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Aging and Goal-Directed Emotional Attention: Distraction Reverses Emotional Biases

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Previous findings reveal that older adults favor positive over negative stimuli in both memory and attention (for a review, see Mather & Carstensen, 2005). This study used eye tracking to investigate the role of cognitive control in older adults' selective visual attention. Younger and older adults viewed emotional-neutral and emotional-emotional pairs of faces and pictures while their gaze patterns were recorded under full or divided attention conditions. Replicating previous eye-tracking findings, older adults allocated less of their visual attention to negative stimuli in negative-neutral stimulus pairings in the full attention condition than younger adults did. However, as predicted by a cognitive-control-based account of the positivity effect in older adults' information processing tendencies (Mather & Knight, 2005), older adults' tendency to avoid negative stimuli was reversed in the divided attention condition. Compared with younger adults, older adults' limited attentional resources were more likely to be drawn to negative stimuli when they were distracted. These findings indicate that emotional goals can have unintended consequences when cognitive control mechanisms are not fully available.

Keywords: aging, cognitive control, emotion, eye tracking

Many aspects of cognitive performance show a downward trajectory across the life span (Craik & Salthouse, 2000; Hedden & Gabrieli, 2004). In contrast, affective experience and regulation tend to remain stable and even show small to moderate gains with increasing age (for reviews, see Charles & Carstensen, 2004; Mather, 2004). Research examining everyday emotional experience in both cross-sectional and longitudinal designs has shown that the frequency of negative emotions decreases and the frequency of positive emotions remains stable or even increases slightly with age (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001; Mroczek, 2001). In addition, emotion regulation and everyday problem solving involving emotional and interpersonal features show stability and modest gains across the life span (for reviews, see Blanchard-Fields, 2007; Carstensen & Mikels, 2005).

A growing body of evidence suggests that increases in the effective use of emotion regulation strategies are associated with changes in information-processing tendencies (for reviews, see Carstensen, Mikels, & Mather, 2006; Mather & Carstensen, 2005). Whereas information processing in younger adults tends to favor negative stimuli (Baumeister, Bratslavsky, Fickenauer, & Vohs, 2001; Rozin & Royzman, 2001), older adults are more likely than younger adults to favor positive information and less likely to favor negative information, resulting in an Age × Valence interaction referred to as the *positivity effect* (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). Positivity effects have emerged when older and younger adults are asked to recall and recognize emotional images, view emotional facial expressions, report autobiographical memories, and make decisions that have emotional features associated with them (for a review, see Mather & Carstensen, 2005). For example, the positivity effect emerged when older and younger adults viewed neutral and emotional images and were later given a memory test (Charles, Mather, & Carstensen, 2003). Overall memory for the images was greater for younger adults. However, compared with younger adults, older adults were more likely to forget negative images than positive images (Charles et al., 2003). Positivity effects can also occur in decision-making processes. Older adults are more likely than younger adults to remember past choices as being better than they actually were (Mather & Johnson, 2000) and older adults are more likely than younger adults to spend a greater proportion of time examining the positive attributes of choice options (Mather, Knight, & McCaffrey, 2005).

Taken as a whole, the evidence reviewed thus far suggests that older adults seek to optimize their emotional experience by favoring positive over negative stimuli in their information processing. Socioemotional selectivity theory provides a framework for understanding this developmental trend toward optimizing emotional experience (Carstensen, 1995; Carstensen, Isaacowitz, & Charles, 1999). According to the theory, when people perceive their time remaining in life to be expansive, they prioritize acquiring information that can lead to future gains. In contrast, near the end of life, when people perceive their time left in life as limited, they prioritize emotional goals directed toward enhancing their present experience. Older adults' shift in goals is associated with systematic biases in attention and memory that favor emotional over nonemotional and positive over negative information (Carstensen

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& Mikels, 2005; Carstensen et al., 2006; Mather & Carstensen, 2005).

Although older adults maintain or even improve their emotion regulation abilities and functioning, they show decline in cognitive control abilities such as the active maintenance and manipulation of novel information, selective attention in the face of distraction, and self-initiated retrieval of information from memory (for reviews, see Hedden & Gabrieli, 2004; Prull, Gabrieli, & Bunge, 2000; Reuter-Lorenz & Sylvester, 2005). Interestingly, recent research links emotion regulation to the same kinds of cognitive control processes that are most likely to be compromised by age (Anderson et al., 2004; Beauregard, Levesque, & Bourgouin, 2001; Ochsner & Gross, 2005; Schmeichel, Vohs, & Baumeister, 2003). It is puzzling that aging compromises cognitive control, yet does not lead to similar declines in emotion control.

One potential explanation for older adults' improved emotional control is that older adults are focused on emotional goals in situations in which younger adults are focused on other goals. Indeed, in contexts in which older adults show more emotionally gratifying memory than younger adults, instructional manipulations that encourage younger adults to focus on their emotions during encoding make their information-processing tendencies resemble those of older adults (Kennedy, Mather, & Carstensen, 2004; Mather & Johnson, 2000). In contrast, older adults are not affected by the explicit cue to focus on their emotions. These findings suggest that emotional goals operate as a default at an unconscious level for older adults, whereas for younger adults, emotional goals are only activated in certain contexts (Mather & Carstensen, 2005).

Although older adults may have fewer cognitive resources overall, we predict that the resources they do have will be allocated in a goal-consistent manner that enables successful emotion regulation and the maintenance of positive emotional experience. Consequently, successful emotion regulation should be a function not only of age, but also of overall cognitive resources. Those older adults whose cognitive control abilities are least compromised by age should show the largest positivity effects. Those older adults whose cognitive control resources are most compromised should have the greatest difficulty carrying out emotional goals and so should show the smallest positivity effects. Thus, it is important to consider how strategic abilities and goal structure may interact to influence one's success at emotion regulation (for reviews, see Mather, 2006; Mather & Carstensen, 2005).

Support for this prediction comes from a recent study in which older participants with the highest scores on tests of cognitive control showed the strongest positivity effects, remembering proportionally more positive and fewer negative images than older adults with lower scores on cognitive control tests (Mather & Knight, 2005). Mather and Knight (2005) followed up this individual difference study with one that directly manipulated attention during picture encoding to further test their claim that positivity effects rely jointly on chronically activated emotional goals and cognitive resources to translate the goals into action. The results from an immediate free recall test were striking. Older adults in the full-attention condition showed the positivity effect, remembering a larger proportion of positive and smaller proportion of negative information than younger adults in the same condition. However, this positivity effect reversed in the auditory distraction condition. Although dividing attention had little effect on the valence of younger adults' memories, about 70% of older adults' memories consisted of negative pictures when they were distracted. These findings indicate that the older adults used their attentional resources to help favor positive rather than negative information in their memories. Thus, for older adults, an enhanced capacity to implement emotional goals leads to memories that are more positive.

Older adults' negativity effect in the divided-attention condition suggests that emotional goals may have unintended consequences when cognitive resources are not available to guide information processing and behavior in a goal-consistent manner. These unintended consequences may be due to the "ironic processes of mental control" (Wegner, 1994, p.34), in which attempts to control one's own mental state can backfire when people are distracted; monitoring processes that seek out goal-inconsistent information do not require much cognitive capacity, whereas the control processes that avoid attending to goal-inconsistent information once it has been detected or focus on goal-consistent information require more cognitive capacity. Thus, when people are distracted, relatively automatic processes may still be seeking out goal-inconsistent information, but no control processes are available to suppress it once it has been detected.

Because successful emotion regulation requires selectively enhancing positive information and actively ignoring negative information, control of visual attention is likely to play a crucial role in positivity effects. Indeed, at durations long enough to permit goal-directed allocation of attention, older adults have shown a pattern indicative of a bias away from negative information (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a; Mather & Carstensen, 2003; Mather et al., 2005). For instance, older adults were slower to indicate the location of a dot appearing behind a negative face than one appearing behind a neutral face, although younger adults showed no such bias (Mather & Carstensen, 2003; but see Isaacowitz et al., 2006a). Eye-tracking studies have also shown similar effects. In a recent study comparing proportions of fixations to pairs of emotional and neutral faces across age groups in an eye-tracking paradigm, older adults showed a preference for happy faces and a bias against negative faces expressing anger and sadness in their visual attention, whereas younger adults showed an attentional bias to fearful faces (Isaacowitz et al., 2006a; Isaacowitz, Wadlinger, Goren, & Wilson, 2006b). In another recent study, although both older and younger participants showed a tendency to fixate first on emotional rather than neutral pictures, healthy older adults, compared with younger adults, showed less attention to negative but equivalent attention to positive stimuli (Rosler et al., 2005).

These eye-tracking findings are consistent with socioemotional selectivity theory's basic tenet that emotional goals are a high priority for older adults. However, these findings do not permit conclusions to be drawn about interactions between chronically accessible emotional goals and cognitive resources. Thus, to test our hypothesis that the positivity effect in visual attention requires cognitive resources, in the present study we presented pairs of emotionally valenced and neutral pictures and faces to older and younger adults under conditions of full and divided attention and used eye tracking to measure their visual attention.

We predicted that the recruitment of cognitive control mechanisms in the service of emotion regulation should be evident in visual attention. Given previous findings of older adults' maintained threat detection and initial saccades toward emotionally arousing stimuli (Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006; Rosler et al., 2005), we predicted that both older and younger adults' first fixations would favor emotionally arousing over neutral information. However, for the remaining fixations, when emotional and neutral information vie for limited attentional resources, we predicted that age differences would emerge. Given the opportunity to shift attentional focus among differently valenced information, our model predicts that older adults in the full-attention condition will show greater sustained visual attention to positive information and fixate less on negative information relative to their younger counterparts. In contrast, reduced availability of cognitive resources should result in the absence, or even reversal, of the positivity effect in the distribution of visual attention. Thus, in the divided-attention condition, older adults should be less effective in maintaining attention to goal-relevant positive information or avoiding attending to negative information, resulting in fewer fixations on positive information and more on negative information.

Method

Participants

The research participants consisted of 27 older (65–83 years old; $M = 75.00$, $SD = 5.99$) and 33 younger (18–29 years old; $M = 19.85$, $SD = 1.28$) adults. Older adults (10 men, 17 women) were recruited through flyers posted throughout Santa Cruz County, CA. All older individuals were screened for dementia using the CERAD (Consortium to Establish a Registry for Alzheimer's Disease) Word List Memory test (Welsh et al., 1994), in which they were tested on their recall and recognition of 10 words after three learning and recall cycles followed by a 10-min filler interval. Participants had to obtain a score greater than 3 correct on the 10-min delayed recall test ($M = 6.00$, $SD = 2.56$) or at least 7 out of 10 on the delayed recognition test ($M = 9.48$, $SD = 0.98$) to be included in the data set. This resulted in the exclusion of one older participant. The younger participants (13 men, 20 women) were students at the University of California, Santa Cruz, participating in exchange for course credit. Older participants driving from off campus received $20. An additional 12 older adults and 7 younger adults participated in the study but were not included in the data analyses because of computer crashes or failures to record data ($n = 10$) or because their eye movements were not trackable ($n = 9$).

Older adults reported having more years of education ($M = 15.38$, $SD = 2.62$) than younger adults did ($M = 13.66$, $SD = 1.33$), $t(54) = 3.21$, $p < .05$. In addition, older adults had higher scores ($M = 19.63$, $SD = 3.76$) than younger adults did ($M = 12.93$, $SD = 4.53$), $t(55) = 6.03$, $p < .05$, on the Nelson–Denny (Nelson & Denny, 1960) vocabulary measure.

Stimuli

Participants viewed 96 pictures (32 negative, 32 positive, and 32 neutral). Ninety-four were from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) and two were from outside sources (pictures of a crowd of people on the street and an empty train station). Across the positive and negative categories, we equated the arousal level of the images by including an equal number of low- and high-arousal images. This resulted in four picture categories: low-arousal positive, high-arousal positive, low-arousal negative, and high-arousal negative images. The average IAPS arousal rating for the high-arousal positive ($M = 6.38 \pm 0.24$) and negative images ($M = 6.37 \pm 0.32$) did not differ significantly from each other, $t(30) = -0.015$, *ns*. Likewise, the average IAPS arousal rating of the low-arousal positive ($M = 4.53 \pm 0.18$) and negative images ($M = 4.55 \pm 0.20$) did not differ significantly from each other, $t(30) = 0.86$, *ns*. The positive images ($M = 7.39 \pm 0.10$) and negative images ($M = 2.71 \pm 0.28$) differed from each other in terms of their normative valence ratings, $t(62) = 30.37$, $p < .001$. The additional 32 neutral pictures had the lowest average arousal rating ($M = 3.16 \pm 0.30$) and fell around the midpoint of the valence scale ($M = 5.07 \pm 0.10$).

Pictures were displayed in emotional–neutral pairs (positive–neutral and negative–neutral) and emotional–emotional pairs (positive–negative). For half of the participants, emotional–emotional pairs consisted of positive and negative images with matched arousal values (positive high–negative high and positive low–negative low). For the remaining participants, emotional pairs consisted of two pictures with mixed arousal values (positive high–negative low and positive low–negative high).

Between participants, each emotional picture was seen half the time with a picture of the opposite valence and the remaining time with a neutral picture. The screen location of the pictures was also counterbalanced between participants. Within participants, half of the positive pictures were paired with negative pictures and the remaining positive pictures were paired with neutral pictures (and likewise for the negative pictures). Across participants, each valence type (including neutral pictures) was seen equally often on each side of the screen. In addition, each neutral picture was seen equally often with positive and negative pictures.

Each picture measured 240 pixels × 240 pixels and was vertically centered on the screen. The pictures presented on the left were 60 pixels from the left border of the screen. The pictures presented on the right were 60 pixels from the right border of the screen.

In addition to emotional and neutral scenes, participants also viewed emotional and neutral faces in a separate phase of the experiment.[1] We used 30 pairs of photographs of different faces (60 faces; 30 male, 30 female). The order of presentation and several aspects of the face pairs were counterbalanced across participants within the presentations: face gender pairing (mixed or matched), expression pairing (happy–neutral, angry–neutral, happy–angry), and side of the screen for display of a particular face.

As in Mather and Knight (2005), for the divided-attention task, we used repeating rhythmic sound patterns that differed in the number of times they changed from trial to trial (see also Kensinger & Corkin, 2003). We alternated each sound sequence between two different tone patterns spliced together using Sound Studio 2.0.7 software (Felt Tip Software, 2002). The sound sequences were equal in duration to the presentation time for the

[1] The face photographs used were the set of faces used in Mather and Carstensen (2003). These came from a larger set of 1,600 photographs collected and normed to reveal emotional categories by Gotlib et al. (2002).

picture pairs (6 s) and randomly alternated between trials in which the sound pattern changed two or three times. There were three different three-tone patterns (for the two-change trials) and three different four-tone patterns (for the three-change trials). Selection of the particular pattern played on each trial was randomized. The patterns differed in the onset time for each change to make it difficult to identify the two- or three-sound changes on the basis of a simple heuristic.

Apparatus

Stimuli were presented on a 17" (43.18-cm) monitor operating with a refresh rate of 85 Hz. Presentation and randomization of stimuli, as well as the recording of manual response data (reaction time and accuracy), were handled by E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) software running on a 1-GHz Pentium computer. Manual responses were entered on a four-button box (Cedrus Corporation, San Pedro, CA). An Arrington Research ViewPoint eye tracker with chin rest was used to monitor and record eye movements at 60 Hz.

Procedure

After obtaining informed consent and completing the CERAD Word List Memory test and the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988), a brief questionnaire consisting of 10 positive and 10 negative emotion words, participants were seated approximately 30 in. (76.2 cm) from the computer screen. Before beginning the task, participants' gaze coordinates were mapped to a standardized gaze space through a standard eye-tracking calibration procedure. Participants were instructed to fixate their gaze on a centrally positioned fixation cross that was either red or blue and to indicate the color of the fixation cross. After they made a selection, the fixation cross was immediately replaced with a pair of images that appeared for 6 s on opposite sides of the screen. In the divided-attention condition, a tone pattern also played during this time. Each trial ended with a screen prompting the participant to indicate whether the tone pattern changed two times (red button) or three times (blue button). Their response was followed by a new fixation cross, and the sequence repeated.

All participants were given eight opportunities to practice. Participants in the divided-attention condition received practice trials with feedback for each response they made and reminders about the response key mappings to ensure that they understood the task. The practice phase was not terminated until participants understood the task and could discriminate the tones without error. The experiment consisted of two blocks of trials. In one block, participants viewed 48 pairs of pictures. In the other block, participants viewed 15 pairs of faces. The order of the blocks was counterbalanced between participants. Each pair of photographs was shown to participants for a total duration of 6 s.

Each initial saccade to a target within a designated velocity threshold was counted. The same was true for computing the dwell time and proportion of total fixations: Any time the velocity of the eye was beneath 20° per second for at least 90 ms, a fixation began and it ended when the velocity threshold exceeded 20° per second. A smoothing (point-averaging) algorithm was applied to the data to make this an appropriate threshold. After the picture-viewing phase, participants completed the vocabulary measure and a brief demographics sheet.

Results

For the analyses in this article, we used an alpha level of 0.05, including 95% confidence intervals, and used partial eta squared (η_p^2) to measure effect sizes.

Mood

On the PANAS, older adults did not differ significantly from younger adults in reported positive affect ($M_{OLD} = 31.00 \pm 3.90$; $M_{YOUNG} = 27.38 \pm 3.10$), $t(57) = 0.15$, *ns*. However, older adults reported significantly lower negative affect ($M = 10.52 \pm 1.14$) than younger adults did ($M = 15.28 \pm 1.78$), $t(57) = -4.33$, $p < .05$.

Pictures

Divided-attention task. Accuracy on the tone task during the picture phase was significantly higher for younger adults (M = 82.67%, SD = 22.73%) than for older adults (M = 62.92%, SD = 17.87%), $t(32) = 2.76$, $p < .05$. Tone accuracy performance was not significantly correlated with participants' relative emotional focus on positive or negative stimuli (as measured by proportion of remaining fixations) when correlations were computed for all participants together or for participants split by age group.

Emotional–neutral picture pairs. The proportions of fixations aimed at positive and negative pictures paired with neutral pictures were analyzed separately for the first fixation and then for the remaining fixations with repeated measures analyses of variance (ANOVAs). Valence (positive, negative) was a within-participant factor and age (younger, older) and attention (full, divided) were between-participants factors. For the first fixations, there were no significant main effects or interactions. On average, across participants, the proportions of first fixations to positive (.59 ± .03) and negative pictures (.59 ± .03) that were paired with neutral pictures were significantly larger than the 50% that would be expected by chance, $t(59) = 7.18$, $p < .001$. Thus, both younger and older adults showed similar patterns of fixating first on emotional pictures rather than on neutral pictures (see Figure 1A).

The analysis of proportions of remaining fixations aimed at positive and negative pictures paired with neutral pictures showed a significant Age × Valence × Attention Condition interaction, $F(1, 56) = 8.44$, $p < .01$, $\eta_p^2 = .13$ (See Table 3 for means).[2] In the full-attention condition (see Figure 2A), the proportion of younger adults' fixations to negative pictures in negative–neutral pairs (.63 ± .05) was larger than the proportion of fixations to positive images in positive–neutral pairs (.57 ± .05). In contrast, the proportion of older adults' fixations directed to positive pictures (.58 ± .05) was larger than the proportion directed to negative pictures (.53 ± .05). The pattern for older adults reversed in the divided-attention condition (see Figure 2B), with a larger proportion of fixations to negative pictures (.57 ± .05) than to

[2] The Age × Valence × Attention interaction for pictures remained significant when including the PANAS positive and negative scores as covariates, $F(1, 51) = 8.48$, $p < .01$, $\eta_p^2 = .14$; when including vocabulary scores as covariates, $F(1, 51) = 6.42$, $p < .05$, $\eta_p^2 = .11$; and when including years of education as a covariates, $F(1, 48) = 8.52$, $p < .01$, $\eta_p^2 = .15$.

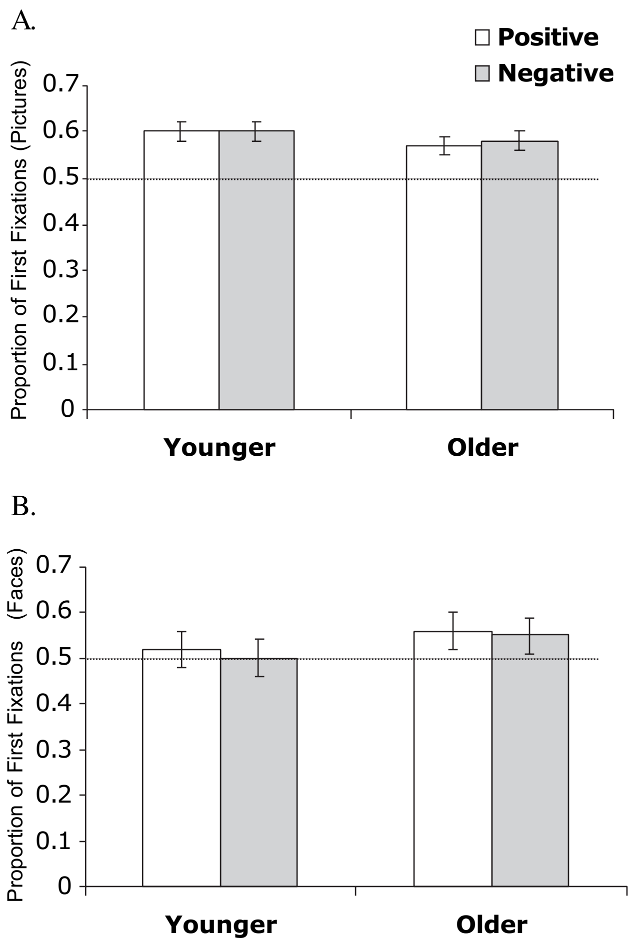

Figure 1. Proportion of first fixations to (A) positive and negative pictures paired with neutral pictures and (B) positive and negative faces paired with neutral faces. Error bars display the standard error. The dashed lines indicate what would be expected by chance.

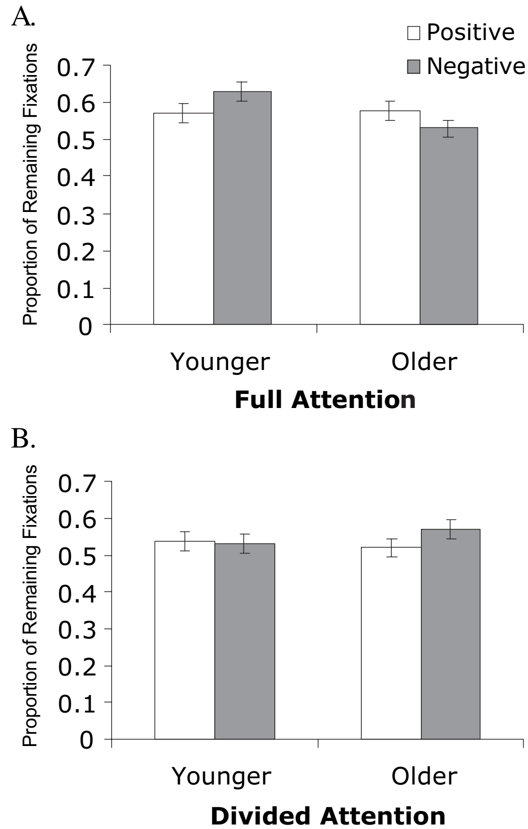

Figure 2. Proportion of remaining fixations to positive and negative pictures paired with neutral pictures in (A) the full-attention condition and (B) the divided-attention condition. Error bars display the standard error.

positive pictures (.52 ± .05). For younger adults in the divided-attention condition, the proportion of fixations to negative pictures (.53 ± .04) was similar to the proportion directed to positive pictures (.54 ± .04).

Emotional–emotional picture pairs. We conducted separate ANOVAs with age (younger, older) and attention (divided, full) as fixed factors to compare the proportion of both first and remaining fixations to negative pictures that were paired with positive pictures. No significant main effects or interactions emerged (see Tables 1 and 2 for means).

Faces

Divided-attention task. Performance accuracy on the tone task during the face presentation phase was significantly higher for younger adults ($M = 78.95\%$, $SD = 32.68\%$) than for older adults ($M = 55.11\%$, $SD = 26.36\%$), $t(32) = 2.29$, $p < .05$. Tone accuracy performance was not significantly correlated with the valence of participants' emotional focus (as measured by proportion of remaining fixations) when correlations were computed for all participants together or for participants split by age group.

Emotional–neutral face pairs. The proportions of first and remaining fixations aimed at positive and negative faces paired with neutral faces were analyzed with repeated-measures ANOVAs. Age (younger, older) and attention (divided, full) were between-participants factors and valence (positive, negative) was a within-participant factor. For first fixations, there were no significant main effects or interactions. Across participants, the proportion of first fixations to positive faces (.54 ± .05) did not differ significantly from the proportion of first fixations to negative faces (.52 ± .04), $F < 1$, *ns*. In contrast with the first fixations to pictures, the proportion of first fixations to an emotional face rather than to its neutral counterpart (.53 ± .04) was not different from chance, $t(59) = 1.52$, $p = .14$ (see Figure 1B); this may be because positive and negative facial expressions were not as arousing as the positive and negative pictures that we used.

Participants' remaining fixations showed a significant Age × Valence × Attention Condition interaction, $F(1, 56) = 7.99$, $p < .01$, $\eta_p^2 = .13$ (see Table 4 for means).[3] The proportion of younger

[3] The Age × Valence × Attention interaction for faces remained significant when including the PANAS positive and negative scores as covariates, $F(1, 49) = 9.53$, $p < .01$, $\eta_p^2 = .16$; when including vocabulary scores as covariates, $F(1, 50) = 10.85$, $p < .01$ and when including years of education as covariates, $F(1, 47) = 9.31$, $p < .01$, $\eta_p^2 = 17$.

Table 1
Proportions (and Standard Errors) for First Fixations to Negative Scenes and Faces in Emotional-Emotional Pairings

	Picture stimuli: Positive-negative pairs			Face stimuli: Positive-negative pairs	
Experiment group	Full	Divided	Experiment group	Full	Divided
Younger adults	.52 (.03)	.51 (.03)	Younger adults	.46 (.05)	.48 (.05)
Older adults	.47 (.03)	.49 (.03)	Older adults	.48 (.05)	.48 (.05)
Total pictures	32	32	Total faces	10	10

adults' fixations to negative faces (.54 ± .08) in the full-attention condition decreased when attention was divided (.40 ± .07). In contrast, the proportion of younger adults' fixations to positive faces (.49 ± .08) in the full-attention condition increased when attention was divided (.55 ± .07; see Figure 3A). The proportion of older adults' fixations to negative faces (.47 ± .08) in the full-attention condition did not change much when attention was divided (.48 ± .08). In contrast, the proportion of older adults' fixations to positive faces (.53 ± .08) decreased when attention was divided (.45 ± .08; see Figure 3B).

Emotional–emotional face pairs. We conducted separate univariate ANOVAs with age (younger, older) and attention (divided, full) as fixed factors to compare the proportion of first and remaining fixations to negative faces that were paired with positive faces. No significant main effects or interactions emerged (see Tables 1 and 2 for means).

Discussion

The goal of this study was to determine the contribution of the strategic deployment of visual attention to positivity effects in older adults. We presented pairs of emotionally valenced and neutral pictures and faces to older and younger adults under conditions of full and divided attention. Using fixation patterns as our measure of visual attention, we found evidence supporting our hypothesis that cognitive control plays a key role in the positivity effect in older adults' information-processing tendencies (Mather & Knight, 2005).

In the full-attention condition, we replicated previous findings of positivity (or antinegativity) effects in older adults' fixation patterns to pairs of emotional and neutral pictures and emotional and neutral faces during full attention (Isaacowitz et al., 2006a, 2006b; Rosler et al., 2005). As socioemotional selectivity theory would predict, the chronic accessibility of emotional goals in the older adult group led to visual fixation patterns that support emotional well-being in the control condition. Thus, the positivity effect was expressed under circumstances permitting full access to cognitive resources to implement emotional goals. In contrast, by dividing attention and thereby reducing available cognitive resources, we were able to reverse older adults' tendency to favor positive faces and pictures more than negative faces and pictures. Consistent with previous research showing that high cognitive load can increase distractor processing (see Lavie, 2005, for a review), goal-irrelevant information received more visual attention when older participants performed the distraction task. These findings support the hypothesis that, in addition to chronically activated goals, cognitive control processes play a crucial role in supporting positivity effects in older adults (Mather & Carstensen, 2005; Mather & Knight, 2005). Of additional interest is the fact that the attentional manipulation also influenced younger adults' gaze patterns. Younger adults were less likely to favor negative stimuli when their attention was divided. In the picture-viewing phase, younger adults' tendency to favor negative stimuli was attenuated, whereas in the face-viewing phase, this tendency was reversed. These findings suggest that the negativity bias seen among younger adults in many domains (for reviews, see Baumeister et al., 2001; Rozin & Royzman, 2001) may have a goal-directed component. The different outcomes for pictures and faces under divided attention (reversal of negativity vs. attenuation of the negativity bias) suggest that younger adults' processing goals are less systematic across situations than they are for older adults.

Table 2
Proportions (and Standard Errors), Excluding the First Fixation, for Fixations to Negative Scenes and Faces in Emotional-Emotional Pairings and Average Total Number of Fixations in Emotional-Emotional Trials

	Picture stimuli: Positive-negative pairs			Face stimuli: Positive-negative pairs	
Experiment group	Full	Divided	Experiment group	Full	Divided
Younger adults	.56 (.03)	.48 (.03)	Younger adults	.52 (.04)	.49 (.04)
Average no. of fixations	149.43	105.58	Average no. of fixations	41.50	28.85
Older adults	.51 (.03)	.51 (.03)	Older adults	.45 (.04)	.49 (.04)
Average no. of fixations	118.42	101.71	Average no. of fixations	36.62	30.36
Total pictures	32	32	Total faces	10	10

Table 3

Proportions (and Standard Errors), Excluding the First Fixation, for Fixations to Positive and Negative Scenes in Emotional-Neutral Pairings and Average Total Number of Fixations in Positive-Neutral and Negative-Neutral Trials

	Picture stimuli: Positive-neutral pairs			Picture stimuli: Negative-neutral pairs	
Experiment group	Full	Divided	Experiment group	Full	Divided
Younger adults	.57 (.05)	.54 (.04)	Younger adults	.63 (.05)	.53 (.04)
Average no. of fixations	147.36	94.05	Average no. of fixations	143.07	100.74
Older adults	.58 (.05)	.52 (.05)	Older adults	.53 (.05)	.57 (.05)
Average no. of fixations	114.67	98.20	Average no. of fixations	119.08	96.20
Total pictures	32	32	Total pictures	32	32

Our examination of participants' first fixations also yielded results in line with our predictions. Consistent with previous research showing no age difference in the likelihood of rapidly detecting emotionally arousing stimuli (Hahn et al., 2006; Mather & Carstensen, 2005; Mather & Knight, 2006), participants' first fixations favored emotionally arousing over neutral pictures, and this effect was similar across the two age groups. This suggests that arousal, not valence, is the critical characteristic that draws the first fixation to a particular image. It is interesting that this effect was restricted to emotional–neutral picture pairs and was not significant for faces. One reason for this could be that, although they conveyed emotions, the emotional faces we used were not very arousing. It is also possible that the restriction of this effect to pictures may be attributable to the higher degree of uniqueness, complexity, or novelty among the picture pairs, relative to the face pairs.

The assessment of visual attention patterns both under full attention and under attentional load distinguishes this work from previous investigations of age-related positivity effects in attention. Our findings argue against alternative explanations of the positivity effect, such as that they are due to age-related deficits in identifying negative facial expressions (e.g., Brosgole & Weisman, 1995; Calder et al., 2003; Sullivan & Ruffman, 2004; Wong, Cronin-Golomb, & Neargarder, 2005) or to age-related impairments in early visual emotion discrimination (e.g., Wieser, Muhlberger, Kenntner-Mabiala, & Pauli, 2006; but see Hahn et al., 2006; Mather & Knight, 2006).

However, a potential alternative account of our findings is that monitoring the sound patterns for the divided-attention task put participants who did well on the task in a good mood and participants who did poorly on the task in a bad mood. Because, in general, older adults did not do as well as younger adults on the sound pattern task, this may account for the age differences in the effect of the divided-attention manipulation. However, performance on the divided-attention task was not correlated with the valence of visual attention biases, as would be predicted by this account. In addition, in Mather and Knight's (2005) study, older participants in the divided-attention condition achieved quite high accuracy on the easier sound pattern task used in that experiment, yet they still showed a reversal of their positivity effect in their later memory. We did not measure mood during or after the divided-attention manipulation, however, and so could not assess this possibility directly. This is a limiting factor in this study. In addition, besides the CERAD Word List Memory test and the vocabulary test, we did not include other measures of sensory or cognitive function (e.g., audition, visuospatial perception, executive control). It seems unlikely that hearing limitations in our older participants would be a confounding factor because we made sure that all participants could hear the tones and were able to perform the tone task without error on practice trials. However, the absence of additional cognitive measures warrants caution in making generalizations to a wider population that includes large variability in cognitive performance. In a previous series of studies that included several cognitive control measures, those older adults with the

Table 4

Proportions (and Standard Errors), Excluding the First Fixation, for Fixations to Positive and Negative Faces in Emotional-Neutral Pairings and Average Total Number of Fixations in Positive-Neutral and Negative-Neutral Trials

	Face stimuli: Positive-neutral pairs			Face stimuli: Negative-neutral pairs	
Experiment group	Full	Divided	Experiment group	Full	Divided
Younger adults	.49 (.08)	.55 (.07)	Younger adults	.54 (.08)	.40 (.07)
Average no. of fixations	41.07	30.65	Average no. of fixations	38.93	29.53
Older adults	.53 (.08)	.45 (.08)	Older adults	.47 (.08)	.48 (.08)
Average no. of fixations	35.31	34.72	Average no. of fixations	38.62	38.42
Total pictures	10	10	Total faces	10	10

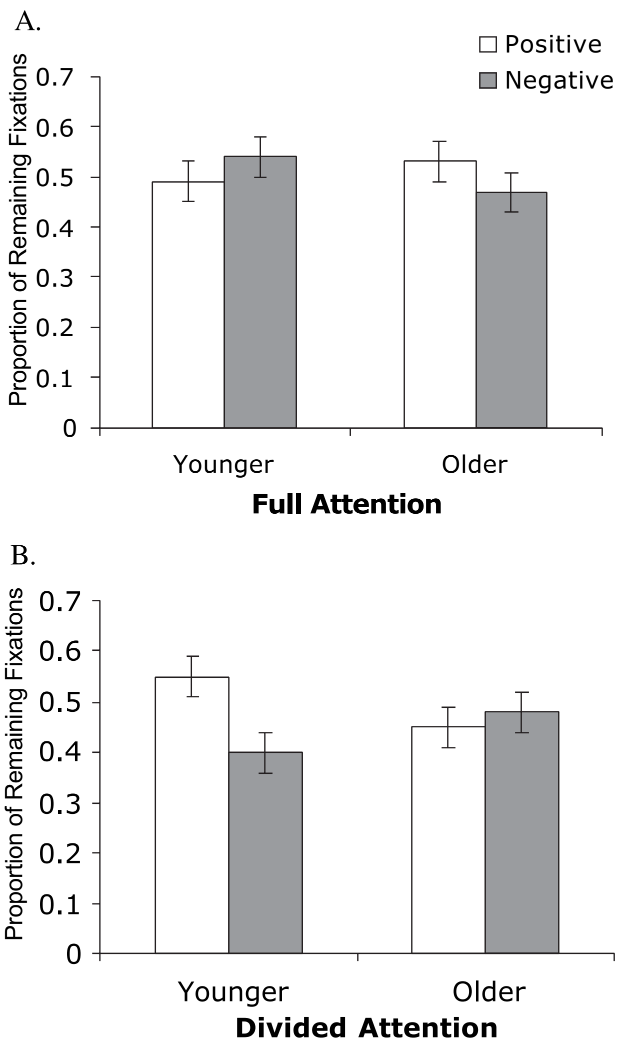

Figure 3. Proportion of remaining fixations to positive and negative faces paired with neutral faces in (A) the full-attention condition and (B) the divided-attention condition. Error bars display the standard error.

highest composite cognitive control scores showed the strongest positivity effects (Mather & Knight, 2005). Thus, the Age × Valence × Attention interactions observed in this study may be driven by those older adults with the strongest cognitive control abilities.

Although previous studies of age and emotional attention have presented pairs of emotional versus neutral stimuli (Isaacowitz et al., 2006b; Mather & Carstensen, 2003; Rosler et al., 2005), our study also included some trials that pitted positive and negative stimuli directly against one another. We were surprised to find no significant attentional biases in this condition because trials pitting pictures and faces with the largest valence differences against one another would presumably provide the strongest context for emotion regulation goals and selective attention to operate. One possibility is that the lack of an Age × Valence interaction in emotional picture pairings is due to the arousal and complexity of the positive and negative pictures presented simultaneously. In the same way that manipulations that decrease cognitive control abilities place older adults at a disadvantage in terms of goal implementation, the simultaneous presentation of positive and negative scenes may have created interference, distraction, or interest that did not have time to resolve itself before a given trial ended. One finding that is relevant for this issue is that the attentional biases in Isaacowitz et al. (2006b) were not apparent when stimuli were presented for 1,000 and 4,000 ms. They only appeared in the 8,000-ms condition. Our stimulus pairs were shown for 6,000 ms.

Given that we counterbalanced which emotional pictures and faces were seen in emotional–emotional trials versus emotional–neutral trials and that the same pattern of findings occurred in both the pictures condition and the faces condition (significant effects in the emotional–neutral condition vs. null effects in the emotional–emotional condition), the lack of attentional biases in the emotional–emotional condition appears to be an intriguing effect that deserves further research. In addition to being something that draws the first fixation, arousal may also place positive and negative faces and images on more equal footing in terms of attentional demand throughout the viewing duration. The fact that the positivity effect was apparent for emotional–neutral trials, in which both valence and arousal differences exist between the paired images, yet disappeared in emotional–emotional trials, in which arousal differences were minimized, suggests that the arousing nature of the emotional pairs may have obscured or diluted valence-driven attentional effects. However, it is also possible that the differences between the types of trials are due to having twice as many emotional–neutral trials as emotional–emotional trials and, thus, more power to detect differences in the emotional–neutral trials.

A growing body of work supports the theoretical proposal that eye gaze can be strategically directed to establish and maintain positive affective states and, more generally, to allocate cognitive resources toward goal-consistent information and away from information that may hinder or prevent goal attainment (for a review, see Isaacowitz, 2006). Gaze patterns that are biased away from negative information have been found in optimistic, younger adults who perceive time as limited and in older adults (Isaacowitz, 2005; Mather & Carstensen, 2003; Pruzan & Isaacowitz, 2006; Rosler et al., 2005). In general, gaze may help people control how their environment affects them (Light & Isaacowitz, 2006). Our findings support the notion that, under circumstances that permit full access to cognitive resources, eye gaze is more likely to reflect goal-directed processing.

According to our model (Mather & Knight, 2005), positivity effects in older adults are a joint function of the automatic activation of emotion regulation goals and the cognitive resources required to implement those goals when circumstances pose a challenge to well-being. Our findings suggest that, although the emotion-focused goals of older adults may be chronically activated (e.g., Kennedy et al., 2004; Mather & Johnson, 2000), the link between motivation and visual attention do not become automated with extensive practice. Disrupting cognitive control interfered with gaze patterns that reinforce emotional well-being. Thus, we can conclude that, although visual attention plays an important role in positivity effects, its use as a tool of motivation requires cognitive effort. However, we do note that these findings do not provide any information about the role of conscious intentions in these effects, as we did not investigate what participants thought their goals were. Given our informal interactions and discussions with participants, we suspect that older adults are not usually aware of the cognitive effort they are making to implement their emotional goals.

Although selective visual attention has been identified as playing a crucial role in positivity effects, it is likely to be only one of several important component processes. A goal of future research is to identify additional component processes involved (e.g., active goal maintenance, inhibition, updating the contents of working memory) in positivity effects and determining which of these processes are relatively automated and which are resource demanding. Another interesting future research direction involves determining the extent to which older adults use gaze as a general tool of motivation beyond the domain of emotion regulation and how measurements of gaze direction can inform us about age-related differences in the goals we set for ourselves. In addition, the proposed link between goal-directed processing and visual attention may have important clinical applications. If motivation and cognitive control are capable of galvanizing visual attention in a goal-relevant manner, interventions that include retraining gaze patterns that support maladaptive or unattainable goals may meet with success.

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