)	90.4 (2.2)	16.1 (.44)
	24 women	Range = 67–79	Range = 14–23							

Notes: Age and education are shown in years. AASS = age-adjusted scaled score; MMSE = Mini-Mental Status Exam (Folstein et al., 1975); WAIS-III = Wechsler Adult Intelligence Scale, third edition (Wechsler, 1997); SE = standard error. Older adults completed significantly fewer entries on the digit symbol copy than did young adults, and older adults correctly defined more words on the vocabulary assessment than did young adults; however, the age groups did not differ from one another in their AASSs on either of these tasks.

*Measure on which there was a significant age difference ($p < .01$).

absolute valence, $p > .15$, and positive and negative objects were more arousing than neutral ones, $p < .001$. Valence and arousal ratings for each group of objects did not differ for the young and older adults, $p > .15$.

We matched negative, positive, and neutral pairs for the overall similarity of the two items, the dimensions (color, size, shape, orientation) that differed between the two items, and the familiarity of the items (see Kensinger, Garoff-Eaton, & Schacter, 2006 for details of the matching procedures).

Study procedure.—Participants viewed 144 objects (one third of each emotion type) for 1 s. Following the object's presentation, participants indicated, by key press, whether the object would fit inside the drawer of a filing cabinet.

Test procedure.—After approximately a 30-min delay for the older adults, and a 2-day delay for the young adults, participants performed a surprise object-recognition task. On subsequent debriefing forms, all participants indicated that they were surprised that their memory was assessed. We chose these delays because pilot data indicated that neither ceiling nor floor effects existed for participants when tested after these delays, and because these delays resulted in approximate, numerical matching of performance for the young and older adults. (Note that our use of this matching procedure was only to provide numerical equation of memory performance; we do not claim that changing the delay interval equated the processes associated with memory performance in the two age groups.) Participants were presented with 180 objects: 72 (24 negative, 24 positive, 24 neutral) were identical to those that had been studied (same objects), 72 shared the same verbal label as a studied item but differed in visual features (similar objects), and 36 were new (see Figure 1). Participants indicated, by key press, whether the item was same, similar, or new. We had the same object within the object pair tested across all participants; we had the studied items counterbalanced between subjects to manipulate the condition of each object shown at recognition. For same items, the identical image was studied;

for similar items, the alternate member of the pair was studied; for new items, neither member of the pair was studied. Only one member of a particular pair was shown on the recognition test.

RESULTS

The data are presented in Table 2: The proportion of items given a *same*, *similar*, or *new* response is reported as a function of item type (same, similar, or new), emotion type (negative, positive, or neutral) and age (young or older adults). We examined the effects of emotional content and age on the three different types of items presented at recognition (new items, items that were similar to studied items, and items that were the same as studied items; see Figure 1).

New Items

For the new items, we conducted an analysis of variance (ANOVA) with response (same or similar) and emotion (negative, positive, or neutral) as within-subject factors and age as a between-subject factor. This analysis revealed a main effect of response, $F(1, 62) = 60.72$, $p < .001$, partial $\eta^2 = .50$, and a marginal Response \times Age interaction, $F(1, 62) = 3.44$, $p < .07$, partial $\eta^2 = .05$. This interaction reflected the fact that older adults gave more *new* responses, but fewer *similar* responses, to new items than did young adults. Importantly, this ANOVA revealed neither effects of emotion nor any interactions with emotion.

Similar Items

For the similar items, an ANOVA revealed only a significant effect of response, $F(1, 62) = 31.49$, $p < .001$, partial $\eta^2 = .34$, with more *similar* than *same* responses given to the similar items. As with the new items, there was neither an effect of emotion nor any interactions with emotion.

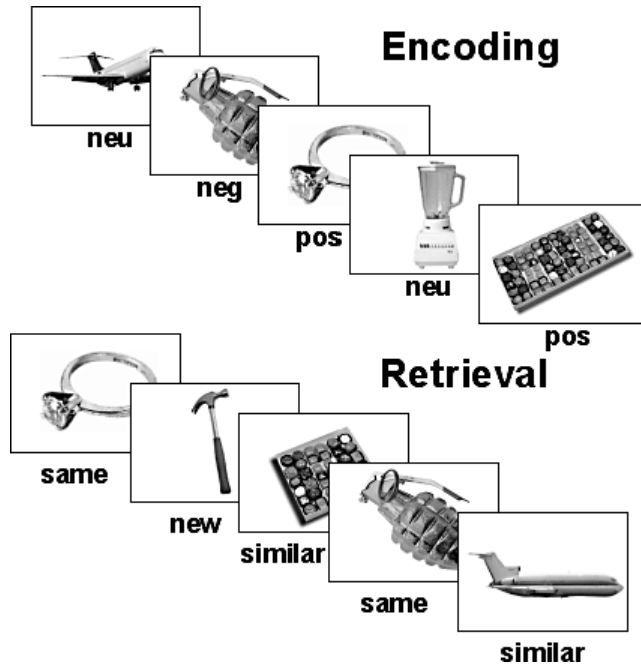


Figure 1. Task design: At study, young and older adults viewed objects for 1,000 ms. One third of the objects were negative (or neg) and arousing (e.g., tarantula), one third were positive (or pos) and arousing (e.g., diamond ring), and the other third were neutral (or neu; e.g., barometer). At test, participants were presented with objects that were the same as the studied item (identical), similar to a studied item (sharing the same verbal label but not an identical picture), or new (not studied). Participants indicated whether the item was same, similar, or new.

Same Items

For the same items, an ANOVA revealed significant main effects of response, $F(1, 62) = 54.87, p < .001$, partial $\eta^2 = .47$, and of emotion, $F(2, 61) = 11.05, p < .001$, partial $\eta^2 = .26$. These main effects were qualified by an Emotion \times Response interaction, $F(2, 61) = 11.31, p < .001$, partial $\eta^2 = .27$, and an Emotion \times Age interaction, $F(2, 61) = 4.37, p < .05$, partial $\eta^2 = .13$. Post hoc t tests indicated that the Emotion \times Response interaction reflected the greater proportion of *same* responses to same negative objects as compared with positive or to neutral ones, $t(63) = 4.94, p < .001$. The Emotion \times Age interaction arose because young adults showed a similar response distribution for positive and neutral items, $p > .25$, whereas older adults gave more *same* or *similar* responses to positive than to neutral objects, $t(31) = 2.69, p < .05$.

Comparison of Specific and General Recognition

To further examine the effects of emotion on young and older adults' responses to the same items, we calculated participants' ability to remember the specific visual details of an item (i.e., the proportion of *same* responses to same items, referred to as specific recognition) and to remember at least the general features of an item, regardless of whether the specific visual details were remembered (i.e., the proportion of *same* and *similar*, not *new*, responses given to same and similar items).

Table 2. Proportion of Same, Similar, and New Responses as a Function of Item Type, Emotion Type, and Age in Experiment 1

Response Type	Same	Similar	New
Young adults			
Negative objects			
Same	.54 (.05)	.23 (.03)	.11 (.02)
Similar	.25 (.03)	.45 (.03)	.24 (.03)
New	.21 (.04)	.33 (.03)	.65 (.03)
Positive objects			
Same	.41 (.04)	.22 (.03)	.09 (.02)
Similar	.28 (.03)	.43 (.03)	.23 (.03)
New	.31 (.05)	.35 (.03)	.68 (.04)
Neutral objects			
Same	.41 (.04)	.23 (.03)	.09 (.02)
Similar	.31 (.02)	.42 (.03)	.23 (.02)
New	.29 (.04)	.35 (.04)	.68 (.03)
Older adults			
Negative objects			
Same	.67 (.03)	.26 (.03)	.09 (.01)
Similar	.18 (.02)	.43 (.03)	.19 (.02)
New	.14 (.02)	.31 (.04)	.71 (.03)
Positive objects			
Same	.52 (.04)	.28 (.02)	.09 (.02)
Similar	.33 (.04)	.40 (.03)	.19 (.02)
New	.15 (.02)	.32 (.03)	.72 (.03)
Neutral objects			
Same	.51 (.05)	.26 (.03)	.11 (.02)
Similar	.22 (.03)	.40 (.04)	.18 (.02)
New	.27 (.04)	.34 (.03)	.71 (.03)

Notes: Responses are shown as the mean, with standard deviation given in parentheses. Specific recognition reflects the proportion of *same* responses to same items, whereas general recognition reflects the proportion of *same* or *similar* responses to same or similar items.

An ANOVA with recognition (specific or general) and emotion (positive, negative, or neutral) as within-subject factors and age as a between-subject factor revealed main effects of recognition, $F(1, 62) = 83.36, p < .001$, partial $\eta^2 = .53$, and emotion, $F(2, 61) = 12.45, p < .001$, partial $\eta^2 = .29$, qualified by a three-way Recognition \times Emotion \times Age interaction, $F(2, 62) = 3.01, p < .05$, partial $\eta^2 = .09$. Separate ANOVAs conducted on the specific recognition and general recognition scores clarified that emotion affected both memory scores, with $F(2, 61) = 9.26, p < .001$, partial $\eta^2 = .24$ for specific recognition and $F(2, 61) = 7.24, p < .01$, partial $\eta^2 = .19$ for general recognition. However, there was an Emotion \times Age interaction for the general recognition scores, $F(2, 61) = 3.13, p < .05$, partial $\eta^2 = .09$, but not for the specific recognition scores, partial $\eta^2 = .02$. These results reflected the fact that young adults showed enhanced general recognition for negative items (73%) as compared with neutral ones (68%), $t(31) = 2.32, p < .05$, or positive ones (67%), $t(31) = 2.86, p < .01$, and no difference between the general recognition rates for the positive and neutral items, $p > .15$ (i.e., negative $>$ positive = neutral). By contrast, older adults showed a boost in general recognition for both positive objects (77%), $t(31) = 2.74, p < .01$, and negative objects (77%), $t(31) = 3.03, p < .01$, as compared with neutral ones (69%), and no difference in general recognition rates for the negative and positive items, $p > .15$ (i.e., negative = positive $>$ neutral).

In contrast, both young and older adults showed enhanced specific recognition only for negative items compared with positive ones, $t(63) = 5.19, p < .001$, or neutral ones, $t(63) = 4.94, p < .001$, and no difference in specific recognition scores for positive and neutral items, $p > .15$ (i.e., negative > positive = neutral). Older adults' general recognition scores for the positive items also were significantly better than those of the young adults, $t(62) = 2.77, p < .01$, whereas despite the shorter retention interval for the older adults, their general recognition scores for the negative and neutral items were no different than those of the young adults, $p > .15$.

DISCUSSION

Emotion had a similar effect on memory specificity in the two age groups. For young and older adults, negative items were associated with enhanced specific recognition, whereas positive items were not. These results suggest that negative emotion in particular facilitates memory for visual detail, and that this benefit of negative emotion persists across the adult life span.

In contrast to the similar effect of emotion on young and older adults' specific recognition, emotion had divergent effects on general recognition in the two ages. Young adults showed a general recognition benefit only for negative (and not for positive) objects as compared with neutral ones, whereas older adults showed equivalently elevated general recognition for negative and positive objects. These results are broadly consistent with evidence that positive emotion benefits older adults' memories more than it does young adults' memories (Charles, Mather, & Carstensen, 2003; Hill, van Boxtel, Ponds, Houx, & Jolles, 2005; Leigland, Schulz, & Janowsky, 2004; Mather & Knight, 2005). However, the present results suggest that, in some instances, older adults' mnemonic benefit for positive information is limited to extraction of general features of an item and does not extend to memory for the specific visual details of the previously encountered information.

Older adults also showed significantly better general recognition for the positive items than did young adults, yet, despite the shorter retention interval for older adults, their general recognition of negative and neutral information was no better than that of young adults. Although this finding is somewhat difficult to interpret because of the different study-test delay intervals for the young and older adults, it suggests a relative age-related sparing of general recognition for positive information as compared with negative or neutral information. In Experiment 2 we more directly examined this issue by testing young and older adults after the same delay.

EXPERIMENT 2

A potential concern in Experiment 1 was that we tested young and older adults after different delays in order to roughly equate the performance of the two ages. On the one hand, this matching reduces the concern that age differences in emotional memory enhancement arise because of different levels of performance for the neutral items (e.g., more room for improvement in the older adults than in the young adults). On the other hand, this matching technique has the potential to create interactions between age and emotion if the effects of emotion on memory change over a delay (and see LaBar & Phelps, 1998), and it also prevents a straightforward comparison of young and older adults' memory performance. To

Table 3. Proportion of Same, Similar, and New Responses as a Function of Item Type, Emotion Type, and Age in Experiment 2

Response Type	Same	Similar	New
Young adults			
Negative objects			
Same	.58 (.03)	.23 (.02)	.10 (.02)
Similar	.23 (.02)	.42 (.03)	.26 (.02)
New	.19 (.02)	.35 (.03)	.64 (.03)
Positive objects			
Same	.49 (.02)	.21 (.03)	.10 (.03)
Similar	.27 (.02)	.42 (.03)	.25 (.02)
New	.24 (.02)	.38 (.03)	.65 (.03)
Neutral objects			
Same	.48 (.02)	.20 (.01)	.10 (.02)
Similar	.25 (.02)	.43 (.03)	.25 (.03)
New	.26 (.02)	.37 (.03)	.65 (.03)
Older adults			
Negative objects			
Same	.51 (.02)	.24 (.02)	.07 (.01)
Similar	.25 (.02)	.35 (.02)	.18 (.02)
New	.24 (.02)	.41 (.03)	.75 (.03)
Positive objects			
Same	.44 (.02)	.26 (.02)	.06 (.01)
Similar	.35 (.02)	.35 (.02)	.18 (.02)
New	.21 (.01)	.39 (.02)	.75 (.03)
Neutral objects			
Same	.40 (.02)	.23 (.02)	.07 (.01)
Similar	.28 (.02)	.35 (.02)	.19 (.02)
New	.32 (.01)	.42 (.02)	.74 (.02)

Notes: Responses are shown as the mean, with standard deviation given in parentheses. Specific recognition reflects the proportion of *same* responses to same items, whereas general recognition reflects the proportion of *same* or *similar* responses to same or similar items.

circumvent these limitations, in Experiment 2 we examined whether the different effects of emotion on young and older adults' general recognition ability would hold when the two ages were tested with the same retention interval.

METHODS

Participants

Participants were 32 young and 32 older adults (see Table 1 for demographic information) who met the criteria outlined for Experiment 1.

Materials and Procedure

The materials and procedure were identical to those of Experiment 1 except that, in order to avoid ceiling effects in the young adults, participants studied a larger number of stimuli: they were presented with 180 stimuli and were tested with 270 objects. All participants performed the recognition memory task after a 30-min delay. During the delay, all participants performed the same cognitive tasks.

RESULTS

The data are presented in Table 3. We examined the effects of emotion and age on the new, similar, and same items; see Figure 1.

As in Experiment 1, there were neither main effects of emotion nor any interactions with emotion for the new and similar items. Thus, we focus here on responses to the same items and on the comparison of specific and general recognition scores.

An ANOVA with response to same items (same or similar) and emotion (negative, positive, or neutral) as within-subject factors and age as a between-subject factor revealed significant main effects of response, $F(1, 62) = 95.47, p < .001$, partial $\eta^2 = .61$, and of emotion, $F(2, 61) = 36.39, p < .001$, partial $\eta^2 = .54$. These main effects were qualified by an Emotion \times Response interaction, $F(2, 61) = 22.84, p < .001$, partial $\eta^2 = .43$; a Response \times Age interaction, $F(2, 61) = 6.06, p < .05$, partial $\eta^2 = .09$; and an Emotion \times Age interaction, $F(2, 61) = 7.77, p < .01$, partial $\eta^2 = .20$. Post hoc t tests indicated that the Emotion \times Response interaction reflected the greater proportion of *same* responses given to same negative objects compared with positive ones, $t(63) = 5.63, p < .001$, or neutral ones, $t(63) = 7.44, p < .001$. The Response \times Age interaction emerged because young adults gave more *same* responses, $t(31) = 2.5, p < .05$, and fewer *new* responses, $t(31) = 2.6, p < .05$, to same items than did older adults (see Table 3). The Emotion \times Age interaction reflected the fact that young adults showed a similar distribution of responses for positive and neutral items, $p > .15$, whereas older adults gave more *same* or *similar* responses to positive objects than to neutral ones, $t(31) = 6.79, p < .001$.

We also calculated participants' specific recognition and general recognition scores as described in Experiment 1. An ANOVA conducted on these recognition scores with recognition (specific or general) and emotion (positive, negative, or neutral) as within-subject factors and age as a between-subject factor revealed main effects of recognition, $F(1, 62) = 77.91, p < .001$, partial $\eta^2 = .59$; emotion, $F(2, 61) = 20.99, p < .001$, partial $\eta^2 = .41$; and age, $F(1, 62) = 8.09, p < .01$, partial $\eta^2 = .12$. These main effects were qualified by an Emotion \times Recognition interaction, $F(2, 61) = 5.07, p < .01$, partial $\eta^2 = .14$, and by a three-way interaction among the factors, $F(2, 61) = 3.64, p < .05$, partial $\eta^2 = .07$.

To elucidate the basis for this three-way interaction, we conducted separate ANOVAs on the specific recognition and general recognition scores with emotion as a within-subject factor and age as a between-subject factor. For the specific recognition scores, the ANOVA revealed a main effect of emotion, $F(2, 61) = 19.97, p < .001$, partial $\eta^2 = .40$, which reflected enhanced specific recognition for the negative items compared with the neutral ones, $t(63) = 4.94, p < .001$, or positive ones, $t(63) = 5.38, p < .001$. The ANOVA also showed a main effect of age, $F(1, 62) = 5.01, p < .05$, partial $\eta^2 = .08$, with older adults exhibiting poorer specific recognition than the young adults, $t(62) = 2.01, p < .05$. Critically, there was no Emotion \times Age interaction.

The general recognition ANOVA revealed an effect of emotion, $F(2, 61) = 17.64, p < .001$, partial $\eta^2 = .37$, and a marginal effect of age, $F(1, 62) = 2.99, p < .09$, partial $\eta^2 = .05$, qualified by an Emotion \times Age interaction, $F(2, 61) = 3.58, p < .05$, partial $\eta^2 = .09$. This interaction emerged because young adults showed enhanced general recognition for negative items (73%) as compared with neutral ones (68%), $t(31) = 3.42, p < .01$, or positive ones (69%), $t(31) = 2.57, p < .05$. By contrast, older adults showed a boost in general recognition

both for positive objects (70%), $t(31) = 4.98, p < .001$, and for negative objects (67%), $t(31) = 3.2, p < .01$, as compared with neutral ones (62%). Older adults' general recognition scores for the positive items also were comparable with those of the young adults, $p > .15$, whereas their general recognition scores were lower than those of the young adults for the negative and neutral items, $t(62) = 2.14, p < .05$.

DISCUSSION

The results of Experiment 2 generally replicated those of Experiment 1. Both ages showed an emotion-related enhancement in memory for detail that was restricted to negative items and did not extend to positive items. Young adults' emotional enhancement of general recognition also was limited to negative items, whereas older adults showed better general recognition for positive and for negative items than they did for neutral ones.

The results of Experiment 2 also corroborated the suggestive evidence from Experiment 1 that aging may leave relatively preserved the ability to recognize the general theme of positive information. Although older adults had lower general recognition scores for the neutral and negative items than did young adults, the two age groups did not differ in their general recognition of the positive items. Older adults often rely more on heuristic processing than do young adults (e.g., Adams et al., 1990; Gould et al., 1991), and, as discussed in the introduction, positive items appear to be a class of stimuli that are particularly prone to this type of schematic processing. It is plausible that older adults' relative preservation of general recognition for the positive items reflects the synergy between the types of information that older adults process well and the types of information that tend to be recorded for positive items.

In contrast to the preservation of general recognition for positive items, older adults had lower specific recognition scores than did young adults for all items. This result is consistent with prior investigations suggesting that older adults do not use memory for visual detail as effectively at retrieval as do young adults (see Koutstaal, 2003), and it suggests that the mnemonic boost provided by emotion is not sufficient to bring older adults' specific recognition scores to the same level demonstrated by the young adults. The implications of these results will be expanded on in the general discussion.

GENERAL DISCUSSION

The fact that young and older adults were able to remember the details of negative items better than those of neutral items is broadly consistent with a few prior studies indicating that both ages are more likely to form vivid memories of negative experiences than of neutral ones (Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004; Davidson & Glisky, 2002; Kensinger, Krendl, & Corkin, 2006; Wolters & Goudsmit, 2005). These results suggest that negative emotion can facilitate memory for detailed information throughout the adult life span.

At first blush the enhanced specificity of memory for the negative items seems to conflict with the findings of Denburg and colleagues (2003), who demonstrated that positive and negative emotion impaired memory for detail while enhancing memory for the gist or general theme of presented information. However, it is important to note that, in the present study,

emotion did enhance memory for the visual details of the objects themselves. In contrast, in the study by Denburg and colleagues, memory for details tangential to the emotional content of the scenes often was required for successful performance. Prior studies have indicated that, in young adults, negative emotion can enhance memory for details directly tied to the emotional stimuli (Burke et al., 1992; Kensinger, Garoff-Eaton, & Schacter, 2006; Kensinger et al., 2007). The present results indicate that this beneficial effect of negative emotion on memory specificity is consistent across the adult life span. Recent neuroimaging evidence has suggested that, in young adults, the enhanced specific recognition for negative items may stem from increased engagement of the amygdala and the fusiform gyrus during encoding of negative items (Kensinger et al.). The amygdala seems to show relatively little age-related decline (reviewed by Chow & Cummings, 2000), leaving open the possibility that amygdala–fusiform modulation of encoding processes occurs in older adults as well.

Negative items also were remembered with visual detail more frequently than were positive items, consistent with prior research demonstrating that, in young adults, positive emotion leads to more gist-based or heuristic processing, whereas negative emotion leads to more detailed processing (Bless et al., 1996; Kensinger & Schacter, in press; Levine & Bluck, 2004; Storbeck & Clore, 2005). Critically, the present findings suggest that these divergent effects of positive and negative emotion remain consistent across the life span. Despite age-related increases in the prioritization of processing for positive emotion-eliciting information (reviewed by Mather, 2006), older adults do not show enhanced memory specificity for positive information.

Although emotional content had similar influences on memory specificity in young and older adults, it had divergent effects on general recognition in the two ages. Whereas young adults showed a general recognition benefit only for negative objects as compared with neutral ones, older adults showed elevated general recognition for positive and negative objects. These results are broadly consistent with data indicating that positive emotion has more of an enhancing effect on older adults' memories than on young adults' memories (Charles et al., 2003; Hill et al., 2005; Leigland et al., 2004; Mather & Knight, 2005). However, these results suggest that there are limitations on the types of information better remembered for positive than neutral information (see also Gruhn, Smith, & Baltes, 2005). Older adults' "positivity effect" is limited to extraction of general information, and it does not extend to memory for the specific visual details of previously encountered positive information.

Not only did older adults show a positivity effect when comparing their general recognition of positive items to neutral items, they also showed selectively preserved general recognition (compared with young adults) for the positive items. Although older adults are not always as likely as young adults to remember items with positive emotional content (Denburg et al., 2003; Gruhn et al., 2005; Kensinger, Piguet, Krendl, & Corkin, 2005), Charles and colleagues (2003) also demonstrated that age-related deficits in memory can be eliminated for positive information. It is plausible that when the memory task is constructed such that memory for the general theme of the information is sufficient for successful task performance, age differences in memory for positive items may be reduced or

eliminated. This proposal fits well with previous research suggesting that older adults sometimes rely more on general than specific information when making recognition decisions (e.g., Kensinger & Schacter, 1999; Koutstaal & Schacter, 1997) or when recalling previously presented information (e.g., Adams et al., 1990; Gould et al., 1991). It may be that older adults can capitalize on the overlap between the types of information that they process well and the types of information most likely to be processed for positive items (i.e., thematic or heuristic information). Age-related increases in reliance on general information thus appear to have significant consequences for the performance of older adults in multiple aspects of memory.

In contrast to the equivalent general recognition for positive items, the presence of emotion never equated young and older adults' specific recognition performance, which is consistent with evidence that older adults rely less on detailed information when deciding whether particular items have been studied (Koutstaal, 2003; Koutstaal & Schacter, 1997; Schacter et al., 1997). Thus, although the presence of emotion can equate some aspects of young and older adults' memories, it does not serve to equalize all aspects of young and older adults' mnemonic performance.

It is important to note that the present study compared individuals at extremes of the adult life span (i.e., college-aged and older adults). Despite this extensive age gap, emotion had similar effects on specific recognition in both groups. Although the results of the present study do not speak to the mechanisms that lead to the divergent effects of positive and negative valence on specific recognition, the results do suggest that these valence-specific processes operate throughout the adult life span. In contrast, the effects of emotion on general recognition ability appear to change with age, with older adults showing a unique recognition advantage for positive information. It will be interesting for further research, including a broader age range of participants, to examine whether this enhancement in general recognition for positive information corresponds with adults' increased reliance on heuristic processing with advancing age.

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