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Use of gaze for real-time mood regulation: Effects of age and attentional functioning

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Abstract

Older adults show positive preferences in their gaze toward emotional faces, and such preferences appear to be activated when older adults are in bad moods. This suggests that age-related gaze preferences serve a mood regulatory role, but whether or not they actually function to improve mood over time has yet to be tested. We investigated links between fixation and mood change in younger and older adults, as well as the moderating role of attentional functioning. Age X Fixation X Attentional Functioning interactions emerged, such that older adults with better executive functioning were able to resist mood declines by showing positive gaze preferences. Implications for the function of age-related positive gaze preferences are discussed.

Keywords

Gaze; attention; emotion regulation

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Older adults show preferential gaze toward positive and away from some negative stimuli. Whereas findings regarding age-related positive preferences in attention and memory have been somewhat mixed (Murphy & Isaacowitz, 2008), gaze patterns assessed at full attention have consistently shown age-related positivity (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a, 2006b; Knight et al., 2007). Why, though, do older adults display such patterns? A functional account of gaze preferences shown by older adults asks what such preferences do for the perceiver. By observing the contexts in which such preferences arise, and what changes they cause for the perceiver, the function of such preferences can be delineated. This is important for understanding the underlying mechanisms that produce age-related changes in processing emotional stimuli. Below, we review the main theoretical perspective offered to

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explain findings from memory and attention studies noting a positive preference in older adults, and describe the methods we developed for examining the functional account offered by that perspective.

Why Do Older Adults Show Positive Gaze Preferences? The Regulatory Account

The idea that older adults may display “positivity effects” in their processing of valenced stimuli arose from a motivational account of age-related shifts in socioemotional goals. Socioemotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999) argues that time perspective changes throughout adulthood: as individuals move from a relatively expansive to a more limited view of their future there is a corresponding change in goals, from acquiring knowledge to regulating and optimizing affective state. “Positivity effects” in information processing (e.g., Carstensen & Mikels, 2005) are a logical cognitive implementation of these goals: focusing processing on positive and away from negative stimuli can help the perceiver to regulate mood and optimize affect. From the motivational perspective of socioemotional selectivity theory, positive gaze preferences are a *regulatory* tool older adults use to manage their affective experience. Importantly, work by Mather and colleagues suggests a cognitive control account, whereby older adults require adequate cognitive resources, especially executive control, to use their information processing for mood regulatory purposes (e.g., Knight et al., 2007).

While a mood regulatory function of positive processing preferences in older adults has been proposed, one lingering problem with the regulatory account is that regulation is presumed; in most studies, older adults’ processing of emotional stimuli is observed in the lab, but preferential processing has not been linked to actual regulation of mood in real-time. We have started to address this by testing whether gaze preferences show a mood regulatory function: do they arise in contexts in which there is a mood state that needs to be regulated, and do they actually work to help regulate mood in those contexts? Using this approach, we found that older adults selectively activate positive gaze preferences when in a bad mood (Isaacowitz, Toner, Goren, & Wilson, 2008), providing preliminary support for the idea that the function of such age-related gaze preferences is regulatory. However, an important functional aspect remains to be tested: namely, do positive gaze preferences actually help older adults to regulate their mood?

The study that has come closest to testing whether positive preferences work to facilitate older adults’ mood regulation involved autobiographical memory in middle-aged and older nuns (Kennedy, Mather, & Carstensen, 2004). Nuns (age 47–102) instructed to focus on their emotions displayed a positive bias in their autobiographical memory; they were also asked about change in mood during the task and findings suggested that the positive autobiographical memory bias was related to better self-reported mood. However, other groups (including the group of non-manipulated older adults) were not asked to report on their mood change, making the mood improvement reported by the “regulate emotions” manipulation group difficult to interpret.

The Role of Individual Differences

Trying to connect activation of gaze preferences to real-time mood change brings up a serious concern: despite evidence of age-related “positivity effects” that are considered to serve a regulatory function (Carstensen & Mikels, 2005), other individual difference variables may also influence whether and how gaze is used for mood regulation. For example, the cognitive abilities of the perceiver may constrain what strategies they can use to regulate how they feel. Mather and colleagues (e.g., Knight et al., 2007) have proposed that older adults need adequate cognitive control resources to display positivity effects in attention and memory, because such positivity may involve top-down modifications of more rapid tendencies to focus on the negative. This suggests that, when linking a particular cognitive mechanism to real-time mood change, relevant individual difference variables related to that cognitive mechanism must also be considered.

In the context of using gaze for mood regulation, the most relevant individual difference is likely to be the functioning of the general attentional system. An older adult with a weak attentional system may be unable to use positivity effects, as proposed by Mather (e.g., Knight et al., 2007). One problem with linking general attentional ability to on-line mood regulatory strategies is that attention is not a unitary construct. For example, Posner (2008) has identified three independent attentional networks: alerting, orienting, and conflict/executive control. The executive control network is closest to Mather's concept of cognitive control.

The Current Study

Therefore, in the current study we directly investigated whether positive preferences help older adults to regulate their mood state in real time, and to what extent this depended on the functioning of their attentional system, especially their executive control. As we had already shown that older adults "turn on" positive gaze preferences when in a bad mood (Isaacowitz et al., 2008), we focused on the later mood effects of these preferences. Our interest was in the use of fixation towards emotional stimuli as a *tool* of regulation rather than as the source, or elicitor, of the mood onset itself: we wanted to see how perceivers used their processing of such emotional images in ongoing efforts to regulate how they feel. The real-world parallel to our task would be when someone argues with their spouse (the elicitor), then watches the news on TV. The news itself has emotional content (some stories may be happy, some may be fearful), but that emotional content is irrelevant to the elicitor. Despite this, what someone watches (and how) can be used by the perceiver to regulate mood, and this is the process we are modeling in our analyses: how does someone regulate how they feel when presented with emotional information?

To investigate this, we evaluated whether gaze preferences during a lengthy stimulus presentation were related to overall mood change from the start to end of that session. Critically, we also analyzed the moderating role of attentional ability to determine the impact of executive control on links between gaze and mood change in young and older samples. This was an attentional parallel of recent work linking cognitive control to positivity effects in memory (Petrican, Moscovitch, & Schimmack, 2008). We expected to find a moderating role of executive functioning for older adults; consistent with the cognitive control account (Knight et al., 2007), positive gaze preferences were hypothesized to serve a mood regulatory function only for those older adults with good executive functioning.

We examined fixation to several negative emotional stimuli (anger, fear and sadness) as well as to one type of positive emotional stimuli (happiness) for two reasons: Methodologically, we have found somewhat differential patterns of fixation preference for different negative emotions in past eye tracking work (Isaacowitz et al., 2006-a,b; 2008). Conceptually, there is a growing body of research suggesting age may affect discrete negative emotions – and their regulation – differentially (e.g., Blanchard-Fields & Coats, 2008).

Method

Participants

Participants were 85 young adults (36 men, 49 women) aged 18–25 years (*M*=19.72, *SD*=1.82) recruited through an introductory psychology course and on-campus flyers, and 106 community-dwelling older adults (30 men, 76 women) aged 58–89 years (*M*=72.39, *SD*=7.23) recruited through a lifelong learning program and community advertisements. All participants were reimbursed with either course credit or a monetary stipend. Participants were excluded if they could not be calibrated (due to droopy eyelids, etc.), if they were not successfully tracked for ≥ 68 (25% of) trials, if their ratio scores were > +/− 3 SDs from the group means, or if they lacked mood scores due to computer error. This left 68 younger adults (80%) and 51 older adults (48%) for analysis. Further information on the sample is available in Isaacowitz et al. (2008).[1]

Visual Stimuli and Recording

Slides portraying an emotional synthetic face and a neutral version of the same synthetic face were used as stimuli for the eye tracking presentation. These faces lack distracting features such as wrinkles, skin and hair texture and control for luminance and color (Wilson, Loffler, & Wilkinson, 2002). The synthetic faces also maintain individual facial identity and reliable negatively-valenced (anger, fear, sadness), positively-valenced (happiness), and neutral expressions. More details on the stimuli can be found in Isaacowitz et al. (2006b). Presentation slides were set against a gray background screen. Three variables were counterbalanced to avoid order effects: side of screen (left, right) on which the emotional face appeared, sex of face (136 male, 136 female), and emotion portrayed (anger, fear, sadness, happiness).

GazeTracker software (Eye Response Technologies, Inc., Charlottesville, VA) presented and randomized stimuli on a 17” display. Eye movements were recorded at a rate of 60Hz using an Applied Science Laboratories Model 504 Eye Tracker. Fixations were defined as an interval in which gaze is focused within 1° visual angle for 100ms or more (Manor & Gordon, 2003).

Mood Recording

A potentiometer slider (Empirisoft Corporation, New York, NY) was used to record participants’ self-reported mood. The potentiometer consists of a slider bar that participants move to indicate their mood, ranging from 0 (worst) to 100 (best), continuously during the eye tracking presentation. Data were recorded using RealTerm software at a rate of once per second; here, we report on slider mood at the start and end of the eye tracking session.

Evaluation of Attentional Functioning

The Attention Network Test (ANT: Fan, McCandliss, Sommer, Raz, & Posner, 2002) was administered to assess the functioning of three attentional systems: alerting, orienting, and conflict/executive control. In the ANT, participants view 288 trials of arrows, which appear either alone or embedded within either congruent or incongruent flankers, and indicate the direction of the arrow (left or right). Asterisks, either alone or in pairs, flash on the screen before many arrow trials. Some of these asterisk cues appear in a central location (center-cue trials), some appear on either side of the following arrow stimuli (double-cue trials), and some appear in the same area of the screen as the arrow stimuli that follow, thus predicting the arrow stimuli location (spatial-cue trials). In addition, there are some trials with no preceding asterisks (no-cue trials). The three attentional measures are calculated based on the relative reaction times to these various combinations of asterisk and arrow trials. The alerting effect is calculated as the mean reaction time (RT) to double-cue conditions subtracted from the mean RT to no-cue trials. This measures the effect of any preceding visual cue upon the reaction to the stimuli that follow as compared to conditions without forewarning. The orienting effect measures the mean RT of predictive spatial-cue trials subtracted from the mean RT to neutral center-cue

[1]Trackable younger participants were found to perform significantly better on the WAIS forward digit span (M = 7.69, SD = 1.18) than their nontrackable peers (M = 6.94, SD = .90), $F(1, 83) = 6.02$, $p < .05$. The same was true for the WAIS backward digit span, such that trackable younger participants (M = 6.21, SD = 1.44) again performed better than nontrackable ones (M = 5.35, SD = 1.46), $F(1, 83) = 4.75$, $p < .05$. However, neither digit span measure correlated with fixation in the sample. Comparisons of trackable and nontrackable participants of each age group revealed no other significant differences on any affective, cognitive, or demographic measures.

trials. Both types of cues alert the participant to the impending stimulus, but as the spatial cues predict the location of that stimulus while the central cues do not, they help to pre-orient the participant's gaze. The conflict effect is calculated by subtracting the mean RT to arrows with congruent flanking stimuli from the mean RT to conditions with incongruent flankers in order to measure the effect of conflicting cues on attention processing; in other words, the conflict effect is a measure of executive control. For a review of the ANT, see Wang, Fan and Johnson (2004). Higher scores on the conflict network indicate impairment by the conflicting stimuli, and thus worse executive control. Higher scores on alerting and orienting indicate a larger boost in performance in the presence of cues as compared to the no-cue and center conditions, respectively.

Procedure

After giving informed consent, participants completed self-report measures including demographic information and several affective questionnaires (see Isaacowitz et al., 2008). The Eich Continuous Music Technique (CMT: Eich & Metcalfe, 1989) was then performed to induce participants into a randomly assigned positive, negative, or neutral mood. In the CMT, participants imagine autobiographical events or hypothetical situations while listening to music selections that match a designated mood in order to induce themselves into that mood. Participants continuously rate their mood using a grid; the mood induction is considered successful when ratings remain within the appropriate area of the grid for at least 30 seconds.

Next, participants were seated in front of the eye tracker and potentiometer slider. A 17-point calibration was performed to ensure accurate measurement of participants' gaze. Participants were then told that they would be viewing a slideshow and should watch "naturally, as if watching TV at home." They were instructed in how to use the potentiometer and told that they would be rating their mood during the eye tracking presentation. Participants then rated their current mood from 0 (worst) to 100 (best) on the potentiometer. While the CMT created a range of moods, we used this initial potentiometer rating and not mood induction condition to divide mood groups for further analyses, using tertiles from the grand mean. These initial mood states were used to split participant groups in order to correct for any mood change that occurred after the end of the induction, thus ensuring accuracy of mood at the beginning of eye tracking. This resulted in six groups: younger adults who were initially in positive (N = 19, M = 81.58, SD = 8.36), neutral (N = 25, M = 57.68, SD = 5.65), or negative (N = 24, M = 34.67, SD = 10.34) moods and older adults starting in either positive (N = 18, M = 82.06, SD = 9.99), neutral (N = 13, M = 58.08, SD = 6.18), or negative (N = 20, M = 39.50, SD = 10.94) moods.

The eye tracking presentation consisted of 272 emotional face pair trials which were each displayed for four seconds and followed by a 0.5 second crosshair slide to re-align gaze to the center of the screen. To minimize skew of results due to blinks and moments of lost tracking (from excessive head movement, pupil obfuscation, etc.), two criteria were used to exclude individual trials in which the fixation pattern indicated unreliable recording: trials with all fixations to "off" regions (no fixations on either face), or trials with < 900ms total fixation anywhere on the slide (see Isaacowitz et al., 2008). Finally, participants completed the ANT before being debriefed and receiving compensation.

Results

A mixed model ANOVA was used to investigate change in mood over the entire presentation. Three IVs were utilized in this analysis: age group (younger adult, older adult), initial mood state (positive, neutral, negative), and time (start of presentation, end of presentation). The dependent variable was "current" mood as assessed by the potentiometer. A main effect of Initial Mood State emerged, $F(2, 113) = 60.12$, $p < .001$, $\eta_p^2 = .52$, indicating that those who started in positive moods had the highest average slider ratings (M = 68.75), those who started in neutral were in the middle (*M* = 49.33), and those who started in negative moods had the lowest (*M* = 38.44). A main effect was also found for Time, $F(1, 113) = 44.99$, $p < .001$, $\eta_p^2 = .29$, such that mood ratings declined overall from the beginning (*M* = 58.93) to the end of the presentation (*M* = 45.42), indicating that most participants found the task mood-disrupting. A marginally significant Age × Initial Mood State interaction emerged, $F(2, 113) = 2.79$, $p = .07$, $\eta_p^2 = .05$, as did a significant Initial Mood × Time interaction, $F(2, 113) = 24.11$, $p < .001$, $\eta_p^2 = .30$: whereas these initial mood groups were distinct at the beginning of the presentation by design, they were less so by the end of the tracking session.

The interaction of Age X Initial Mood State X Time also reached significance, $F(2, 113) = 3.92$, $p < .05$, $\eta_p^2 = .07$. Figure 1 suggests that young adults tended to end up in similar mood states regardless of their initial mood, whereas the initially positive older adults maintained a significantly better mood than did their initially neutral, $F(1, 29) = 12.93$, $p < .001$, $\eta^2 = .31$, and negative, $F(1, 36) = 10.01$, p < .05, $\eta^2 = .22$, age peers. Initially negative older adults ended with more positive mood ratings (*M* = 40.95, *SD* = 21.18) than did initially neutral older adults (*M* = 35.15, *SD* = 19.03), but this effect was not significant, $F(1, 31) = 0.64$, $p = 0.43$, $\eta^2 = .02$.

To investigate whether age, fixation and attentional ability predicted mood change from before to after the eye tracking session, a series of four regression models were conducted, each with mood change as DV but including fixation preferences to a different one of the four discrete emotions (anger, fear, sad or happy) as predictors in separate models.[2] Mood change was expressed as post-tracking mood minus pre-tracking mood; most scores were negative, indicating worsening of mood during the tracking. In each model, main effects of age, fixation, and each type of attentional ability (alerting, orienting, conflict) were entered in the first step, followed by 2-way interactions in the second step, and 3-way interactions in the final step.

The only significant effects were for happy and anger: both had significant Fixation (to happy or anger) X Conflict interactions (Happy: $\beta = .77$, $t = 2.01$, $p = .047$; Anger: $\beta = -.77$, $t = -2.40$, $p = .018$), qualified by significant Age X Fixation (to happy or anger) X Conflict interactions (Happy: $\beta = -.83$, $t = -2.09$, $p = .039$, model $R^2 = .140$; Anger: $\beta = .93$, $t = 2.68$, $p = .009$, model $R^2 = .176$). The three-way interactions are shown in Figure 2. In both cases, older adults with the lowest conflict scores – indicative of the best executive control – showed stable rather than declining mood when looking toward happy faces and away from angry ones. In contrast, young adults with the best executive control showed stable rather than declining mood when looking away from happy faces and toward angry ones.

Discussion

Do positive gaze preferences shown by older adults help them to escape bad moods and to prolong good ones? The current study tested whether age-related positive preferences in gaze, found in previous studies (Isaacowitz et al., 2006a, 2006b) and shown to emerge in contexts in which older adults are in a bad mood they need to regulate (Isaacowitz et al., 2008), actually do function to help regulate their moods. We asked whether there are links between fixation patterns and mood changes, and whether these links vary as a function of age and attentional ability.

Older adults who started in a positive mood retained their positive mood to the greatest degree throughout the eye tracking, whereas those in neutral and negative moods were comparably low in mood by the end of the tracking. More importantly, in multiple regression analyses, we

[2]All pairwise comparisons of fixation ratios by emotion type were correlated with each other significantly, both across age and separated by age group: coefficients were positive, except for happy fixation being negatively correlated with the others.

found interactions among age, fixation and conflict, one of three attentional networks that is an index of executive control of attention. Those older adults who best resisted declines in mood over the tracking period were those with good executive control who displayed positive gaze preferences by looking toward happy and away from angry faces. These findings extend Mather and colleagues' assertion (e.g., Knight et al., 2007) that positivity effects in attention may depend on the perceiver having adequate cognitive control ability: we show that it may not be the display of positive preferences per se but rather whether such preferences actually facilitate mood regulation that depends on the good functioning of the executive control system.

Young adults showed a different pattern of links between fixation, attentional ability and mood change. Those young adults with good executive control resisted mood decline when they showed negative gaze preferences, looking away from happy and toward angry faces. The nature of these effects requires further investigation; elsewhere, we have argued that young adults do not use gaze as a mood regulatory tool to the extent that older adults do (Isaacowitz et al., 2008), so how these gaze patterns relate to other regulatory efforts will be of interest for future research. Research in young adults suggests that reappraisal can demand cognitive resources if it happens late in the emotion process, even when it is successful (e.g., Sheppes & Meiran, 2008). High resource young adults may display a relatively negative looking pattern in order to gather relevant information for reappraisal; looking at a to-be-reappraised negative stimulus can guide thinking toward more favorable interpretations.

The paradigm used in the current study involved a strong time effect: participants' mood generally declined during the eye tracking session. The best outcomes were mood stability, not improvement. Nonetheless, in contexts in which most people experience mood decline, stability can be considered a successful regulatory outcome (e.g., Koole, 2008). Many participants did not experience mood stability; their mood declined over the course of the study. This was the case even though some showed positive gaze preferences. It will be a key question for future research to unravel why those older adults who showed positive gaze preferences but did not have excellent executive control were not able to effectively regulate their moods, and thus showed mood decline. One possibility is that their positive attention was not enough to help them override their dominant negative response to the context; their lack of cognitive resources prevented them from being able to use the positive attention to downregulate their response.

It makes sense that gaze may not help optimize affect in every situation; for example, in a time of extreme trauma it would not be expected that simply looking away from negative and toward positive stimuli would improve one's mood. However, there might still be moments of gaze-driven mood regulation, and even when positive gaze does not work to regulate mood, perceivers have other options such as cognitive change that can be used to achieve mood regulatory goals. In the case of young adults, who do not seem to benefit from using positive gaze for regulation, these downstream options may be preferred and most likely to facilitate their mood regulation.

Gaze is but one tool, albeit an important one, in the regulatory toolbox of older adult perceivers. This study shows that positive gaze preferences *can* help people feel good, but it depends on age, attentional functioning and the demands of the regulatory context. While there appear to be various paths to mood change, age and individual differences predict which paths will (and will not) facilitate regulation. Assertions that age-related "positivity effects" in attention arise for mood-regulatory purposes may therefore tell only part of the story; given that they accomplish this function only sometimes and only for some people, positive preferences either do not always work, or they can arise for other reasons.

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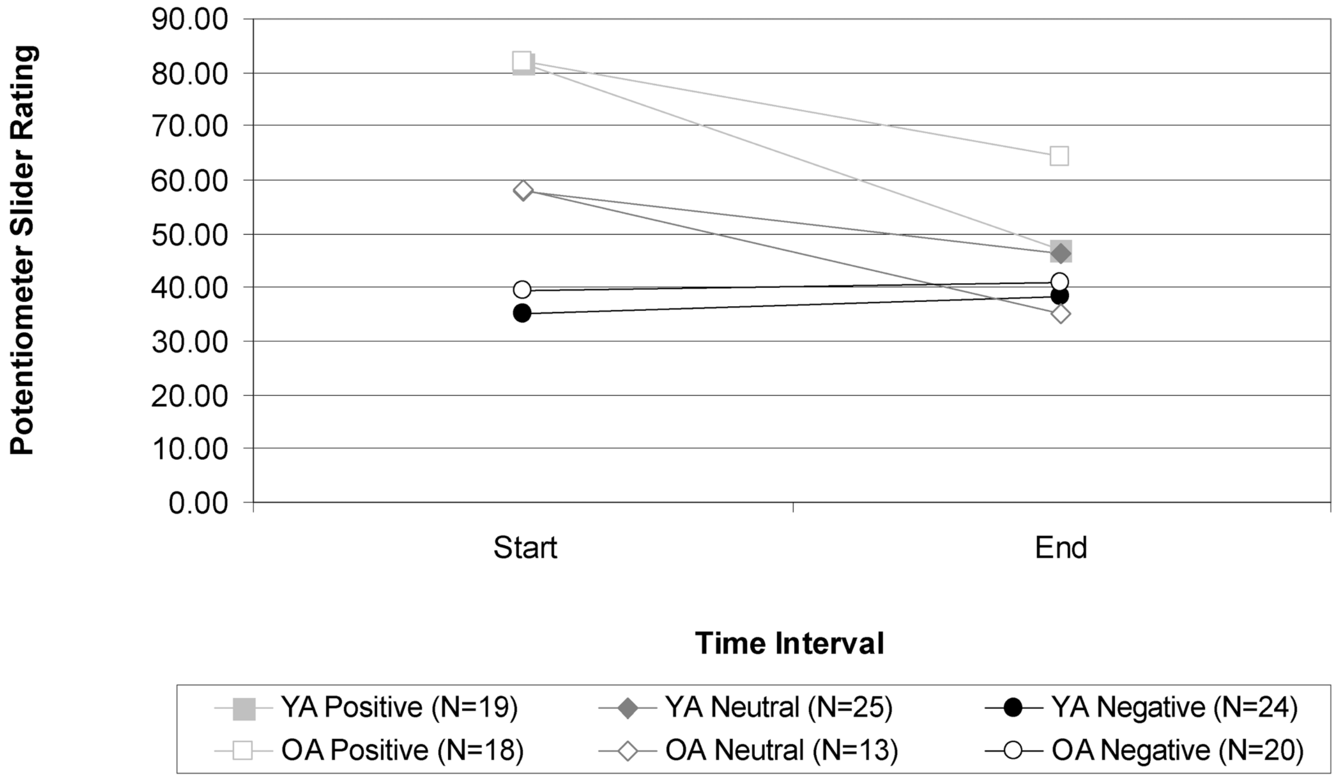
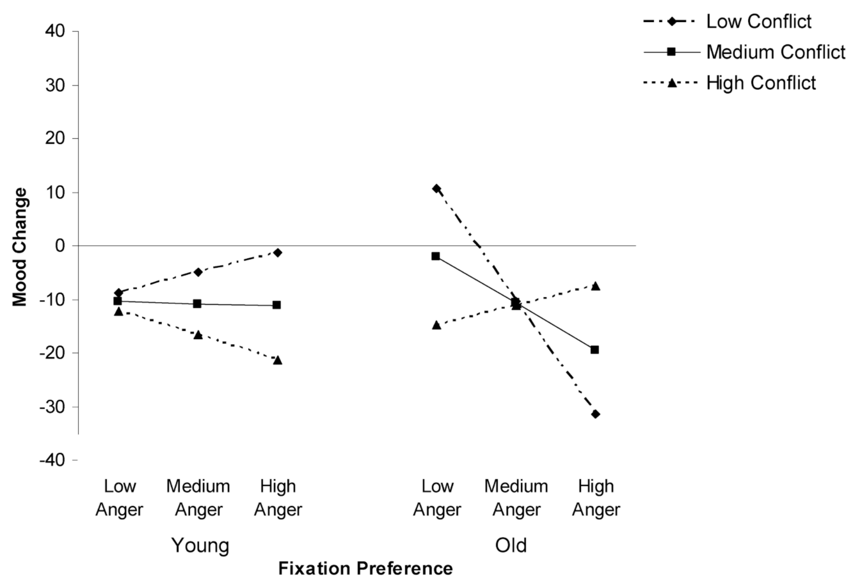


Figure 1.
Mean mood ratings by age group and initial mood state, at start and end of eye tracking.

A.)



B.)

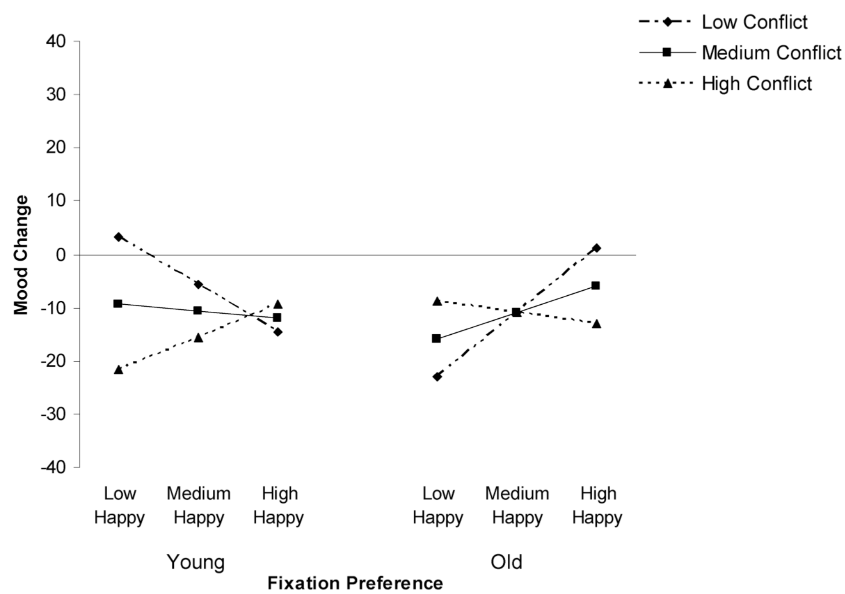


Figure 2.

Interactions of Age X Fixation X Conflict in the prediction of macro-level mood change for (a) anger and (b) happy. Low conflict scores indicate better executive control.