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Aging and Emotional Memory: The Forgettable Nature of Negative Images for Older Adults

Susan Turk Charles
University of California, Irvine

Mara Mather
University of California, Santa Cruz

Laura L. Carstensen
Stanford University

Two studies examined age differences in recall and recognition memory for positive, negative, and neutral stimuli. In Study 1, younger, middle-aged, and older adults were shown images on a computer screen and, after a distraction task, were asked first to recall as many as they could and then to identify previously shown images from a set of old and new ones. The relative number of negative images compared with positive and neutral images recalled decreased with each successively older age group. Recognition memory showed a similar decrease with age in the relative memory advantage for negative pictures. In Study 2, the largest age differences in recall and recognition accuracy were also for the negative images. Findings are consistent with socioemotional selectivity theory, which posits greater investment in emotion regulation with age.

The past decade witnessed a major shift in the way theorists view emotional functioning in old age. Early theories portrayed later life as a time of blunted affect and emotional dysregulation. Because emotions were conceptualized primarily as physiological processes, they were presumed to follow the same downward trajectory observed in other biological arenas (Banham, 1951; Frenkel-Brunswik, 1968). These theories, though influential, were based more on conjecture than on evidence. Currently, a growing number of empirical studies have revealed an age-related pattern better characterized by relatively positive emotional experience and improved emotional control (e.g., Carstensen & Charles, 1998). With age, negative affect is experienced less frequently (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001), and positive affect as often (Carstensen et al, 2000) if not more frequently (Mroczek & Kolarz, 1998) in daily life.

Socioemotional selectivity theory (Carstensen, 1993, 1995; Carstensen & Charles, 1998; Carstensen, Isaacowitz, & Charles, 1999) accounts for such findings in motivational terms, arguing that with age, people place increasingly more value on emotionally meaningful goals and thus invest more cognitive and behavioral resources in obtaining them. This greater emphasis on emotional goals promotes emotion regulation. To the extent that motivation influences cognitive processes, memory for emotionally relevant information may also vary by age. In the present two studies we explore the relation between the emotional valence of information and memory performance across the adult life span.

Socioemotional Selectivity Theory

Socioemotional selectivity theory is a life-span theory of motivation that predicts enhanced emotion regulation with age (Carstensen, Fung, & Charles, in press). According to the theory, time perspective is the dominating force that structures human motivations and goals. The theory contends that humans have a conscious and subconscious awareness of their time left in life, and that perceived boundaries on time direct attention to emotionally meaningful aspects of life. When time is perceived as expansive, as it is in healthy young adults, goal striving and related motivations center around acquiring information. Novelty is valued and investments are made in expanding horizons. In contrast, when time is perceived as limited, emotional experience assumes primacy; people are motivated to monitor and select their environments to optimize emotional meaningfulness and emotional functioning. According to the theory, and supported by empirical evidence, younger people who are approaching the end of life show similar motivational changes (Carstensen & Fredrickson, 1998). However, because chronological age is related, for the most part, to time left in life, socioemotional selectivity theory posits that the regulation of emotional states receives greater priority as people age.

Consistent with the theory, older age is associated with improved emotion regulation. Emotion regulation, defined as the maintenance of positive affect and the decrease of negative affect,

Susan Turk Charles, Department of Psychology and Social Behavior, University of California, Irvine; Mara Mather, Department of Psychology, University of California, Santa Cruz; Laura L. Carstensen, Department of Psychology, Stanford University.

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Correspondence concerning this article should be addressed to Susan Turk Charles, Department of Psychology and Social Behavior, 3340 Social Ecology II, University of California, Irvine, California 92697-7085. E-mail: scharles@uci.edu

improves with age in studies using self-report measures (Carstensen et al., 2000; Charles et al., 2001). The frequency of positive affect shows minimal change over time (Charles et al., 2001), and one study found that positive affect was actually higher in older people (Mroczek & Kolarz, 1998). Older adults report feeling less anxiety and depression and greater contentment compared with younger adults (Lawton, Kleban, & Dean, 1993), and older age is associated with shorter durations of negative mood throughout the day (Carstensen et al., 2000). The only noticeable decrease in positive emotions found in the literature is for emotional surgency—an emotion similar to excitement—which older adults report experiencing less often compared with the responses of younger adults (Lawton, Kleban, Rajagopal, & Dean, 1992). When asked about emotional experiences, older as compared with younger adults report higher levels of control over both external processes—that is successfully hiding feelings from others—and internal processes—that is, actively enhancing mood at will (Gross et al., 1997; Lawton et al., 1992).

Despite mounting evidence that people regulate emotional experience equally if not better with age, understanding the processes by which this is accomplished is sorely lacking. Over the years, our research team has informally asked scores of older people how they regulate their emotions, particularly during difficult periods in their lives. Regularly, people respond with the answer, "I just don't think about [problems or worries]." At first, this statement seemed to offer little insight into how older adults were regulating their feelings; however, the consistency of their responses made us turn to the possibility that processing positive and negative information may vary as a function of age. Perhaps older adults, indeed, do not place as much emphasis on negative information or moods as younger adults, not encoding them to as great an extent, rehearsing them as often, or using less successful retrieval strategies, and thus would be less likely to remember these negative daily experiences. On the basis of this premise concerning age differences in the processing of negative and positive information by age, we directed our research to the role of memory for positive and negative experiences, and how cognitive processes may play a role in emotion regulation.

Memory as a Process in Emotion Regulation

Memory is not simply direct retrieval, but an elaborative process in which current goals influence constructions of the past (Johnson & Sherman, 1990; Ross, 1989; Ross & Wilson, 2000). Although rarely conceptualized as a self-regulatory process, the events, people, and places that individuals retrieve from memory clearly influence, and are influenced by, well-being. Socioemotional selectivity posits increasing importance placed on emotionally valenced information with age. A handful of studies have examined the extent to which this age-related change may influence memory. Testing the hypothesis that older people have disproportionately better memory for emotional as compared with emotionally neutral information, Carstensen and Turk-Charles (1994) administered an incidental memory test to a sample aged 20 to 83 years. They found that the proportion of emotional information recalled increased with each successive age group. Studies focused on source monitoring show a similar pattern. Hashtroudi, Johnson, and Chrosniak (1990), for example, asked older and younger adults first to read and to imagine everyday situations, and then to recall the content and source of the content. These researchers found that older people recalled more thoughts, feelings, and evaluative statements than their younger counterparts, and based their confidence ratings concerning their memory performance on the amount of emotional detail, as opposed to perceptual detail, recalled. In addition, older adults' patterns of memory distortion in control conditions tends to resemble that of both older and younger adults who are specifically directed to focus on emotions (Kennedy, Mather, & Carstensen, 2002; Mather & Johnson, 2000, in press), suggesting that older adults may be more likely to focus spontaneously on their emotions.

Rationale for the Current Studies

Prior research strongly supports the association between older age and increased emphasis on emotion, but none of these studies have distinguished between positive and negative material. Thus, it remains unclear whether the age effect is driven primarily by differences in memory such that positive material is remembered better than negative material, which would support the contention that memory is associated with self-regulation, or if the effect is equivalent for positive and negative emotion, which would suggest a more general increase in emotion salience associated with age that is not necessarily related to regulatory benefits.

Researchers have found that younger adults have a general tendency to weigh negative information more heavily than positive information in impression formation (e.g., Kanouse & Hanson, 1972) and decision making (e.g., Tversky & Kahneman, 1991), and that negative information is processed more thoroughly and is more difficult to disconfirm (see reviews by Baumeister, Bratslavsky, Fickenauer, & Vohs, 2001; Rozin & Royzman, 2001). Some studies with younger adults have also found that negative information is remembered better than positive information (e.g., Dewhurst & Parry, 2000; Mather, Shafir, & Johnson, 2000; Ochsner, 2000). Younger adults do not always show a negativity bias in memory, however. Some studies even find that younger adults remember positive information better than negative information (e.g., Matlin & Stang, 1978; Taylor, 1991; Walker, Vogl, & Thompson, 1997). The studies that find a positivity bias tend to be those examining memory for autobiographical information or other types of self-relevant materials. Thus, Baumeister et al. (2001) suggested that there is a negativity bias in memory, but that it is counteracted by self-enhancement processes that promote memory for one's own positive traits and actions.

In contrast, there is evidence that advancing age is accompanied by a shift away from negative information (e.g., Berntsen, 2001; Berntsen & Rubin, in press; Field, 1981; Mather, in press). For example, older adults attribute more positive qualities and fewer negative qualities to choices they have made than do younger adults, even after controlling for memory accuracy (Mather & Johnson, 2000). Moreover, in retrospective reports of psychological distress experienced the prior week, older adults are less likely to be biased by a single negative experience than younger adults, who anchor their rating on the basis of their most stressful day (Almeida, 1998). Thus, it may be that performance on tasks including positive and negative information varies by age, such that in old age negative information no longer has an advantage in memory over positive information.

The present research examined age differences in free recall and recognition memory for positive, negative, and neutral images. Age is associated with reliable decrements in recall; however, age differences are minimized in heuristic, automatic processes (Craik & McDowd, 1987; Johnson & Raye, 2000; Light, 2000; Prull, Gabrieli, & Burge, 2000). Thus, we were interested not only in whether age differences would be observed, but also in whether similar patterns would be evident on recall and recognition tasks. To see whether there are shifts across the life span in what type of information is most memorable, we examined whether the relative number of images of each emotional valence recalled and correctly recognized varies by age group. In Study 1, we examined whether age was associated with different patterns of memory performance for positive, negative, and neutral material. In Study 2, we modified the experimental paradigm such that participants viewed positive and negative images at their own pace (in contrast to the timed presentation in Study 1) as an initial step toward examining the role of attention in age differences. In Study 2, we also considered the alternative explanation that mood congruency accounts for observed age differences in what is remembered.

Study 1

Study 1 examined the central hypothesis that the relationship between memory for positive and negative material would change systematically with age, with older adults performing better on memory for positive than negative material, and younger adults performing better on memory for negative than positive material. We predicted that age differences would be more pronounced on the recall than recognition task because the former demands more self-directed processing that is more likely to be influenced by current motivations and goals. Younger, middle-aged, and older adults were included to study age trajectories across adulthood. Because emotional images often include pictures of people, and neutral images often include nonsocial scenes, we included equal proportions of social and nonsocial images within each emotion category to control for this potential confound.

Method

Participants. Participants were recruited by a survey methods research firm and asked to participate in a study examining people's reactions to a set of pictures. All participants lived in the San Francisco Bay Area and were compensated $50.00 for their involvement in the study. They represented three age groups consisting of young adults aged 18–29 ($n = 48$, $M = 24.56$, $SD = 2.84$), middle-aged adults aged 41–53 ($n = 48$, $M = 46.83$, $SD = 3.62$), and older adults aged 65–80 ($n = 48$, $M = 70.98$, $SD = 4.64$). Each age group included equal numbers of men and women, European Americans and African Americans, and blue- and white-collar workers, with occupational status determined on the basis of the U.S. census index of occupations. Both socioeconomic status and gender were stratified across age group and ethnicity.

Years of education did not vary significantly across young ($M = 15.04$, $SD = 2.19$), middle-aged ($M = 15.70$, $SD = 2.12$), and older ($M = 15.27$, $SD = 2.26$) adults. Age differences were found, however, on two measures of cognitive ability—the Vocabulary and Digit Symbols subtests of the Wechster Adult Intelligence Scale—Revised (WAIS–R). Consistent with the literature, each successively older age group scored lower on the fluid intelligence measure, that is, the Digit Symbol subtest, $F(2, 140) = 48.51$, $p < .001$, $MSE = 137.27$, $\eta^2 = .41$, minus 1 middle-aged participant whose score was missing for this test. Also consistent with previous research, middle-aged and older adults obtained significantly higher scores than younger age groups on the crystallized intelligence indicator, the Vocabulary subtest, $F(2, 141) = 6.11$, $p < .01$, $MSE = 126.52$, $\eta^2 = .08$. Means for the Vocabulary and Digit Symbol subtests, respectively, are presented here for the young ($M = 44.79$, $SD = 13.14$; $M = 63.02$, $SD = 12.78$), middle-aged ($M = 52.81$, $SD = 9.78$; $M = 52.09$, $SD = 9.32$), and older adults ($M = 48.58$, $SD = 10.54$; $M = 39.40$, $SD = 12.61$).

Only people who rated their physical health as about the same or better than other people their own age were invited to participate in the study. Those participating also completed the Wahler Health Symptoms Inventory (Wahler, 1973)—a self-report measure of the daily experience of physical distress, which entails asking people to report the frequency, ranging from *never* to *everyday*, of 42 different somatic symptoms. No differences among age groups were found on this measure, which is not surprising given that screening criteria selected for healthy populations, $F(2, 141) = 0.87$, $p = .42$, $MSE = 0.28$. Mean scores for each group were 0.79 ($SD = 0.51$), 0.84 ($SD = 0.59$), and 0.70 ($SD = 0.48$) for young, middle, and older age groups, respectively.

Experimental materials. Participants initially viewed 32 images, 16 neutral and 16 emotional (8 positive and 8 negative). Within each emotional valence group, half of the images consisted of scenes including people and half were pictures of animals, nature scenes, or inanimate objects. Twenty-seven images were selected from the International Affective Picture System (IAPS; Ito, Cacioppo, & Lang, 1998), a set of stimuli for which there are normative emotional valence ratings for each image, ranging from 1 (*the most negative*) to 9 (*the most positive*) on a Likert-type rating scale.

The IAPS emotion valence scores for each group (negative, positive, and neutral) differed significantly from each other, $F(2, 24) = 503.98$, $p < .01$, $MSE = 0.118$, $\eta^2 = .98$, with the valence of positive images averaging 7.76, neutral images 4.70, and negative images 2.32. The IAPS numbers, a brief title for the image, and their emotion valences are given in the Appendix for all images used in this study. Because the IAPS ratings are based predominantly on responses from college-aged men and women, all participants in the current study rated the emotionality of each image at the end of the study as negative, positive, or neutral to ensure that valence ratings were similar across age groups. All participants rated the images consistent with their assigned emotion category, (e.g., negative images were rated as negative), and there were no age differences in these ratings. IAPS images also include normative ratings for overall arousal, ranging from a low of 1 to a high of 9. The arousal level of negative ($M = 5.08$, $SD = 0.67$) and positive images ($M = 4.35$, $SD = 0.92$) did not vary significantly from each other, $t(14) = 1.83$, $p = .09$, but both were higher than the arousal scores for the neutral images from the IAPS ($M = 2.87$, $SD = 0.56$), $F(2,24) = 23.99$, $p < .001$, $MSE = 0.51$, $\eta^2 = .67$.

The IAPS lacked sufficient numbers of images that contained people but were neutral (i.e., had a rating that fell between 4 and 6 on the 9-point scale). For this reason, 5 additional images were included in the neutral/person category. Participants rated these images as neutral in their emotional valence. All images were chosen to be sufficiently different from each other in content so scorers could easily identify the images to which the participants were referring during the recall period. Thus, for example, no 2 images in this set of 32 were of the same animal or the same social situation.

Each of these 32 images had a novel partner similar in content, and when possible, matched on emotional valence that was used in the recognition task. Like the original images, the 32 matching, novel images were selected largely from the IAPS, with the exception of 5 neutral images that contained people.

Procedure. After the experimenter obtained informed consent, each participant sat in front of a 17-in. computer screen. Participants were told that they would be viewing a series of images on the computer screen, and to watch them as they would a television. Participants were shown 32 consecutive images, at 2-s intervals, in random order. Following this initial presentation, participants completed questions asking about their physical health and well-being and responded to questions testing their cognitive functioning. They also completed a demographic questionnaire.

After approximately 15 min dedicated to the questionnaires and cognitive tasks, participants were asked to write down a description of as many of the images as they could recall. They were told that a short and simple description was sufficient and not to dwell on details. After completing this task, they again sat in front of the computer screen and were asked to view 64 images, half of which had been viewed previously and half of which were novel. These images were presented in random order, and participants were asked to endorse whether the image presented was novel or had been presented previously by pressing either the *a* or *l* keys on the keyboard that represented either a "yes" response or a "no" response, with half of the participants using *a* for "yes" and *l* for "no," and the other half with the key meaning reversed. After responding with either a "yes" or "no," the next image would appear.

Results and Discussion

Both recall and corrected recognition scores were analyzed using a repeated measures general linear model with both between- and within-subjects factors. Emotional valence of the image (i.e., neutral, positive, or negative) was the within-subject factor, and age group (young, middle, or old) was the between-subjects factor. In analyses that included demographic information, socioeconomic status, gender, and ethnicity were included as additional between-subjects variables.

Recall. Two coders matched all of the written recall responses to the corresponding images. They agreed on 97.15% of the images; the coders then met and reached consensus over the discrepancies. Of the 144 participants, 49 people generated one or more responses that could not be matched to the stimuli, with the number of responses that could not be coded increasing with each successive age group, $F(2, 141) = 7.13$, $p < .001$, $MSE = 1.39$, $\eta^2 = .09$. People who generated responses that could not be matched to the stimuli included 9 younger adults ($M = 1.44$, CI $\pm$ 0.96), 15 middle-aged adults ($M = 1.60$, CI $\pm$ 0.73), and 25 older adults ($M = 2.20$, CI $\pm$ 0.58), yielding significantly different overall means for the amount of responses that could not be coded for the entire sample of younger, middle-aged, and older groups of 0.27, (CI $\pm$ 0.34), 0.50 (CI $\pm$ 0.34), and 1.15 (CI $\pm$ 0.34), respectively, $F(2, 141) = 7.13$, $p < .001$, $MSE = 1.39$, $\eta^2 = .09$.

Across all participants, an average of 11 images ($M = 11.01$, $SD = 4.63$) could be matched to actual images. Consistent with prior research showing age decrements for recall tasks, older adults recalled fewer images overall ($M = 7.52$, CI $\pm$ 0.99) compared with the middle-aged ($M = 13.00$, CI $\pm$ 1.07) and younger ($M = 12.50$, CI $\pm$ 1.35) groups. We hypothesized that older participants would recall relatively fewer negative than positive images. Positive, negative, and neutral images were examined using a 3 (emotional valence: positive, negative, or neutral) $\times$ 3 (age group: younger, middle, and older) repeated measures analysis of variance (ANOVA). Because there were twice as many neutral slides presented as positive and negative ones, we divided the number of neutral slides recalled in half for the purposes of comparing equal amounts of stimuli in the three emotion groups.

Results are illustrated in Figure 1. As predicted, results indicated a significant Emotional Valence $\times$ Age Group interaction, $F(4, 139) = 4.03$, $p < .001$, $MSE = 1.36$, $\eta^2 = .05$. Both middle-aged and older adults recalled a greater number of positive images compared with negative images. Younger adults recalled similar numbers of positive and negative images. All three age groups recalled significantly fewer neutral images compared with either positive or negative images.

Analyses also revealed an overall emotional valence effect, and post hoc comparison of the proportions and their 95% confidence intervals indicated that positive images were recalled in greater numbers ($M = 3.63$, CI $\pm$ 0.26) than negative images ($M = 3.08$, CI $\pm$ 0.21), which were recalled in greater numbers relative to neutral images ($M = 2.22$, CI $\pm$ 0.20), $F(2, 141) = 58.58$, $p < .001$, $MSE = 1.36$, $\eta^2 = .29$. This finding is most likely the result of an overall greater number of positive images recalled among the older adults. In addition, a between-subjects main effect for age

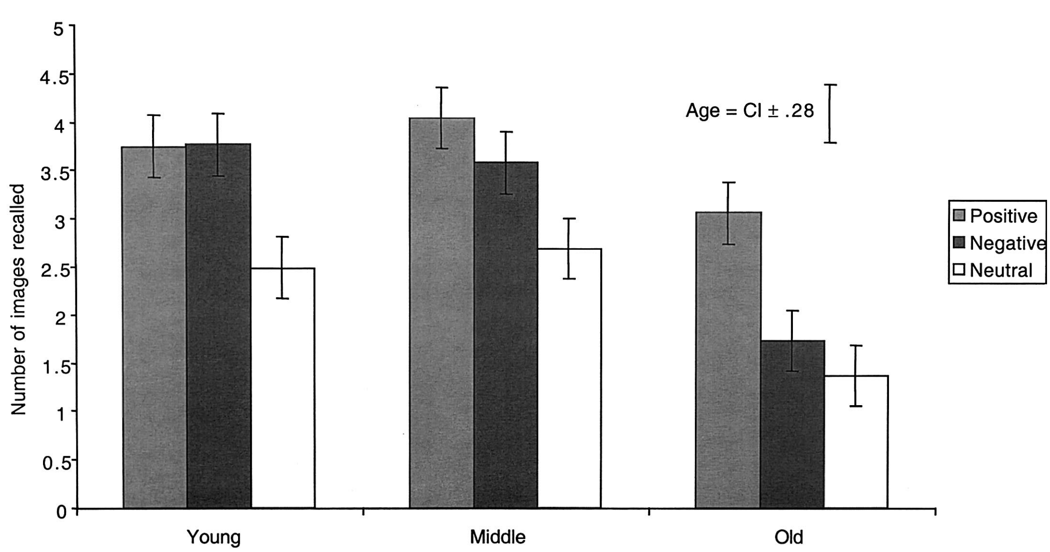

Figure 1. The average number of positive, negative, and neutral images recalled, with the confidence intervals (CIs) for the Age $\times$ Valence interaction (represented by the vertical lines) as well as the between-subjects factor (age), from Study 1.

Table 1
The Proportion of Hits and False Alarms for Three Age Groups From Study 1

Age group	Positive images $M \pm$ CI		Negative images $M \pm$ CI		Neutral images $M \pm$ CI	
	Hits	False alarms	Hits	False alarms	Hits	False alarms
Young adults (n = 48)	0.85 ± 0.04	0.03 ± 0.11	0.93 ± 0.03	0.02 ± 0.03	0.85 ± 0.04	0.02 ± 0.03
Middle-aged adults (n = 48)	0.94 ± 0.04	0.03 ± 0.11	0.93 ± 0.03	0.03 ± 0.03	0.90 ± 0.04	0.04 ± 0.03
Older adults (n = 48)	0.90 ± 0.04	0.09 ± 0.11	0.92 ± 0.03	0.11 ± 0.03	0.89 ± 0.04	0.09 ± 0.03

was significant, $F(2, 141) = 29.75$, $p < .001$, $MSE = 2.94$. Younger ($M = 10.01$, CI ± 0.84) and middle-aged adults ($M = 10.31$, CI ± 0.84) recalled an equal number of images, and more images than older adults ($M = 6.16$, CI ± 0.84).[1]

To examine this phenomenon across socioeconomic status, gender, and ethnicity, the analysis was rerun including these demographic variables as additional between-subjects variables. A modified Bonferroni significance test of .05/(number of tests − 1) was used to decrease the likelihood of a Type I error in these exploratory analyses; interactions had to reach this new criterion (p = .004) to be considered. The analysis revealed the same main effect for emotional valence, $F(2, 141) = 58.39$, $p < .001$, $MSE = 1.25$, $\eta^2 = .33$, and the hypothesized Age Group × Emotional Valence interaction effect found previously, $F(4, 139) = 4.11$, $p < .01$, $MSE = 1.25$, $\eta^2 = .06$. No other interactions reached significance.[2]

Recognition memory. Corrected recognition was calculated by subtracting the proportion of images the participant reported as viewed but were actually novel (false alarms) from the proportion of correctly identified previously viewed images (hits). Numbers of hits and false alarms for positive, negative, and neutral images by age group are presented in Table 1.

Response bias was calculated for the images using C (Macmillan & Creelman, 1991), where values of C above zero indicate a conservative bias (less willing to judge an item as having been previously seen) and values of C below zero indicate a liberal bias (more willing to judge as having been previously seen). Examining differences by valence and age group revealed a main effect for age, $F(2, 141) = 9.65$, $p < .001$, $MSE = 0.134$, $\eta^2 = .12$. Younger adults had a more conservative bias ($M = 0.19$, CI ± 0.06) than the middle-aged group ($M = 0.09$, CI ± 0.06), who had a more conservative bias than the older age group ($M = -0.002$, CI ± 0.06). Valence was also significant, $F(2, 141) = 15.08$, $p < .001$, $MSE = 0.04$, $\eta^2 = .10$, where people were more conservative for neutral images, ($M = 0.17$, CI ± 0.05) than for positive ($M = 0.08$, CI ± 0.05) or negative images ($M = 0.03$, CI ± 0.05). The interaction of age and valence was not significant, $F(4, 137) = 1.75$, $p = .14$, $MSE = 0.04$.

The hypothesis that the proportion of negative images recognized would decrease with age relative to positive and neutral ones was tested using a 3 (emotional valence: positive, negative, or neutral) × 3 (age group: young, middle, older) repeated measures ANOVA. An Emotional Valence × Age Group interaction was significant, $F(4, 137) = 3.03$, $p < .05$, $MSE = 0.013$, $\eta^2 = .04$, and post hoc comparison revealed that younger adults recognized a significantly greater proportion of negative images compared with positive and neutral images. Older and middle-aged adults, in contrast, recognized relatively equal proportions across emotional valence.

There were also two main effects. Emotional valence was significant, $F(2, 139) = 5.17$, $p < .01$, $MSE = 0.013$, $\eta^2 = .04$, as was a between-subjects effect of age, $F(2, 139) = 4.33$, $p < .05$, $MSE = 0.06$, $\eta^2 = .06$. Post hoc comparisons indicated that the proportion of correctly recognized negative images ($M = 0.87$, CI ± 0.03) was greater than either positive ($M = 0.84$, CI ± 0.03) or neutral ($M = 0.83$, CI ± 0.03) images. In addition, the overall recognition proportion for the middle-aged group ($M = 0.89$, CI ± 0.04) was greater than that of the younger ($M = 0.85$, CI ± 0.04) and older ($M = 0.81$, CI ± .04) age groups.[3] Figure 2

[1] The recall analyses were run with the entire sample, excluding uncodeable responses. In addition, we ran the analyses again excluding all people who reported any uncodeable responses (n = 95). The results were identical to those reported in the main text. The same Age × Valence interaction was significant, $F(4, 90) = 2.95$, $p < .03$, $MSE = 1.34$, $\eta^2 = .05$, as well as the main effects for age, $F(2, 92) = 9.92$, $p < .001$, $MSE = 2.37$, $\eta^2 = .18$, and valence, $F(2, 92) = 45.58$, $p < .001$, $MSE = 1.34$, $\eta^2 = .33$, in this subsample of 95 participants with only codeable data. In addition, we divided older adults into two groups on the basis of low and high recall performance, using a mean split. The pattern of results, where positive images were recalled to a greater degree than negative images, was consistent for both the lower performing older adults, $F(2, 22) = 19.12$, $p < .001$, $MSE = 0.87$, $\eta^2 = .44$, and the higher performing older adults, $F(2, 20) = 22.34$, $p < .001$, $MSE = 0.81$, $\eta^2 = .50$.

[2] African Americans and European Americans were included to examine generalizability of results across majority and minority groups. We did not predict group differences. No interactions that included race reached either the .01 level in the analyses of either the recall or recognition data. Thus, we are confident that using the more stringent modified Bonferroni criterion for significance did not inadvertently increase our probability for a Type II error when comparing these two groups. Had we not used the Bonferroni criterion, the only other interaction to reach significance would have been an emotional Valence × Gender × Socioeconomic Status interaction, $F(2, 141) = 5.47$, $p = .006$, $MSE = 1.36$, $\eta^2 = .04$. Women, regardless of socioeconomic status, were more likely to recall positive versus negative stimuli, whereas men were more likely to recall equal numbers of positive and negative stimuli. For blue-collar women, the number of negative images equaled that of neutral images recalled, whereas white-collar women recalled greater number of negative images compared with neutral images. For all other interactions, no F values exceeded 1.92, and no p values were less than .04.

[3] Alternative methods of calculating corrected recognition scores are A' and d'. Examining responses using A', the results are replicated with the same Age × Valence interaction, $F(2, 141) = 3.37$, $p < .01$, $MSE = 0.001$, $\eta^2 = .05$, in addition to the same main effects for age group, $F(2, 141) = 4.02$, $p < .05$, $MSE = 0.006$, $\eta^2 = .06$, and valence, $F(2, 141) = 3.35$, $p < .05$, $MSE = 0.001$, $\eta^2 = .02$. Using d', the main effects for age, $F(2, 141) = 3.40$, $p < .05$, $MSE = 0.68$, $\eta^2 = .05$, and valence, $F(2, 141) = 24.06$, $p < .001$, $MSE = 0.18$, $\eta^2 = .15$, were significant, and the Age × Valence interaction trended toward significance, $F(2, 139) = 2.20$, $p = .07$, $MSE = 0.18$, $\eta^2 = .03$.

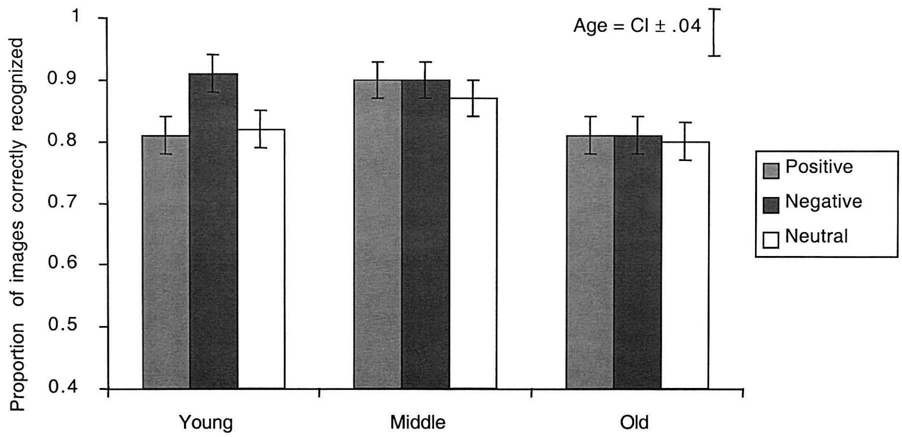

Figure 2. Proportion of correctly recognized positive, negative, and neutral slides, with the confidence intervals (CIs) for the Age × Valence interaction (represented by the vertical lines) as well as the between-subjects factor (age), from Study 1.

illustrates the corrected recognition of positive, negative, and neutral images for each age group.

To examine whether this finding was consistent across gender, ethnicity, and socioeconomic status, another ANOVA including these between-subjects variables was run using a modified Bonferroni significance level to test the additional interactions, as described previously. Results revealed the same hypothesized Age Group × Emotional Valence interaction, $F(4, 137) = 3.15$, $p < .05$, $MSE = 0.01$, $\eta^2 = .05$, but no other between-subjects differences, based on the conservative Bonferroni measure or even at a .01 level, were found; all F values were less than 2.80 and all p values were less than .06. In other words, findings are consistent across gender, ethnicity (European American and African American), and socioeconomic status (blue-collar vs. white-collar current or prior work history).

Summary of Findings From Study 1

Results from Study 1 provide support for the hypothesis that older, but not younger, adults display better memory for positive images than negative images. On the recall task, older adults and middle-aged adults recalled more positive images than negative images, whereas younger adults recalled almost equal amounts of positive and negative information. Memory for negative images decreased with age both in recall and recognition tasks, with both tasks displaying an Age × Valence interaction. Negative images were recalled less often than positive images by older adults, but not by younger adults, with middle-aged adults' performance falling in between. On the recognition task, younger participants correctly recognized a greater proportion of negative images compared with positive or neutral images whereas middle-aged and older participants performed similarly on the recognition task regardless of image valence.

Study 2

Socioemotional selectivity theory posits that age is related to an increased preference for emotionally meaningful experiences. This greater focus on emotional goals and emotion regulatory strategies may also influence memorial processes. Findings from Study 1 suggest that, with age, negative stimuli are recalled less often and correctly recognized to a lesser degree relative to positive stimuli. Of course, memory relies on attention, encoding, storage, and retrieval, any one of which could account for the observed pattern. In Study 2, we focused on attentional processes. There is some evidence that older adults proactively avoid negative experiences. Relative to their younger counterparts, older adults are more likely to avoid negative social interactions and seek emotionally gratifying contacts (Carstensen, Gross, & Fung, 1997). When shown two faces at the same time, older adults avoid negative faces in their initial attention (Mather & Carstensen, in press). Given findings from Study 1, we hypothesized that older people differentially attend to negative and positive images. To test this hypothesis, viewing time was self-paced in Study 2 so that age differences in attention to positive, negative, and neutral images could be examined.

According to our theoretical model, reduced cognitive focus on negative information contributes to superior emotional well-being in older people. Of course, the reverse is also plausible; namely, effective regulation results in greater affective well-being, which subsequently influences cognitive processing. Mood congruency is the phenomenon whereby people are more likely to remember material that was previously learned in the same mood that they are currently experiencing—that is, a sad person will be more likely to remember information pertaining to a sad event than a pleasant event. Similarly, a depressed person may more readily remember material that is sad than happy. Mood congruency in memorial processes has been established in studies of younger adults (see Bower, 1981). Extrapolating across the life span, older adults' generally more positive moods may influence valence differences in memory. To test this rival hypothesis, positive and negative affect as well as level of depressive symptoms were measured in participants in Study 2.

Method

Participants. Participants were recruited from newspaper advertisements, an on-line classified advertisement for the San Francisco Bay Area (www.craigslist.com), and fliers in the community soliciting participants between the ages of 18–28 and 65–85 for psychology experiments that investigate how people think or process information. Participants represented two age groups consisting of young people aged 19–30 ($n = 32$, $M = 23.53$, $SD = 3.14$) and older adults aged 63–86 ($n = 32$, $M = 74.06$, $SD = 6.55$). One third of the sample was African American and two thirds were European American, with ethnic composition equal across age groups ($n = 20$ for European Americans and $n = 12$ for African Americans per age group). The two age groups included equal numbers of men and women stratified by age and ethnicity and did not vary in education level (young: $M = 15.7$, $SD = 1.48$; old: $M = 15.7$, $SD = 2.47$). Older adults scored lower on the Digit Symbol subtest of the WAIS-R (young: $M = 17.59$, $SD = 4.20$; old: $M = 13.53$, $SD = 3.31$), $t(62) = 4.30$, $p < .001$, a finding consistent with the literature on fluid intelligence. For the Vocabulary subtest, scores for the younger ($M = 59.28$, $SD = 5.68$) and older adults ($M = 57.09$, $SD = 8.41$) did not significantly vary from one another, $t(62) = 1.22$, $p = .23$.

Similar to Study 1, only people who rated their health as about the same or better than other people their own age were invited to participate in the study. Younger and older adults did not differ significantly in their overall responses on the Wahler Health Symptoms Inventory (Wahler, 1973), $t(62) = 0.71$, $p = .48$, reflecting the screening criteria selected for healthy populations. Mean scores were 0.54 ($SD = 0.06$) and 0.61 ($SD = 0.42$) for younger and older age groups, respectively.

Experimental materials and procedures. Experimental materials and procedures differed slightly from Study 1. Similar to Study 1, stimuli consisted of images both with and without people from the IAPS coded as positive, negative, and neutral in emotional valence on the basis of their IAPS valence ratings. Unlike Study 1, where neutral images represented 50% of the stimuli, each valence in study 2 was equally represented. In addition, the number of images was increased to 52 in each emotion valence category, half of which were used in the initial presentation and half of which were used to contrast previously seen images from novel ones in the recognition task. Old and new items were counterbalanced.

Examining the IAPS scores for emotional valence, ranging from 1 to 9, indicate that emotional valence clearly distinguished negative images ($M = 2.32$, CI $\pm$ 0.12), neutral images ($M = 5.01$, CI $\pm$ 0.23), and positive images ($M = 7.60$, CI $\pm$ 0.12), $F(1, 154) = 1{,}973.27$, $p < .001$, $MSE = 0.18$, $\eta^2 = .98$. Arousal also varied by valence. For these slides, negative images had higher arousal ratings ($M = 5.84$, CI $\pm$ 0.28) than positive images ($M = 4.95$, CI $\pm$ 0.28), $t(103) = 4.85$, $p < .001$, and both were higher in arousal than neutral images ($M = 3.57$, CI $\pm$ 0.28), $F(2, 1153) = 63.95$, $p < .01$, $MSE = 1.07$, $\eta^2 = .46$.

The procedure, like Study 1, began with participants completing a consent form and then sitting before a 17-in. computer screen. Participants were told that they would be viewing a series of pictures on the computer screen, and to watch them as they would a television. They were told to press the *space bar* after they had seen each picture and another picture would appear. Participants were shown 78 consecutive images, in randomized order. Upon completion, participations spent approximately 15 min completing the same series of demographic, psychosocial, and cognitive questions described in Study 1.

Following these filler tasks, participants completed the recall and the recognition memory tasks. The only difference in the memory tests between Study 1 and Study 2 is that the presentation of the recall and recognition tasks was counterbalanced in this study within age group to control for any potential order effects. After completion of the memory tasks, participants completed two measures of affective well-being: The Center for Epidemiologic Studies–Depression Scale (CES-D), and the Positive and Negative Affect Schedule (PANAS). The CES-D measures levels of depressive symptoms with 20 questions, each ranging from 0 to 3, with a total score ranging from 0 to 60 (Radloff, 1977). A score of 16 is considered the cutoff score for depression (Radloff, 1977). This scale has been validated across age groups and across national samples (Gatz, Johansson, Pedersen, Berg, & Reynolds, 1993). The 20-item PANAS provides a score for both positive and negative affect by asking participants about their current feelings and having them respond to 10 positive and 10 negative adjectives on a scale ranging from 1 (*not at all*) to 5 (*very much*; Watson, Clark, & Tellegen, 1988). The total scores for positive and negative affect each can range from 10 to 50.

Results and Discussion

Negative and positive affect. Consistent with prior findings (e.g., Carstensen et al., 2000), older and younger adults differed in their negative mood state, as measured by the negative affect scale of the PANAS and as indicated by the CES-D. Younger adults ($M = 13.03$, CI $\pm$ 1.30) reported more negative mood than older adults on the negative affect score of the PANAS ($M = 11.09$, CI $\pm$ 1.30), $F(1, 62) = 4.40$, $p < .05$, $MSE = 13.64$, $\eta^2 = .07$, and scored significantly higher on the CES-D ($M = 8.44$, CI $\pm$ 1.50) than older adults ($M = 5.44$, CI $\pm$ 1.50), $F(1, 62) = 7.61$, $p < .01$, $MSE = 18.93$, $\eta^2 = .11$. Positive affect did not differentiate between younger ($M = 32.75$, CI $\pm$ 5.69) and older age groups ($M = 35.84$, CI $\pm$ 5.69), $t(62) = -1.55$, $p = .13$. Both the negative affect score of the PANAS and the CES-D scores were included in subsequent analyses to examine the relationship of mood on memory performance.

Attention. Viewing time was considered a measure of attention. Means are presented in Table 2. A main effect of valence, $F(2, 61) = 20.35$, $p < .001$, $MSE = 855{,}109.00$, $\eta^2 = .25$, indicates that all participants spent a longer time viewing the negative images than the neutral or positive images. As indicated in Table 2, the median time for older adults is higher than that for younger adults, but both show wide variation in responses, and the main effect for age fell short of statistical significance, $F(2, 61) = 2.98$, $p = .09$, $MSE = 65{,}304{,}687.70$, $\eta^2 = .05$.

Recall. Two coders matched all recall responses to actual images, with the percent of agreement at 87.15%. Afterwards, the coders met and reached consensus on all discrepancies. Of the 64 respondents, 5 younger adults and 9 older adults had responses that could not be matched to images because they were too vague (e.g.,

Table 2
The Medians for the Time Viewing the Images (in Milliseconds) for Participants in Study 2

Age group	Median attention		
	Positive images Median ± CI	Negative images Median ± CI	Neutral images Median ± CI
Young adults ($n = 32$)	2,461.70 ± 1,786.50	3,056.70 ± 1,793.77	2,397.69 ± 1,199.67
Older adults ($n = 32$)	4,399.80 ± 1,786.50	5,422.73 ± 1,793.77	4,132.66 ± 1,199.67

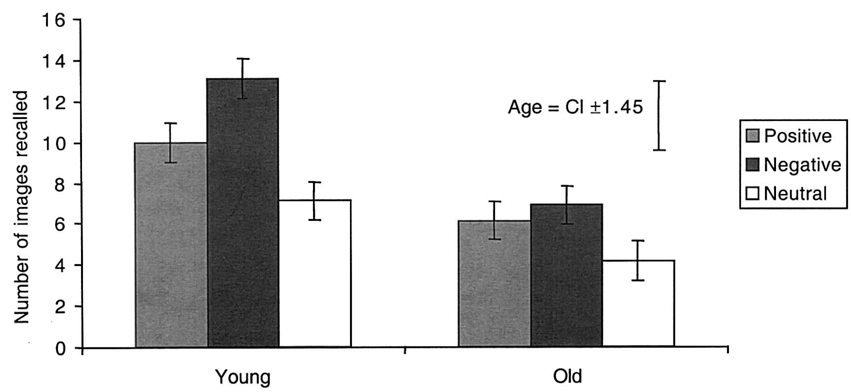

Figure 3. The average number of slides recalled that were positive, negative, and neutral, with the confidence intervals (CIs) for the Age × Valence interaction (represented by the vertical lines) as well as the between-subjects factor (age), from Study 2.

a home) or were not like any of the options (e.g., scissors). Means for the number of responses that could not be coded for only those people who reported any uncodeable response were similar for younger ($M = 1.00$, CI ± 0.56) and older adults ($M = 1.33$, CI ± 0.42), yielding overall means not significantly different between younger and older adults of 0.15 (CI ± 0.20) and 0.38 (CI ± .20), respectively, $F(2, 61) = 2.41$, $p = .13$, $MSE = 0.32$, $\eta^2 = .02$. Across all participants, younger adults recalled a greater number of codeable responses ($M = 30.19$, CI ± 4.30) than older adults ($M = 17.19$, CI ± 4.30), $t(62) = 4.28$, $p < .01$. The number of images recalled for each age group is higher compared with the number recalled in Study 2, most likely as a result of the self-paced nature of viewing these slides, as well as the fact that half of the participants in Study 2 viewed the images in the recognition task immediately prior to recalling them. People who engaged in the recognition task first recalled on average 28 images ($M = 28.25$, $SD = 14.41$) and those who engaged in the recall task first reported around 19 images ($M = 19.39$, $SD = 11.71$).

We hypothesized that older participants would recall fewer negative images relative to positive or neutral images than younger participants. A 2 (age group: younger and older) × 3 (emotional valence: positive, negative, or neutral) repeated measures ANOVA revealed the predicted Emotional Valence × Age Group interaction, $F(2, 61) = 6.19$, $p < .001$, $MSE = 7.16$, $\eta^2 = .09$. Results are illustrated in Figure 3. Younger adults recalled more negative images ($M = 13.09$, CI ± 1.94) than positive images ($M = 9.97$, CI ± 1.60) and fewest neutral images ($M = 7.13$, CI ± 1.31). Older adults, in contrast, recalled a similar number of negative ($M = 6.91$, CI ± 1.94) and positive images ($M = 6.13$, CI ± 1.60), but fewer neutral images ($M = 4.16$, CI ± 1.31).

The analysis also revealed a main effect by valence, $F(2, 61) = 42.60$, $p < .001$, $MSE = 7.16$, $\eta^2 = .41$, driven by younger adults' superior memory for negative images. Comparisons of means and 95% confidence intervals revealed that negative images ($M = 10.00$, CI ± 1.35) were more likely to be recalled than positive images ($M = 8.05$, CI ± 1.13), which were in turn more likely to be recalled than neutral images ($M = 5.64$, CI ± .93).

In addition, a between-subjects analysis revealed a main effect for age, $F(1, 62) = 18.29$, $p < .001$, $MSE = 49.28$, $\eta^2 = .23$; younger adults recalled more images ($M = 30.19$, CI ± 4.30) than did older adults ($M = 17.19$, CI ± 4.30). Including the additional between-subjects ethnicity and gender variables resulted in the same main and interaction effects mentioned above and no additional significant results. The ordering of recall, either administered as the first or second memory task, was included as an additional between-subjects variable, yielding a main effect for ordering, $F(1, 62) = 8.72$, $p < .01$, $MSE = 43.67$, $\eta^2 = .13$, such that when the recall task was administered after the recognition task, both younger and older adults recalled more items of each valence ($M = 9.33$, CI ± 1.30) compared with when recall was administered before the recognition task ($M = 6.51$, CI ± 1.30). The differences between the ordering of these tasks, however, did not influence the Age × Valence interaction, as the three-way interaction between recall, valence, and age was not significant, $F(2, 61) = 0.48$, $p = .62$, $MSE = 7.28$, $\eta^2 = .008$.

Because this pattern of results varied from the recall results from Study 1, we also examined the effects of two factors that differed from Study 1: differences in arousal by valence and the time spent examining each image. We found that although increased arousal and viewing time were both related to an increased probability of recalling an image, neither arousal level or viewing time altered the Age × Valence interaction patterns.[4] Findings from Study 2 suggest that younger adults recall more negative images than other types of images and that older adults recall negative and positive images equally well. To examine whether the greater negative

[4] To examine the probability of recalling each image as a function of its arousal level and the time spent examining each image, we used hierarchical linear analyses. The Level 1 variables were the probability of recalling each image as the outcome variable, and time spent initially viewing the image and both Lang's (Ito et al., 1998) arousal rating and valence rating of the image as the predictor variables. Level 2 variables included age group and other demographic factors. Results revealed significant effects, in that both time spent examining the image ($b = .0001$, $SE = .00002$), $t(4923) = 4.09$, $p < .001$, and arousal level, ($b = .0001$, $SE = .003$), $t(4923) = 2.70$, $p < .01$, were related to increased probability of recalling an image, but the Age × Valence interaction remained ($b = .0002$, $SE = .0001$), $t(4923) = 2.70$, $p < .01$, and the pattern of this interaction was identical to that found using the repeated measures general linear model. For ease of interpretation, we report the findings of the repeated measures analyses in the text.

Table 3
The Proportion of Hits and False Alarms for the Images for Participants in Study 2

	Positive images $M \pm$ CI		Negative images $M \pm$ CI		Neutral images $M \pm$ CI	
Age group	Hits	False alarms	Hits	False alarms	Hits	False alarms
Young adults (n = 32)	0.83 ± 0.06	0.06 ± 0.03	0.91 ± 0.05	0.04 ± 0.03	0.80 ± 0.07	0.07 ± 0.02
Older adults (n = 32)	0.79 ± 0.06	0.08 ± 0.03	0.85 ± 0.05	0.08 ± 0.03	0.79 ± 0.07	0.06 ± 0.02

affect and depressive symptoms reported by younger adults accounted for the findings, the analyses were run again using both negative affect (from the PANAS) and depressive symptoms (from the CES-D) as covariates. Again, the Age × Valence interaction was significant, $F(1, 62) = 4.27$, $p < .05$, $MSE = 6.77$, $\eta^2 = .07$, and the main effect for age was likewise significant, $F(1, 62) = 18.94$, $p < .001$, $MSE = 6.77$, $\eta^2 = .24$.[5] After the addition of ethnicity and gender, the Valence × Age interaction remained significant, $F(1, 62) = 4.23$, $p < .05$, $MSE = 6.74$, $\eta^2 = .07$, but no interactions with ethnicity or gender were significant with a modified Bonferonni alpha level of $p < .008$. All F values were less than 3.41 and all p values were greater than .04.

In follow-up analyses, correlations examining the association between recall performance and negative affect revealed a mood congruency effect for the entire sample. For all participants, although depressive symptoms were not related to greater reports of images of any valence, the current level of negative affect was positively correlated with the recall of negative images ($r = .34$, $p < .01$) but not neutral ($r = .13$) or positive images ($r = .12$). Of importance, however, the previous analyses indicated that mood congruency effects were not responsible for the Age × Valence interactions.

Recognition memory. Corrected recognition was calculated using the same procedure described in Study 1, namely subtracting the proportion of false alarms from the proportion of hits. Hits and false alarms, reported by age group and valence, are reported in Table 3. In addition, we examined age differences in response bias (C) for the recognition of images of each type of valence, and found a main effect for valence, $F(2, 61) = 7.92$, $p < .001$, $MSE = 0.06$, $\eta^2 = .11$. Participants, regardless of age, had a more conservative bias for positive images ($M = 0.28$, CI ± 0.09) and neutral images ($M = 0.29$, CI ± 0.09) compared with negative images ($M = 0.14$, CI ± 0.09). The between-subjects factor of age and the Age × Valence interaction were not significant, with F values not greater than 0.35 and p values not less than .71.

A 2 (age group: young, old) × 3 (emotional valence: positive, negative, or neutral) repeated measures ANOVA revealed a significant Valence × Age Group interaction, $F(2, 61) = 4.25$, $p < .05$, $MSE = 0.009$, $\eta^2 = .06$. Younger adults recognized a significantly greater proportion of negative images ($M = 0.86$, CI ± .07) compared with positive ($M = 0.76$, CI ± .08) and neutral images ($M = 0.73$, CI ± 0.08). Older adults, in contrast, correctly recognized relatively equal proportions across negative ($M = 0.76$ CI ± 0.07), positive ($M = 0.71$, CI ± 0.08), and neutral ($M = 0.73$, CI ± 0.08) images. Between groups, younger and older adults recognized a similar proportion of positive and neutral images, but younger adults recognized a greater proportion of negative images (see Figure 4).

A main effect for valence was also significant, $F(2, 61) = 16.20$, $p < .001$, $MSE = 0.009$, $\eta^2 = .21$. Negative images ($M = 0.81$, CI ± 0.05) were correctly recognized in greater proportion relative to positive ($M = 0.74$, CI ± 0.07) and neutral ($M = 0.73$, CI ± 0.08) images, most likely driven by the superior performance for negative stimuli among younger adults. Including a between-subjects variable indicating ordering effects—whether recall or recognition was administered first—was not significant, suggesting that recognition did not benefit, or suffer, from the prior administration of recall compared with no previous recall task.

An analysis including negative affect and depressive symptoms as covariates again revealed the significant Age × Valence interaction, $F(2, 61) = 3.23$, $p < .05$, $MSE = 0.11$, $\eta^2 = .05$. Unlike in the recall task, negative affect was not related to a greater tendency to remember negative images ($r = .01$, *ns*). Analyses including ethnicity and gender again revealed the Age × Valence interaction, $F(2, 61) = 3.35$, $p < .05$, $MSE = 0.008$, $\eta^2 = .06$. No interactions were significant using a modified Bonferonni alpha ($p < .008$) as the criterion.[6]

Summary of Findings From Study 2

Study 2 confirmed an Age × Valence interaction effect, and the consistent results for both the recall and recognition task indicate that an age-related decrease in memory for negative stimuli is

[5] The recall data from Study 2 were examined for all participants, excluding all uncodeable responses, and again for those who offered no uncodeable responses ($n = 50$). The Age × Valence interaction, $F(2, 47) = 4.47$, $p < .01$, $MSE = 7.14$, $\eta^2 = .09$, and the main effect for valence, $F(2, 47) = 28.28$, $p < .001$, $MSE = 7.14$, $\eta^2 = .37$, and age, $F(1, 48) = 25.07$, $p < .001$, $MSE = 43.98$, $\eta^2 = .34$, remained. Similar to Study 1, we divided older adults into two groups on the basis of low and high recall performance, using a mean split. The pattern of results, where both positive and negative images were recalled significantly better than neutral, was consistent for both the lower scoring older adults, $F(2, 17) = 7.31$, $p < .01$, $MSE = 2.36$, $\eta^2 = .30$, as well as the higher scoring older adults, $F(2, 11) = 28.28$, $p < .001$, $MSE = 5.90$, $\eta^2 = .44$.

[6] In addition to corrected recognition, recognition accuracy was also measured using A' and d'. Analyses with A' revealed a main effect for valence, $F(2, 61) = 10.11$, $p < .001$, $MSE = 0.001$, $\eta^2 = .14$, and the Age × Valence interaction trended toward significance, $F(2, 61) = 2.87$, $p = .06$, $MSE = 0.001$, $\eta^2 = .04$. The between-subjects effect of age was not significant, $F(1, 62) = 1.41$, $p = .24$. Results using d' revealed a main effect for valence, $F(2, 61) = 14.55$, $p < .001$, $MSE = 0.22$, $\eta^2 = .19$, and the same Age × Valence interaction as found in the analyses using corrected recognition, $F(2, 61) = 5.24$, $p < .01$, $MSE = 0.22$, $\eta^2 = .08$. The between-subjects factor of age was not significant, $F(1, 62) = 0.60$, $p = .44$.

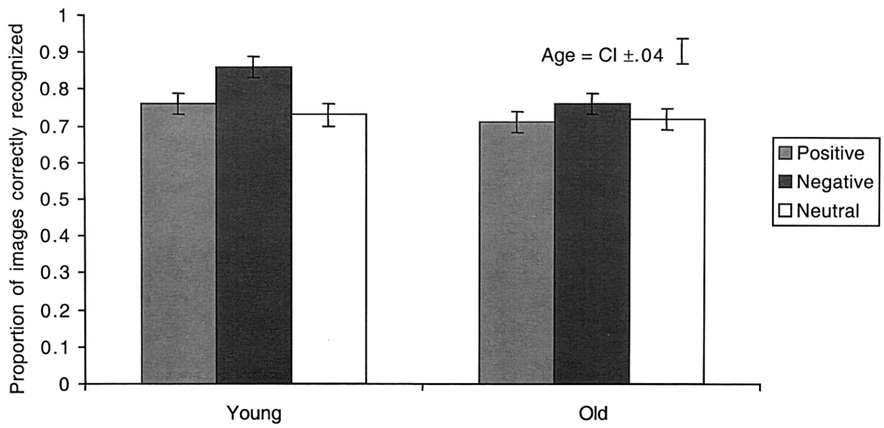

Figure 4. Proportion of correctly recognized positive, negative, and neutral slides, with the confidence intervals (CIs) for the Age × Valence interaction (represented by the vertical lines) as well as the between-subjects factor (age), from Study 2.

responsible for this interaction. Younger adults showed superior memory for negative images relative to positive or neutral images on both recall and recognition memory tasks, whereas older adults recalled and recognized positive and negative images equally well.

In Study 2, we had hypothesized that older adults, compared with younger adults, would spend less time viewing the negative images than positive images. This hypothesis was not supported. Both younger and older adults spent more time viewing negative images. In contrast, a previous study looking at aging and attentional biases using the dot probe paradigm (MacLeod, Mathews, & Tata, 1986) found that, when briefly presented with two faces on a computer screen and then shown a dot on one side or the other of the screen, older adults were faster to indicate which side of the screen the dot was on when it appeared behind a neutral face than behind a sad or angry face whereas younger adults did not show any attentional biases (Mather & Carstensen, in press). These results suggest that when presented with stimuli competing for attention, older adults avoid attending to negative information. In the current study, however, the images were presented one at a time and participants were instructed to look at them. Thus, biases guiding initial attention should not have played as much of a role. Instead, looking time presumably reflected the amount of sustained attention devoted to each image.

The fact that both younger and older adults spent more time viewing negative images than other types of images suggests that the amount of sustained attention (as measured by viewing time) cannot explain age differences in memory by valence. It is possible, however, that viewing time failed to capture a difference in the way in which images were processed across age groups. For example, when older adults see negative images, they might focus more on the surface details and make fewer personal connections than when they see positive images. Further studies are necessary to see how much of a role differential encoding processes play in older adults' diminished memory for negative material. However, our initial finding that older adults (like younger adults) looked at negative images longer than positive or neutral images yet failed to show a memory benefit indicate that the amount of time spent attending to an image cannot account for age differences in the valenced patterns observed.

In addition, the reduced performance of negative stimuli among older adults relative to younger adults was not accounted for by mood congruency. Even though younger adults reported greater negative affect and a higher level of depressive symptoms compared with older adults, controlling for these differences did not change the pattern of results. Consistent with prior studies of the effect of mood congruency, however, all participants who reported higher levels of negative affect recalled more negative images. In addition, mood congruency was not evident for the recognition task, consistent with prior findings where mood has a larger impact on effortful processing compared with more automated processes (e.g., Eich, 1995).

General Discussion

Socioemotional selectivity theory posits that with age, goals shift such that motivational emphasis is placed increasingly on emotion regulation. A considerable literature demonstrates that there are, indeed, age differences in goals, and these differences are consistent with those posited by the theory (Lang & Carstensen, 2002; Staudinger, Freund, Linden, & Maas, 1999). Far less attention has been paid, however, to the implications of goal changes for cognitive processing. In the current study, we postulated that the increased emphasis on emotion regulation associated with deriving emotional meaning from life would result in decreased performance for negative material. That is, because memory is a process influenced by motivational goals, we expected that when presented with images that vary in valence (neutral, negative and positive), memory for positive and negative stimuli will differ as a function of age. The sample, by design, included people of different age groups, racial minority and majority members, men and women, and blue and white collar workers to provide a stringent test of the hypotheses in a diverse sample. Because the governing mechanism in socioemotional selectivity theory is the perception of time—a human universal—age differences should occur regardless of sex, race, or socioeconomic status. In all of our analyses, they did. Below we briefly recapitulate our aims and discuss the profile of findings we obtained in light of the broader literature.

Age Differences in Recall and Recognition by Emotional Valence

We were interested in both recall and recognition tasks, and we examined age differences for these tasks in two studies. Findings from Studies 1 and 2 documented age differences in memory by valence. Across studies, findings from recall and recognition tasks point to a shift in memory performance such that relatively less negative than positive information is recalled with age. Enhanced memory for negative images compared with positive images among younger adults was consistent in the recognition tasks of both Study 1 and Study 2. Older adults (in Studies 1 and 2) showed comparable memory for positive and negative material, but younger adults recognized a greater proportion of negative images. Age-associated reductions in memory for negative images complement and are consistent with findings from other studies of emotion and aging that indicate reductions in the duration and frequency of negative emotions in older age groups (Carstensen et al., 2000) and in the reduction of negative expressions in social interactions (Carstensen, Gottman, & Levenson, 1995). Indeed, both of the current studies support this Age × Valence interaction, with the consistent findings from Study 2 suggesting that this interaction is driven by age differences for negative stimuli.

Developmental tasks of youth often focus on learning information about the world and establishing relationships that will continue for years. Learning and knowing which negative aspects should be avoided, or pushing to resolve negative conflict in relationships, may have special significance for adaptation in early life. Once learned, however, this focus may not be as necessary later in life, when time left in life is more limited. Perhaps, for the first time, negative information that is not so central to everyday functioning, or that requires less immediate action, is deemed less important, or processed less efficiently, so that energy reserves can be spent elsewhere. Combined with subjective reports of increased control over emotions (Gross et al., 1997; Lawton et al., 1992), the emerging profile of findings suggests that older adults, compared with younger adults, are regulating their emotions effectively in ways that reduce the impact of negatively valenced experiences.

The recall tasks of Study 1 and Study 2 both revealed Age × Valence interactions in which there was a shift in what was most likely to be remembered. In both studies, older adults' recall included less negative relative to positive information than younger adults' recall. However, this interaction took a different form in the two studies. In Study 1, middle-aged and older adults recalled a greater proportion of positive images compared with negative or neutral images whereas younger adults did not recall greater numbers of positive images. In Study 2, older adults recalled an equal number of positive and negative stimuli whereas younger adults recalled more negative than positive images. This pattern occurred for both recall and recognition in Study 2, and was also present in the recognition task in Study 1, suggesting that relative age-related decreases for negative information, relative to positive information, is consistent and capable of replication. These findings suggest that changes in memory for negative material, more than changes in memory for positive material, is responsible for the hypothesized Age × Valence interaction pattern.

In the second recall task, the task was self-paced, and we hypothesized that older adults would spend less time examining negative images compared with positive or neutral images, and that this time difference would lead to even greater performance of positive images over negative images among older adults than what we had found in the first recall task. Of interest, this was not the case. When self-paced, both older and younger adults spent the most time examining negative stimuli. However, even with the advantage of spending more time looking at the negative images compared with positive or neutral images, older adults' memory performance did not benefit, whereas the performance of younger adults did. One possible explanation is that older adults did not process them as deeply as younger adults. Findings from a recent study by our research team suggest that this may be the case (Mather et al., 2002). Amygdala activation distinguished older and younger adults when viewing emotional images. Younger adults showed relatively more activation to negative images than older adults whereas older adults showed as much activation in response to positive images as younger adults. Thus, an intriguing possibility, implicating encoding, is beginning to emerge. Additional research will be needed to precisely isolate the mechanisms underlying age differences in emotion memory.

Alternative Explanations

This study was guided by the socioemotional selectivity theory, which maintains that perceived time left in life motivates changes in memory for positive and negative information. The studies reported herein do not offer direct evidence that time perception is driving the Age × Valence interaction, leaving open the possibility that other mechanisms contribute to, or account for, the findings. However, the pattern of findings is consistent with prior studies that have experimentally manipulated time perspective and obtained motivational changes posited in the present studies. Still, alternative explanations are possible. Experience, for example, may influence performances because older adults have had a longer time in which to practice emotion regulation skills, and this greater experience may lead to reductions in memory for negative, as opposed to positive, material. Older adults also may learn, over time, to process emotional information in more complex, and perhaps less negative, frameworks. Or, older cohorts may have been socialized to remember less negative, relative to positive, information. These current studies cannot rule out these other possibilities.

In addition, researchers have also discussed physiological changes as responsible for differences in the processing of information of different valences. Age differences in memory for material of different valences—specifically, increased performance for emotional material over neutral material—are often considered the result of cognitive decline. Hasher and Zacks (1988) have outlined how failures of executive functioning may lead to age-related increases in reports of emotional detail at the expense of other information. Inhibition failures thus permit task-irrelevant material, that is, emotional material, to receive more sustained activation than it would otherwise, resulting in heightened distractibility, increased forgetfulness, and longer response latencies (Hasher & Zacks, 1988; Stoltzfus, Hasher, Zacks, Ulivi, & Goldstein, 1993). Hashtroudi et al. (1990) raised the interesting possibility that older adults' relatively good recall for thoughts and feelings may, in fact, represent failures of inhibitory mechanisms to ignore this less important material. Consistent with this idea, when younger adults are told to focus on their emotions, their performance more closely resembles that of older adults (Mather & Johnson, 2000, in press). The models of inhibitory decline, however, speak to general increases in emotional material compared with neutral material, and not to differences that promote emotion regulation. A motivational view does not reject age differences in overall memory performance—and indeed recall performance decreased by age—but instead proposes that younger and older adults vary in the type of information that is most relevant to them.

Proponents who maintain that cognitive decline influences memory for material of different affective valence have turned to studies comparing older adults with dementing conditions to healthy same-aged controls (Hamann, Monarch, & Goldstein, 2002; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002). Findings are mixed, as one study found that older adults with Alzheimer's disease showed no bias for emotional material (Kensinger, Brierley, Medford, Growdon, & Corkin, 2002) and another study found that people with Alzheimer's disease had enhanced performance for positive stimuli, but not negative stimuli (Hamann et al., 2002). In both Studies 1 and 2, older adults with lower recall scores showed the same pattern of results compared with older adults with higher recall scores, suggesting that our findings were not driven by a subset of older adults who had the poorest memory overall.

A second potential explanation for this Age × Valence interaction is that differences in arousal between positive and negative stimuli may be influencing these findings. The principle of negative potency states that given positive and negative stimuli of equal objective magnitude, negative emotion is more potent (Rozin & Royzman, 2001). The principle of the negativity bias is that "negative events are more salient, potent, [and] dominant . . . than positive events" (Rozin & Royzman, 2001, p. 297), and people react more strongly to negative than to positive stimuli (see review by Cacioppo & Gardner, 1999). At least for younger adults, negative events elicit greater event-related potentials in physiological studies compared with positive events, and this response increases relative to the negativity of the stimuli (Carretie, Mercado, Tapia, & Hinojosa, 2001). Nonnegative stimuli of similar arousal do not elicit this same physiological response (see review by Cacioppo & Gardner, 1999). Negative emotions create greater differences in physiological functioning, and thus it is difficult to parse apart arousal from emotional valence. Nonetheless, the results in Study 1, when arousal was relatively equal between positive and negative images, were very similar to those in Study 2, suggesting that mechanisms other than arousal are responsible for these findings. In addition, further analyses using hierarchical linear modeling revealed that differences in arousal were not responsible for the Age × Valence interaction.

Perhaps the most obvious alternative explanation for our findings is mood congruency. As we have described, younger adults report greater negative affect than older adults (e.g., Carstensen et al., 2000; Charles et al., 2001). They may, therefore, recall a greater number of negative stimuli simply as a result of mood congruency. Study 2, however, found that although negative affect was related to the recall of negative stimuli, this hypothesis failed to explain the age differences in the study. Even after taking mood into account, older adults still recognized and recalled a lower proportion of negative images relative to positive images. Thus mood congruency cannot account for our findings.

We contend that motivational shifts in which greater emphasis is placed on emotion regulation is responsible for findings of the current studies. Findings suggesting less emphasis on negative information relative to positive information in older age groups were replicated in Study 1 and Study 2. When mood congruency, arousal level of each image, and time spent viewing each image were examined as potential mechanisms, the Age × Valence interaction remained.

Limitations and Conclusions

This study focused on high functioning adults, and thus these findings are limited to very healthy populations of younger and older adults. We chose to focus on healthy adults, however, because our main research focus centered around age-related processes and not processes that are related to poor health. In addition, this study did not test older adults for cognitive deficits that may also impact these findings. Future studies that control for health and cognitive status for people of all ages, including healthy and chronically ill young, middle-aged, and older adults, may extend these findings.

Of course, many other questions remain. We only examined our questions using incidental memory tasks, and it is unclear whether the results would be similar if intentional coding tasks were used instead. Future studies will need to address the question of Age × Valence interactions using both types of paradigms. In addition, the present study did not examine differences in memory for positive and negative emotional information necessary for everyday functioning. Rather, we examined memory for emotional images, content similar to what someone may see on the television, read about in the newspaper, or hear about during a casual conversation. Thus, in a safe, experimental environment, negative information may be especially irrelevant to older people. Age differences in memory for negative information explicitly tied to a future decision, for example, may yield different results. In addition, longitudinal studies are needed to parse developmental processes from cohort effects, and additional research is needed to elucidate age differences in the attention, storage, and retrieval processes involved in the memorial sequence for information of different emotional valence. Age differences may be evident in many of these processes. Indeed, if—as socioemotional selectivity theory suggests—the regulation of emotion increases in importance with age, more cognitive resources may be invested in memory for emotionally gratifying information than neutral information, in a manner that reduces performance for negative information.

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(*Appendix follows*)

Appendix

The Title, IAPS Numbers, and IAPS Valence Score for All Slides Used in Study 1, Including the Ones Presented Originally and the Matching Slides Used in the Recognition Task

Slides presented originally			New slides presented during the recognition task		
Title	IAPS no.	*M*	Title	IAPS no.	*M*
Positive—people					
1. Older man with children	2340	8.03 (1.26)	1. Boy with grandpa	2391	7.11 (1.77)
2. Men wearing tuxedos	2370	7.14 (1.46)	2. Couple	4640	7.18 (1.97)
3. Child and seagulls at sunset	5831	7.63 (1.15)	3. People with sunset	5830	8.00 (1.48)
4. Family	2360	7.70 (1.76)	4. Three kids	2341	7.38 (1.59)
Positive—no people					
1. Sunflower	5001	7.16 (1.56)	1. Flowers	5200	7.36 (1.52)
2. Puppies	1710	8.34 (1.12)	2. Seal	1440	8.19 (1.53)
3. Bunnies	1750	8.28 (1.07)	3. Rabbit	1610	7.82 (1.34)
4. Fireworks	5910	7.80 (1.23)	4. Active volcano	5920	5.16 (1.92)
Negative—people					
1. Couple in the hospital	2205	1.95 (1.58)	1. Hospital scene	3220	2.49 (1.29)
2. Couple in cemetery	9220	2.06 (1.54)	2. Cemetery	9000	2.55 (1.55)
3. Plane crash	9050	2.43 (1.61)	3. Plane crash	9611	2.71 (1.95)
4. Person with gun	6560	2.16 (1.41)	4. Gun to head	6570	2.19 (1.72)
Negative—no people					
1. Pizza and cockroaches	7480	2.46 (1.42)	1. Pie with flies	7360	3.59 (1.95)
2. Duck in oil	9560	2.12 (1.93)	2. Gannet	1450	6.37 (1.62)
3. Bomb	9630	2.96 (1.76)	3. Jet	9622	3.10 (1.90)
4. Garbage	9340	2.41 (1.48)	4. Garbage	9290	2.88 (1.52)
Neutral—people					
1. Male twins wearing red	2890	4.95 (1.09)	1. Lady in red	2830	4.73 (1.60)
2. Workers with trash	9700	4.77 (1.24)	2. Boy with helicopter	9411	4.63 (1.58)
3. Runner	8010	4.38 (1.86)	3. Rock climber	8160	5.07 (1.97)
4. Shop selling sundries	—	—	4. Clothes market	—	—
5. People sitting in a bar	—	—	5. People on the boardwalk	—	—
6. People with scuba gear	—	—	6. Scuba divers	—	—
7. Waiting for fast food	—	—	7. A crowd of people	—	—
8. Farmers working in field	—	—	8. Loggers working	—	—
Neutral—no people					
1. Trash can	7060	4.43 (1.16)	1. Kleenex box	7950	4.94 (1.21)
2. Bowl	7006	4.88 (0.99)	2. Mug	7009	4.93 (1.00)
3. Fire hydrant	7100	5.24 (1.20)	3. Bed	7710	5.42 (1.58)
4. Stool	7025	4.63 (1.17)	4. Door with light	7180	4.73 (1.31)
5. File cabinets	7224	4.45 (1.36)	5. Messy office	7700	4.25 (1.45)
6. Umbrella	7150	4.72 (1.00)	6. Chair	7235	4.96 (1.18)
7. Truck	7130	4.77 (1.03)	7. Lamp	7175	4.87 (1.00)
8. Shoes	7031	4.52 (1.11)	8. Rolling Pin	7000	5.00 (0.84)

Note. Slides that do not have an IAPS number and ratings are not from the IAPS. Standard deviations are shown in parentheses. IAPS = International Affective Picture System.

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