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Aging and Goal Directed Emotional Attention:

Distraction Reverses Emotional Biases

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Abstract

Previous findings suggest the operation of selective information processing tendencies in older adults that 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. Consistent with a cognitive-control-based account of the positivity effect in older adults' information processing tendencies (Mather & Knight, 2005), relative to younger adults, 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. Older adults' tendency to avoid negative stimuli was reversed in the divided attention condition. Relative to 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 counter-goal effects when cognitive control mechanisms are not fully available.

Aging and Goal-Directed Emotional Attention:

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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 the frequency of negative emotions to decrease and the frequency of positive emotions to remain stable or even increase slightly with age (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001; Mroczek, 2001).

A growing body of evidence suggests that older adults' successful emotion regulation is associated with changes in memory and attention (for reviews, see Carstensen, Mikels, & Mather, 2006; Mather & Carstensen, 2005). While information processing in younger adults tends to favor negative stimuli (Baumeister, Bratslavsky, Fickenaue, & Vohs, 2001), older adults are more likely than younger adults to favor positive information and less likely to favor negative information, resulting in an age by valence interaction referred to as the *positivity effect* (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). For example, the positivity effect emerged when older and younger adults viewed neutral and emotional images in the absence of encoding instructions and were later given a memory test (Charles, Mather, & Carstensen, 2003). Overall memory for the images was greater for younger adults. However, older adults were more likely to forget negative images relative to younger adults than to forget positive images (Charles et al., 2003). Positivity effects can also occur in decision-making processes. Older adults are more likely to remember past choices as being better than they actually were than are younger

adults (Mather & Johnson, 2000) and older adults spend a greater proportion of time than younger adults focusing on positive attributes of choice options (Mather, Knight, & McCaffrey, 2005).

Age-related cognitive decline is evident in tasks that require cognitive control processes and recruit prefrontal brain areas, 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). There is a growing body of evidence showing that emotion regulation relies on the same kinds of cognitive control processes that are most likely to be compromised by age (Anderson et al., 2004; Beaugard, Levesque, & Bourgooin, 2001; Ochsner & Gross, 2005; Schmeichel, Vohs, & Baumeister, 2003). Older adults' successful regulation of affective experience seems puzzling in light of their impaired cognitive control processes. However, this seeming paradox can be resolved by the following theoretical account.

Socioemotional Selectivity Theory proposes a shift in the way goals are structured, which is driven by the perception of time left in life (Carstensen, 1995; Carstensen, Isaacowitz, & Charles, 1999). When the future is expansive, priority is given to goals that maximize information acquisition. In contrast, as the time left in life shrinks, the future is perceived as limited and emotional goals take center stage. This shift in goals is linked to systematic biases in attention and memory that favor emotional over non-emotional and positive over negative information (Carstensen & Mikels, 2005; Carstensen et al., 2006; Mather & Carstensen, 2005).

While older adults may have fewer cognitive resources overall, socioemotional selectivity theory predicts that the resources they do have can be allocated in a goal-consistent manner that enables successful emotion regulation and the maintenance of positive emotional

experience. However, Mather and Knight (2005) argued that this proposal requires further qualification. Success at 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 fewer resources to allocate to emotional goals and so should show the smallest positivity effects. Thus, it is important to consider how cognitive control and goal structure may interact to influence one's success at emotion regulation (for reviews, see Mather, in press; Mather & Carstensen, 2005).

A series of studies examining older and younger adults' memories after they viewed equal numbers of emotional and neutral images support this model in which older adults' chronically activated emotional goals call upon cognitive control processes to enhance positive and diminish negative information (Mather & Knight, 2005). Repeated versus single retrieval opportunities, stronger versus weaker cognitive control abilities, and uninterrupted versus blocked access to cognitive control resources all yielded larger positivity effects in older adults. Thus, for older adults, an enhanced capacity to implement emotional goals leads to memories that are more positive.

The direct manipulation of attention during encoding in Experiment 3 provided the strongest test of this model (Mather & Knight, 2005). During the encoding phase, older and younger adults in the full attention condition were asked to watch a series of emotional and neutral pictures as if they were watching a film or television show. In a divided attention condition, older and younger adults received the same instructions but also listened to repeating tone patterns during the presentation of each picture and, after each picture was presented, were required to indicate how many times the tone pattern had changed.

The pattern that emerged on an immediate free recall test was 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 divided attention condition. While dividing attention had little impact on the valence of younger adults' memories, about 70% of distracted older adults' memories consisted of negative pictures. These findings indicate that the older adults used their attentional resources to help favor positive rather than negative information in their memories. In addition, older adults' negativity effect in the divided attention condition suggests that emotional goals may have unintended consequences when cognitive resources are not available to fully implement the emotional goals. These unintended consequences may be due to the "ironic processes of mental control" (Wegner, 1994), in which attempts to control one's own mental state can have opposing effects to the goal, because 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.

The ability of threatening information to automatically capture younger adults' attention is a well-established finding (for reviews, see Dolan, 2002; Ohman, Flykt, & Esteves, 2001). One possible contributing factor to positivity effects may be an age-related selective impairment in the neural mechanisms responsible for detecting negative information. If age compromises this capacity, positivity effects could be the downstream consequence. However, recent findings of equivalent threat detection advantages for older and younger adults searching for discrepant faces among arrays of neutral faces suggest that, like younger adults, older adults detect threatening stimuli more quickly than other types of stimuli and the magnitude of this threat

detection advantage does not decline with age (Hahn, Carlson, Singer, & Gronlund, in press; Mather & Knight, 2006).

In contrast, 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 even though 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, healthy older adults showed less sustained attention to negative but not positive stimuli relative to younger adults (Rosler et al., 2005). Rosler et al. (2005) presented older and younger adults with emotional-neutral image pairs for 10 seconds each and measured their initial fixation and dwell times. There were no age differences in the pattern of initial fixations. Both age groups showed a tendency to fixate first on emotional rather than neutral pictures. Overall, both age groups spent more time looking at emotional (positive and negative) rather than neutral pictures. In addition, younger adults showed greater sustained attention to negative pictures in negative-neutral pairs than older adults (Rosler et al., 2005).

Both sets of findings are consistent with socioemotional selectivity theory's basic tenet that the perception of diminishing time left in life makes emotional goals a high priority. Because

older adults are presumably more focused on making the most of their immediate emotional experience relative to younger adults, this should be reflected in the kinds of stimuli they pay the most attention to. However, these positivity effects in attention are suggestive of a goal-directed process, but not definitive. A more direct way of testing our hypothesis that the positivity effect results from goal-directed processes is to manipulate the degree of cognitive control participants can exert during their viewing of emotional information and look for differences in patterns of eye movements as a function of age and the availability of cognitive control processes. In the current 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 towards emotionally arousing stimuli (Hahn et al., in press; 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 age differences in the way visual attention is allocated that correspond with age differences in the salience of emotion regulation goals. 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, if we interfere with older adults' ability to recruit the cognitive resources necessary to implement their emotional goals, this 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 a group of older (65-83 years; $M = 75.00$, $SD = 5.99$; $N = 27$) and a group of younger (18-29 years; $M = 19.85$, $SD = 1.28$; $N = 33$) adults. Older adults (10 men and 17 women) were recruited through flyers posted throughout Santa Cruz County. All older individuals were screened for dementia using the CERAD 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 minute filler interval. Participants had to obtain a score greater than 3 correct on the 10-minute delayed recall test ($M = 6.00$, $SD = 2.56$) or at least 7/10 on the delayed recognition test ($M = 9.48$, $SD = .98$) to be included in the data set. This resulted in the exclusion of one additional older participant. The younger participants (13 men and 20 women) were either students at UC Santa Cruz participating in exchange for course credit or members of the community who received payment. Participants driving from off campus received \$50 and those from on campus received \$40. An additional 12 older adults and seven 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 vocabulary measure (Nelson & Denny, 1960).

Stimuli. Participants viewed 96 pictures (32 negative, 32 positive, and 32 neutral). Ninety-four were from the 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 ($M = 6.38 \pm .24$) and negative images ($M = 6.37 \pm .32$) did not differ significantly from each other, $t(30) = -.015$, ns. Likewise, the average IAPS arousal rating of the low arousal positive ($M = 4.53 \pm .18$) and negative images ($M = 4.55 \pm .20$) did not differ significantly from each other, $t(30) = .86$, ns. The positive images ($M = 7.39 \pm .10$) and negative images ($M = 2.71 \pm .28$) 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 ($M = 3.16 \pm .30$) and fell around the midpoint of the valence scale ($M = 5.07 \pm .10$).

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 subjects, 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 subjects. Within subjects, 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 by 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. We used 30 pairs (30 males and 30 females) of photographs of different faces. 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). Each sound sequence alternated between two different tone patterns spliced together using Sound Studio (Software, 2002). The sound sequences were equal in duration to the presentation time for the picture pairs (6 seconds) and randomly alternated between trials in which the sound pattern changed two or three times. There were three different 3-tone patterns (for the 2-change trials), and three different 4-tone patterns (for the 3-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 2-or 3-sound changes on the basis of a simple heuristic.

Apparatus. Stimuli were presented on a 17" monitor operating with a refresh rate of 85 Hz. Presentation and randomization of stimuli, as well as the recording of manual response data (RT and accuracy) were handled by E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) software running on a 1GHz Pentium computer. Manual responses were entered on a four-button box (Cedrus, Inc.). 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 and the Positive and Negative Affect Scale (PANAS), a brief questionnaire consisting of 10 positive and 10 negative emotion words (Watson, Clark, & Tellegen, 1988), participants were seated approximately 30 inches from the computer screen. Before beginning the task, participants' gaze coordinates were mapped to a standardized gaze space via 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 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 seconds 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 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 seconds.

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: anytime the velocity of the eye was beneath 20 degrees/second for at least 90 ms, a fixation began, and it ended when the velocity threshold exceeded 20 degrees/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 paper, we used a .05 alpha level, included 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 ($M_{OLD} = 31.00 \pm 3.90$; $M_{YOUNG} = 27.38 \pm 3.10$), $t(57) = .15$, 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 to 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 first fixations aimed at positive and negative pictures paired with neutral pictures were analyzed with a repeated-measures ANOVA. Valence (positive, negative) was a within-subjects factor and age (younger, older) and attention (full, divided) were between-subjects factors. There were no significant main effects or interactions. On average, across participants, the proportions of first fixations to positive ($.59 \pm .03$) and negative pictures ($.59 \pm .03$) that were paired with neutral pictures were significantly larger than would be expected by chance, $t(59) = 7.18, p < .001$. Thus, younger and older adults showed similar patterns of fixating first on emotional pictures rather than on neutral pictures (Figure 1A).

The proportions of remaining fixations aimed at positive and negative pictures paired with neutral pictures were analyzed with a repeated-measures ANOVA. Age (younger, older) and attention (divided, full) were between-subjects factors and valence (positive, negative) was a within-subject factor. There was a significant age by valence by attention condition interaction, $F(1, 56) = 8.44, p < .01, \eta_p^2 = .13^1$. In the full attention condition (Figure 2A), the proportion of younger adults' fixations to negative pictures in negative-neutral pairs ($.63 \pm .05$) was larger than the proportion of fixations to positive images in positive-neutral pairs ($.57 \pm .05$). In contrast, the proportion of older adults' fixations directed to positive pictures ($.58 \pm .05$) was larger than the proportion directed to negative pictures ($.53 \pm .05$). The pattern for older adults reversed in the divided attention condition (Figure 2B), with a larger proportion of fixations to negative pictures ($.57 \pm .05$) than to positive pictures ($.52 \pm .05$). For younger adults in the divided attention

condition, the proportion of fixations to negative pictures ($.53 \pm .04$) was similar to the proportion directed to positive pictures ($.54 \pm .04$).

Emotional/Emotional Picture Pairs. Separate ANOVAs with age (younger, older) and attention (divided, full) as fixed factors were carried out 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 fixations aimed at positive and negative faces paired with neutral faces were analyzed with a repeated-measures ANOVA. Age (younger, older) and attention (divided, full) were between-subjects factors and valence (positive, negative) was a within-subject factor. There were no significant main effects or interactions. Across participants, the proportion of first fixations to positive faces ($.54 \pm .05$) did not differ significantly from the proportion of first fixations to negative faces ($.52 \pm .04$), $F < 1$, ns. In contrast with the first fixations to pictures, the proportion of first fixations to an emotional face rather than its neutral counterpart ($.53 \pm .04$) was not different from chance, $t(59) = 1.52$, $p = .14$ (Figure 1B), which may be because positive and negative facial expressions are not as arousing as the positive and negative pictures we used.

The proportions of remaining fixations aimed at positive and negative faces paired with neutral faces were analyzed with a repeated-measures ANOVA. Age (younger, older) and attention (divided, full) were between-subjects factors and valence (positive, negative) was a within-subject factor. The results showed a significant age by valence by attention condition interaction, $F(1, 56) = 7.99, p < .01, \eta_p^2 = .13^2$. The proportion of younger adults' fixations to negative faces ($.54 \pm .08$) in the full attention condition decreased when attention was divided ($.40 \pm .07$). In contrast, the proportion of younger adults' fixations to positive faces ($.49 \pm .08$) in the full attention condition increased when attention was divided ($.55 \pm .07$) (Figure 3A). The proportion of older adults' fixations to negative faces ($.47 \pm .08$) in the full attention condition did not change much when attention was divided ($.48 \pm .08$). In contrast, the proportion of older adults' fixations to positive faces ($.53 \pm .08$) decreased when attention was divided ($.45 \pm .08$) (Figure 3B).

Emotional-Emotional Face Pairs. Separate univariate ANOVAs with age (younger, older) and attention (divided, full) as fixed factors were carried out 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 consistent with our cognitive control-based account of the positivity effect in older adults' information processing tendencies (Mather & Knight, 2005).

In the full attention condition, we replicated previous findings of positivity (or anti-negativity) 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). However, what distinguishes this work from previous investigations of the role of visual attention in age-related positivity effects is the fact that we assessed attentional patterns both under full attention and under attentional load. The manipulation of attentional resources is important in light of the fact that previous findings of an attentional bias away from negative stimuli in older adults could potentially be related to age-related deficits in identifying negative facial expressions (e.g., Brosigole & Weisman, 1995; Calder et al., 2003; Sullivan & Ruffman, 2004; Wong, Cronin-Golomb, & Nearing, 2005) or in impairments in early visual emotion discrimination (e.g., Wieser, Muhlberger, Kenntner-Mabiala, & Pauli, 2006; but see Hahn et al., in press; Mather & Knight, 2006).

By dividing attention and thereby reducing available cognitive resources, we were able to reverse older adults' tendency favor positive faces and pictures in their attention more than negative faces and pictures. These findings support the hypothesis that positivity effects in older adults are the result of goal-directed processes that require cognitive control (Mather & Carstensen, 2005; Mather & Knight, 2005). Of additional interest is the fact that the attentional manipulation also influenced younger adults' gaze patterns. When distracted, they were less likely to favor negative stimuli in their attention. 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.

These findings implicating cognitive control processes in older adults' positivity effect support Knight and Mather's (2006) interpretation of recent neuroimaging results showing

greater brain activity in prefrontal and anterior cingulate regions in the context of decreased amygdala activity in response to negative stimuli among older adults relative to younger adults (e.g., Fischer et al., 2005; Gunning-Dixon et al., 2003; Tessitore et al., 2005; Williams et al., 2006; Wright et al., 2006) as reflecting emotion regulatory top-down control processes rather than compromised neural integrity.

Consistent with our predictions, participants' first fixations favored emotionally arousing over neutral pictures and this effect was similar across the two age groups. This suggests that, regardless of valence, arousing stimuli attract attention for both younger and older adults before they have been looked at directly. It is interesting to note 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. From our pattern of findings, it appears that arousal, not valence, is the critical characteristic that draws the first fixation to a particular image. The amygdala seems to play a critical role in the preattentive processing that identifies arousing stimuli (Morris, Ohman, & Dolan, 1998; Pessoa, 2005; Öhman, 2005) and thus our finding that older adults' first fixations were drawn to arousing pictures just as much as younger adults' first fixations adds to previous evidence that amygdala still operates effectively among older adults (Mather & Knight, 2006; Mather et al., 2004).

A potential alternative account of our findings that divided attention reversed the emotional biases in more sustained attention 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 might 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 still showed a reversal of their positivity effect in their later memory.

Previous studies of age and emotional attention using pairs of items have only included trials with emotional vs. neutral stimuli, rather than two emotional stimuli (Isaacowitz et al., 2006b; Mather & Carstensen, 2003; Rosler et al., 2005). In our study, we also included some trials that pitted positive and negative stimuli directly against one another. We were surprised to find no significant attentional effects in this condition, in contrast with the opposing attentional biases to positive and negative stimuli when shown with neutral stimuli.

One possibility is that the lack of an age by 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. 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 and the faces conditions (significant effects in the emotional-neutral condition versus 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. 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 individuals who are optimistic, younger adults who perceive time as limited, and older adults (Isaacowitz, 2005; Mather & Carstensen, 2003; Pruzan & Isaacowitz, 2006; Rosler et al., 2005). While such findings are consistent with socioemotional selectivity theory, which emphasizes the impact of time perspective on the prioritization of emotional goals, there is evidence that gaze may serve a broader purpose involving the achievement of control over one's environment (Light & Isaacowitz, in press). Our findings support the notion that eye gaze reflects goal-directed processing.

In addition, our findings suggest that although the emotion-focused goals of older adults may be chronically activated (e.g., Kennedy, Mather, & Carstensen, 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. An interesting future direction involves determining to what extent older adults use gaze as a general tool of motivation beyond the affective domain 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 is 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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Footnotes

¹ The age by valence by attention interaction for pictures remained significant when including the PANAS positive and negative scores as covariates, $F(1,51) = 8.48, p < .01, \eta_p^2 = .14$, and when including vocabulary scores as covariates, $F(1, 51) = 6.42, p < .05, \eta_p^2 = .11$.

² The age by valence by attention interaction for faces remained significant when including the PANAS positive and negative scores as covariates, $F(1,49) = 9.53, p < .01, \eta_p^2 = .16$, and when including vocabulary scores as covariates, $F(1,50) = 10.85, p < .01, \eta_p^2 = .18$.

Table 1. Proportion of first fixations to negative scenes and faces in emotional-emotional pairings.

	Full	Divided		Full	Divided
Picture Stimuli: Positive-Negative Pairs			Face Stimuli: Positive-Negative Pairs		
Younger	.52 (.03)	.51 (.03)	Younger	.46 (.05)	.48 (.05)
Older	.47 (.03)	.49 (.03)	Older	.48 (.05)	.48 (.05)
Total Pictures	32	32	Total Faces	10	10

Note. Standard errors are in parentheses

Table 2. Proportion of fixations (excluding the first fixation) to negative scenes and faces in emotional-emotional pairings.

	Full	Divided		Full	Divided
Picture Stimuli: Positive-Negative Pairs			Face Stimuli: Positive-Negative Pairs		
Younger	.56 (.03)	.48 (.03)	Younger	.52 (.04)	.49 (.04)
Older	.51 (.03)	.51 (.03)	Older	.45 (.04)	.49 (.04)
Total Pictures	32	32	Total Faces	10	10

Note. Standard errors are in parentheses

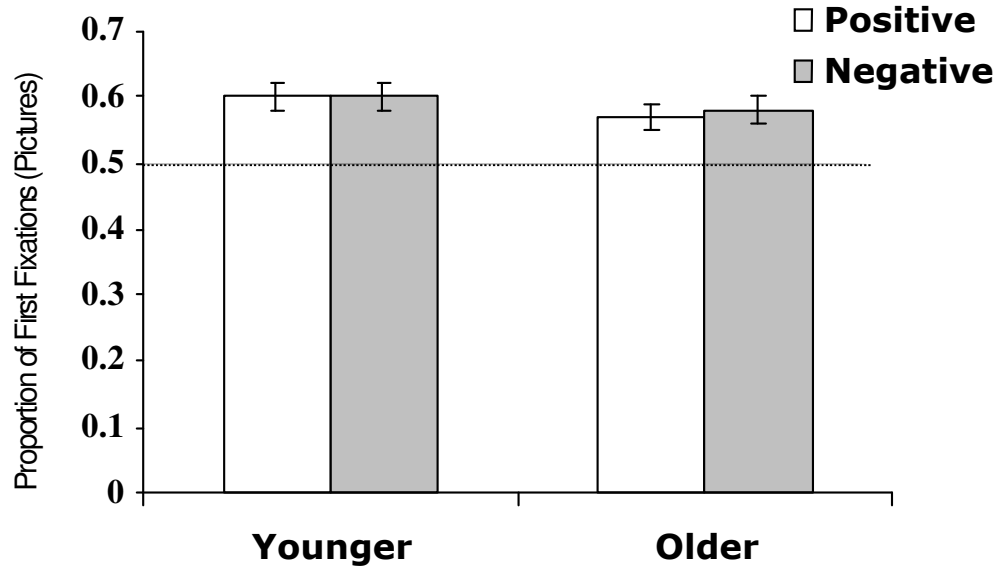
Figure Captions

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

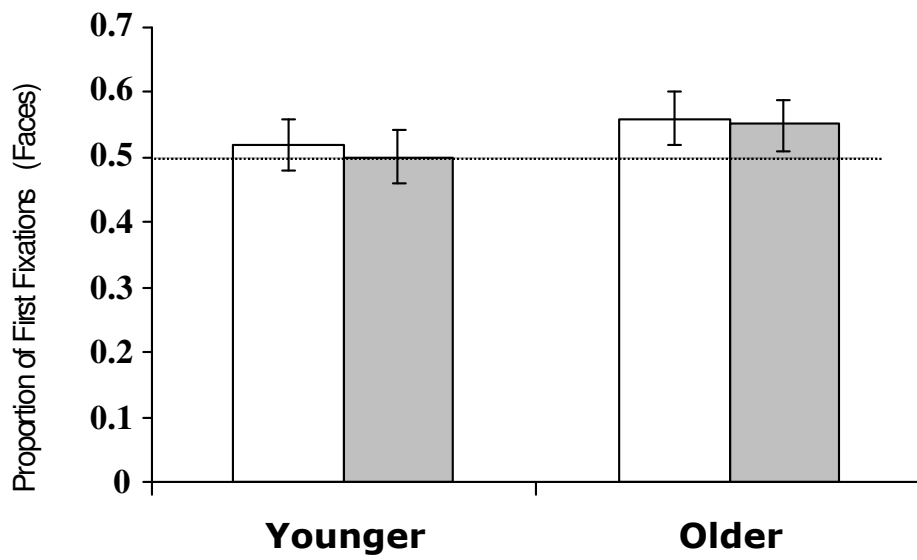
Figure 2. Proportion of remaining fixations to positive and negative pictures paired with neutral pictures in the full attention (A) and divided attention condition (B). Error bars display the standard error.

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

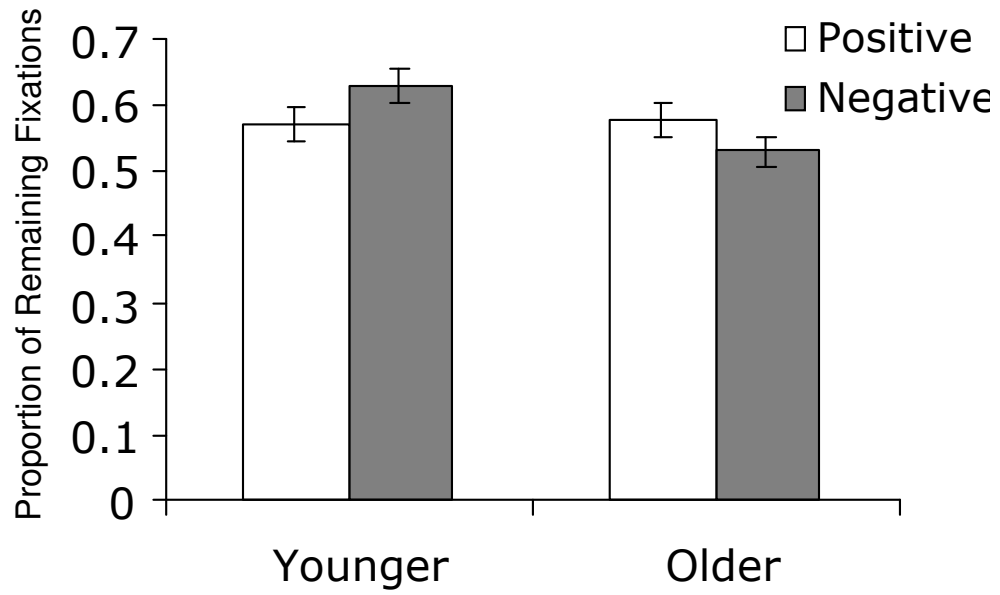
A.



B.

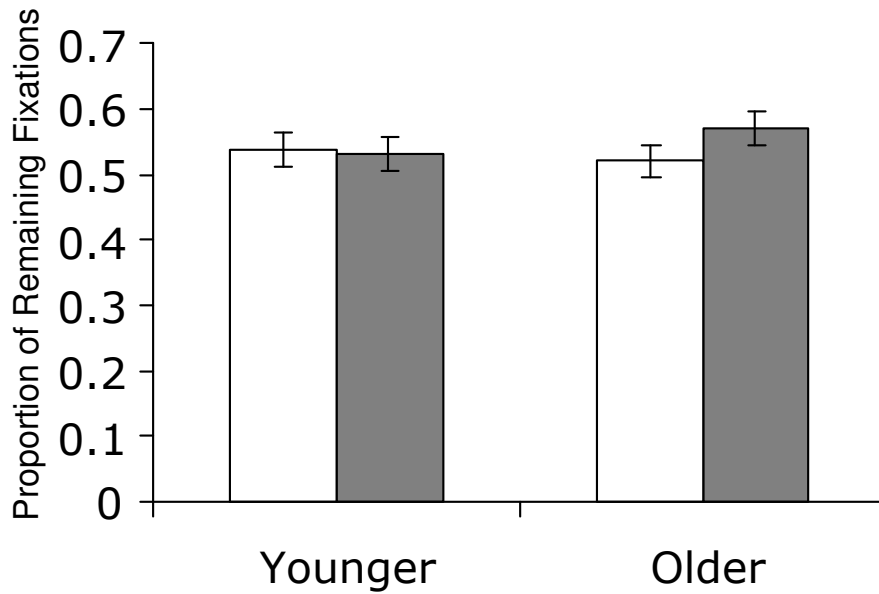


A.



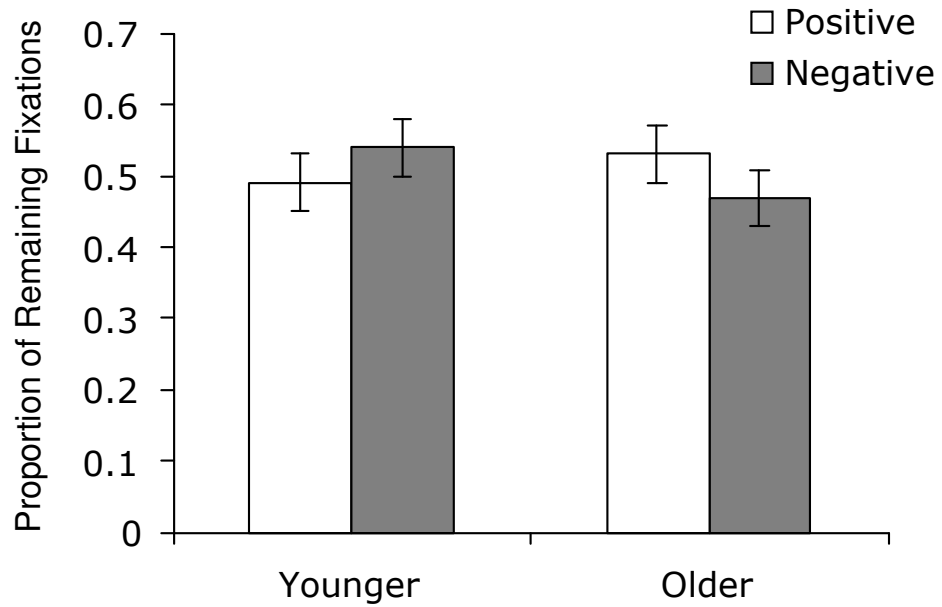
B.

Full Attention



Divided Attention

A.



B.

