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Emotion Biases in Older and Younger Adults: Novelty Preference as an Index of Attention

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Abstract

Past research indicates that emotionally-relevant stimuli attract visual attention, but also that the relationship between emotion and attention allocation varies between young and older adults. Although both young and older adults respond automatically to threatening stimuli, older adults spend more time attending to positive stimuli, while younger adults attend more to all types of emotional stimuli. This age difference is proposed to be an effect of older adults' emotion-regulation goals in attention allocation. The present study used eye tracking to establish a sensitive measure of attention – novelty preference – and to observe the age-disparate effects of emotional valence on overt visual attention over time. Although older and younger adults showed similar novelty preferences to emotional (happy, angry, sad) stimuli compared to neutral and familiar stimuli, the time course of effect varied between the groups. Older adults allocated more attention to negative stimuli in the first few seconds of looking and more toward stimuli near the end of the 10-second looking period, whereas younger adults preferred all emotional stimuli to neutral and to familiar stimuli throughout the looking period. Novelty preference appears to be an effective way to measure differences in preferences for emotional information between age groups.

Emotion Biases in Older and Younger Adults: Novelty Preference as an Index of Attention

The investigation of the affective experiences of older adults, be it via autobiographical reports, empirical experimentation, or other methods, points toward an overarching positivity in individual daily affect, particularly when compared to younger adult populations (Mather & Carstensen, 2003, 2005; Charles, Mather & Carstensen, 2003; Charles, Reynolds, & Gatz, 2001). Given the general deterioration of many of the body's physical and cognitive systems as part of the natural aging process, it is worth investigating how older adults continue to regulate their emotional experiences as well as, or even better than, younger adults. Discovery of the mechanisms behind successful emotion regulation and behind the differences between younger and older adults in this process can contribute to the research of clinical emotion dysregulation across multiple populations. These populations span all ages, including children with conduct disorder and oppositional defiant disorder, teenagers and adults with depression, anxiety, and phobias, and older adults with dementias. Recently, the greater positivity experienced by older adults has been increasingly attributed to an augmentation of attention to positive information in one's surroundings and an attenuation of attention to negative information, termed a *positivity bias* (Mather & Carstensen, 2003). Research on the bias, however, has been marked by widely varying methodologies and conflicting results. The present study will propose a new, and perhaps more suitable method for studying the attention-driven aspect of this effect, and will discuss differences between younger and older adult populations in this effect.

There are at least two theories explaining the difference in how younger and older adults respond to emotional stimuli in these experiments. One theory is that it is psychophysically more challenging for older adults to perceive emotionally negative stimuli because sensory systems and cognitive processes deteriorate with age, and negative stimuli (specifically, human faces expressing anger) are physically more complex stimuli than neutral ones (Wilson, Loffler, &

Wilkinson, 2002). This would cause older adults to require more time when responding to angry faces, an effect that is interpreted as an attentional shift away from angry stimuli (Mather & Carstensen, 2003). However, excessively positive faces are also very complex, and studies that control for luminance, contrast, and even number of line segments using synthetic faces continue to find slower responses to negative faces (Isaacowitz, Wadlinger, Goren, & Wilson, 2006a, 2006b; Ohman, Lundqvist, & Esteves, 2001). Additionally, research has shown that older adults are just as accurate at identifying threatening information as younger adults are, that both older and younger adults detect emotional stimuli more quickly than neutral stimuli, and that both also detect threatening (angry) stimuli faster than non-threatening (happy or sad) stimuli (Mather & Knight, 2003; Ohman et al., 2001; Calvo, Avero, & Lundqvist, 2006). The latter two studies indicate that the decreased reaction time for detection of threatening information, regardless of age group, is due to an attention-capture effect. That is, they argue that orienting toward a threatening stimulus is an immediate and automatic process, whereas orienting toward a non-threatening stimulus is slower and requires serial processing. The automatic process appears uninhibited in older adults, making a difference in perceptual ability between older and younger adults an unlikely explanation for their divergent responses to emotional stimuli. In an emotion-discrimination experiment, Calvo et al. (2006) found quicker recognition across age groups for angry faces than for other emotional faces. They mention that this could be an indication that the image is being preattentively processed for emotional content or that some emotions lead to preattentive processing, supporting a "processing efficiency hypothesis." This hypothesis is that angry faces require fewer resources to process. Whether the processing efficiency is restricted to angry faces is unclear, however, as Phelps, Ling, and Carrasco (2006) found overall enhancement of perception related to emotional stimuli, and unrelated to attention or valence.

An alternative explanation of the positivity bias in older adults is socioemotional selectivity theory (SST) proposed by Carstensen, Isaacowitz, and Charles (1999). This theory relates motivational goals in information processing to the perception of one's life timeline. According to SST, older adults approaching the end of their lives are motivated by a goal of emotion regulation – to avoid negative or enhance positive emotions, or both. Younger adults, without this heightened awareness of a limited lifetime, are instead motivated to acquire information for survival. Evolutionarily, emotional stimuli, especially threatening ones, are an important source of information, as they often pertain to dangerous situations (Carstensen, Isaacowitz, & Charles, 1999). This could explain why, in showing greater attention to emotional stimuli than to neutral stimuli, younger adults seem to attend more to both positive and negative affect, not just positive. Socioemotional selectivity theory explains the performance results of older adults on memory tests for negative, neutral, and positive information. Older adults (aged 60 years and older) respond more quickly to, and have better memory for, emotionally positive stimuli relative to emotionally neutral and emotionally negative stimuli (Mather & Carstensen, 2003; Rösler et al., 2005; Isaacowitz et al., 2006a, 2006b), and this is attributed to the amount of attention allocated to the information or stimulus during initial encoding.

In younger adults, the pattern of effect is far from established. Whereas the positivity bias in older adults is a relatively robust finding – typically found to some extent across sub-populations and methodologies – younger adults vary more in response to viewing stimuli with emotional content. In the same study in which Mather and Carstensen found a positivity bias among older adults, they found no biases in reaction time or memory for emotional faces among younger adults (Mather & Carstensen, 2003). However, in 2005, Rösler et al. found that the same younger adult age group paid more attention to all types of emotional (both positive and negative) stimuli relative to neutral stimuli, displaying both a positivity and a negativity bias. Ito

et al. (1998) found that negative emotional stimuli received more processing attention following presentation than neutral and positive stimuli did. Using two different methodologies, eye tracking and dot-probe tasks (described below), Isaacowitz et al. (2006b) found younger adults to specifically attend more to fearful faces over neutral ones, and to respond no differently to happy, sad, or angry faces. Within the same year, however, they found an attentional bias away from sad information only in eye tracking and no biases in the dot-probe task (Isaacowitz et al., 2006a).

Emotional stimuli in the experiments discussed above are usually in the form of human faces displaying either one of several emotional expressions or a neutral expression. Alternatively, they may be of emotional scenes (e.g., positive: mother and child embracing; neutral: a piece of fruit; negative: a child holding a firearm). In some studies, attention allocation is measured with reaction time in a dot-probe task. In this task, participants view a display of at least two faces, often one neutral and one of varying emotional expressions. After a given time interval a probe replaces one of these faces, and participants respond either to its location or to some characteristic of the probe (e.g., orientation). If attention is already allocated to the spatial location of the face where the probe will appear, response time to the probe will be relatively short. Alternatively, if attention is allocated to the other face, it will have to be redirected to the other side of the visual field before detection can occur and a response can be made, thus increasing response time. In this way researchers use the dot-probe task to measure a preference toward or away from the emotional characteristics of the face stimuli that are presented. This method relies on the assumption that a detection time paradigm is a reliable measure of attention allocation. However, the method provides only a snapshot of where attention was allocated immediately before the probe appeared. This is typically exactly one and at most two or three time intervals after stimulus presentation. The method does not take into account the rapid shifts

of attention that occur when more than one stimulus is present on the screen (Rösler et al., 2005; Isaacowitz, 2006a, 2006b), and it certainly cannot measure stages of attention allocation. Indeed, displaying the probe one second earlier or later could potentially show a very different set of results and tell a very different story. More could be contributed to this discussion by measuring attention location multiple times during a test period. However, given this methodology, each additional time interval tested requires another permutation of trials to give enough power for statistical testing.

By using an overt measure of attention, eye tracking, one can measure relatively continuously without having to run an enormous number of trials. Eye movements can be a more robust and reliable measure of attention than dot-probe and memory tasks because they are typically automatic behaviors that closely follow covert shifts of attention (Kwak et al., 2007; Deubel & Schneider, 1996; Bradley, 2000; Hermans, Vansteenwegen, & Eelen, 1999). Eye tracking can indicate not only where attention is being allocated but also when (under what circumstances) it is redirected. Additionally, previous measures that introduce a variety of task demands may change the participants' goals during the experiment, thus distorting the underlying perceptual mechanism one is attempting to access. The ability to eliminate task demands from a study by using eye tracking can allow for ecologically valid testing when studying natural biases in attention in daily life.

Isaacowitz et al. (2006b), in reporting their results and analyses, used only total dwell time across the entire test phase (averaged over trials of 1, 4, or 8 seconds). This makes it impossible to see how preference for each stimulus of a pair changed over the course of those eight seconds, and it could be the underlying reason they found no tendency for older adults to attend toward negative images, or why they found disparate results with younger adults from one experiment to the next. It is therefore important to break the test phase into multiple time periods

and analyze attention allocation within each one separately. Additionally, their results indicate trends toward a negativity effect in younger adults, but these do not consistently reach significance. To more accurately measure the relative strengths of emotion and emotional regulatory mechanisms, and to provide a more sensitive measure of their interaction, the present study will introduce the aspect of novelty preference.

The novelty preference effect, a highly-studied modulator of overt attention, has primarily been used with infants and non-human primates to infer memory and to determine perceptual thresholds and stimulus preferences (e.g., Richmond, Sowerby, Colombo, & Hayne, 2004). Participants spend some set amount of time (the familiarization phase) looking at a visual stimulus. They are then presented with a pair of stimuli, one familiar and one novel, in the test phase. Preference for the novel stimulus is calculated as the proportion of time spent looking at the novel of these stimuli during the test phase. For example, if an infant is familiarized on a checkerboard of a given frequency, and in test phase attends longer to a novel, slightly higher frequency checkerboard, the infant's acuity is inferred to be high enough to perceive the difference (Fantz, 1964). The implication is that if no difference in looking time is observed the infant does not perceive that difference in frequency. Although it has not been shown to be an automatic process, novelty preference reliably occurs when participants are given no explicit instructions about where to allocate their attention. Richmond and colleagues (2004) used this paradigm to show that novelty preference occurs in adult humans across all ages.

By adding novelty preference to the study, it becomes possible to create a baseline for each group of interest, showing how they naturally follow interesting information across time. In the condition where the novel face is emotionally neutral, this method provides a control condition between the age groups. In essence it forces a preference toward one of the faces (even if both faces are neutral), and allows for using the change in this preference in response to

an emotional novel face as the dependent variable. Adding novelty gives older adults more natural inclination to look at the emotional faces. Preference for looking at a face that is not only uninformative but also familiar (rather than an informative, novel face) can best be explained by top-down regulatory mechanisms. Therefore, observing such a result would add scope to the investigation of the positivity effect by providing another dimension under which it operates, and identifying a natural viewing pattern that it inhibits. Additionally, the novelty preference effect is expected to diminish over time, making it possible to measure the modulation of duration of the effect as well as its strength. Supporting SST, older and younger adults alike would show a stronger (larger) novelty preference effect for emotional compared to neutral novel faces in the beginning of the test phase and make their first saccade toward an angry face, if one is presented. Younger adults would show a larger and longer-lasting novelty preference for all types of emotional faces in the test phase compared to neutral faces. However, in older adults the degree and duration of novelty preference is expected to be reduced when the novel face is threatening (angry), and to be larger and last longer when the novel face is positive (happy). Emotion-regulation goals would have led older adults to attend away from negative stimuli and toward positive stimuli, even in light of the reflexive processes that may initially draw attention toward threatening and toward novel stimuli.

Method

Participants

Thirty-five undergraduate students at Georgia Institute of Technology received course credit for participating in this study (*M* age = 19.3, *SD* = 1.42; 12 male). Thirty-five older adults (*M* age = 68.27, *SD* = 5.57; 17 male) were recruited from the community and compensated 20

USD for participation. All participants had normal or corrected-to-normal vision and gave informed consent before participating in this experiment.

Stimuli and Apparatus

The stimuli were black-and-white head and shoulder images of young adult actors and actresses (23 men, 17 women), displaying neutral, happy, angry (negative-threatening), and sad (negative-non-threatening) facial expressions. The images were pulled from the NimStim Face Stimulus Set – a battery of 646 facial expression stimuli developed by The Research Network on Early Experience and Brain Development (http://www.macbrain.org/resources.htm). Each image subtended 9.5° visual angle by 12.0 °. Each neutral image was used as a familiarization image a maximum of four times and was never paired with the same type of emotional face more than one time. The familiarization face was always neutral. The face it was paired with during the testing phase (the "novel" face) was matched on race and gender, and was never of the same actor or actress. The novel face displayed each of the four expressions (neutral, happy, angry, and sad) on ¼ of the trials. Although the same actors and actresses were viewed as the novel face multiple times, they always displayed a different emotional expression. The order and frequency with which each face appeared as the familiarization picture was counter-balanced across participants.

Eye movements were recorded with a SensoMotoric Instruments iView X corneal reflection eye tracker, recording at 60Hz. The eye tracker measured the pupil-to-reflection distance and angle at each calibration point, at known pixel locations, and interpolated pixel locations for any point within the calibration grid during the experiment. Visual fixation was measured with accuracy +- 1° visual angle. Participants were seated approximately 57 cm from

an 18-inch 1024x768 px monitor with an 85Hz refresh rate. An adjustable chinrest was used to minimize head movement.

Procedure

The eye tracker was calibrated on a nine-point grid before any trials began. This calibration was repeated between each block of trials to maintain consistent measurement and to correct for drift. After the chair and chinrest were adjusted to a comfortable height and calibration was completed, the participant was given verbal and written instructions. The participant began each trial by pressing the space bar when they were fixated on a fixation cross in the center of the screen. On each trial, one of the 40 neutral faces was presented at fixation for a familiarization period of 15 seconds, followed by a 1000 ms blank screen. Immediately thereafter, two faces appeared, one on each side of the visual field. The inner edge of each face's framing box was 10° from the fixation cross. One of these faces was identical to the image from the prior familiarization period; the other was a novel image. The novel image was either a neutral or an emotion face. If emotional, it displayed the happy, angry, or sad expression. The novel face was displayed on the right and left sides of the screen an equal number of times; and across the course of the experiment, each emotional valence was displayed in both hemispheres equally. The face pair remained on the screen for a test phase of 10 seconds. Participants were instructed to observe the face and the pair of faces as naturally as possible for the entire time of presentation. Minimal looking instructions and no task requirements were given in order to elicit natural looking patterns and preferences as much as possible. Eye movements and fixation durations during this test period were recorded. After the face pair disappeared, participants began the next trial by pressing the space bar when the black fixation cross remained in the

center of an otherwise blank screen. Each participant ran one session of 5 blocks, with 20 trials per block, for a total of 100 trials.

Analysis

This experiment included three factors of interest. The first, between-subjects, factor was Age Group, which had two levels: younger and older (ages 18-30 and 60-80, respectively). The two within-subjects factors were Emotion and Time. Emotion was the emotional expression displayed on the novel face. This factor had four levels: angry, happy, sad, and neutral. The second within-subjects factor was Time. The duration of the test phase was 10 seconds, with recordings every 16ms (i.e., 60 Hz). The most interpretable way to assess this data across time was to begin by breaking the test phase into two time periods (seconds 0-4 and seconds 5-10) and to follow emergent effects via subsequent analyses using shorter time periods. Therefore we initially gave the Time factor two levels.

Novelty preference score was computed as the amount of time spent looking at the novel picture as a proportion of the amount of time spent looking at either the novel or the familiar picture during the ten-second test phase. A novelty preference score for the entire test phase was calculated, as were individual scores for each of the ten seconds within the test phase. As we were most interested in what happened to the preference for novel information separately per Age Group when the information included emotional content, we ran separate 2 x 4 (Time x Emotion) within-subjects repeated measures ANOVAs for the two Age Groups. Within each of these analyses, we were interested in how any effects of emotion changed over time. To address this, we ran comparisons in each second of the ten second test phase, split by Emotion.

Given that no preference toward either face would result in looking at each face 50% of the time, any significant increase or decrease from 0.50 indicated preferential looking. Therefore,

we tested for the overall existence of a novelty preference effect by conducting t-tests to compare

overall, per emotion, and per second means to 0.50 for each group.

Results

Five adults in each age group were removed from analysis due to calibration errors or

otherwise faulty tracking, leaving 30 younger and 30 older participants for analysis. Novelty

preference is shown broken down by second in the ten-second test period and by emotion,

separately for younger and older adults in Figure 1(a-b). Results of the 2 x 4 Time x Emotion

comparisons for each age group are discussed below.
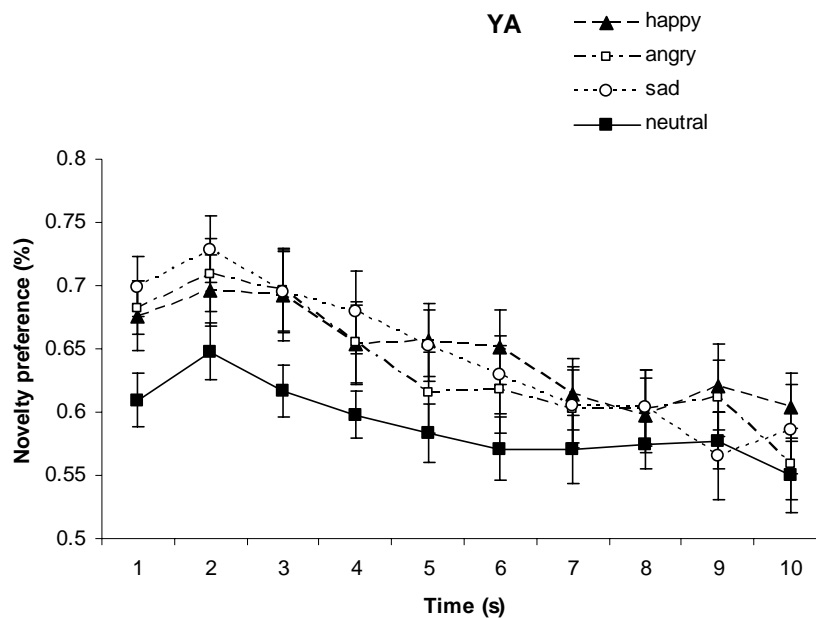
(a)
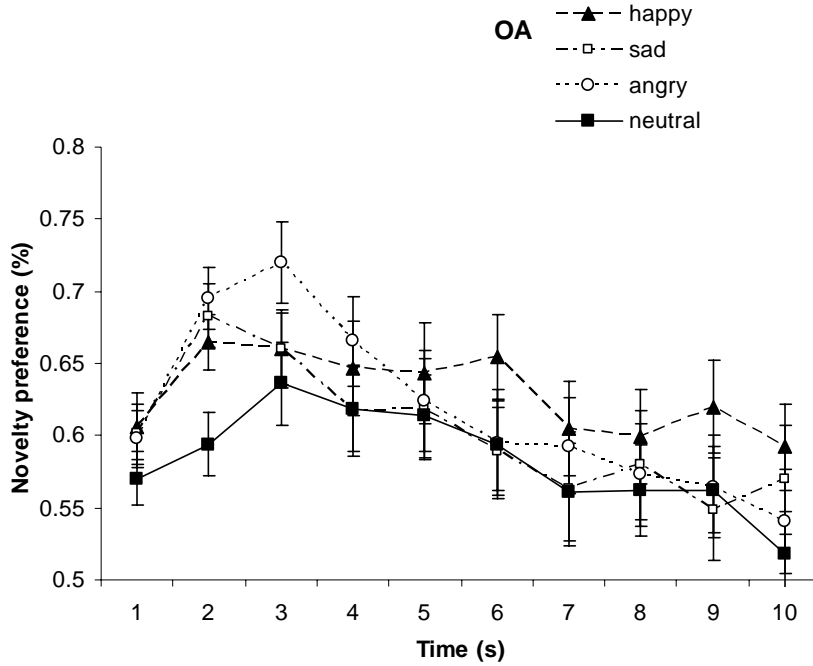
(b)

Figure 1. (a)YA novelty preference per emotion over time. The neutral condition shows a lower novelty preference across the first 7 seconds of the test phase. (b) OA novelty preference per emotion over time. Error bars represent standard error of the means.

Novelty preference effect

The overall preference (across emotion conditions) of novel stimuli over familiar stimuli – calculated as novelty preference difference from 50% – was significant for both younger and older adults (YA: M_{novel} = 62.8%, SE = .10; t = 7.033, $p < 0.001$; OA: M_{novel} = 61.65%, SE = 1.3; t = 4.983, $p < 0.001$).

For both age groups, all emotional conditions were significantly different from 0.50 (all t > 4.000, all $p < 0.001$). Also for both groups, the novelty preferences for the happy and angry conditions were significantly greater than the novelty preference for the neutral conditions (t = 2.698, t = 3.130, respectively for the younger group; t = 4.865, t = 2.961, respectively for the older group; all $p < 0.05$). In addition, for younger adults the difference in sad and neutral

novelty preference was significant ($t = 2.067$, $p < 0.05$), while that difference for older adults was marginally significant ($t = 1.939$, $p = 0.062$). The groups did not show between-subjects effects. They did not differ on novelty preference for the individual emotion conditions, although within each group the differences in novelty preference by emotion varied (see below, and Figure 2a).

Main effects of emotion and time

Both groups showed main effects of emotion (YA: $F = 4.097$, $p < 0.01$; OA: $F = 6.344$, $p = 0.001$) and of time (YA: $F = 24.291$, $p < 0.001$; OA: $F = 15.835$, $p < 0.001$).

The main effects of emotion and of time for each age group are shown in Figure 2(a-b). Each age group showed a significant linear effect of time (YA: $F = 24.291$, $p < 0.001$; OA: $F = 15.835$, $p < 0.001$). Additionally, in both groups the main effect of emotion was significant when comparing the average of the three emotional novel faces (angry, happy, sad) to neutral (YA: $F = 9.578$, $p < 0.005$; OA: $F = 14.292$, $p = 0.001$). Regarding Time, all preference scores for both age groups remained significantly above 0.50 until the 10th second of viewing (all $t > 2.723$, all $p < .05$), indicating a prolonged effect of novelty.

(a)
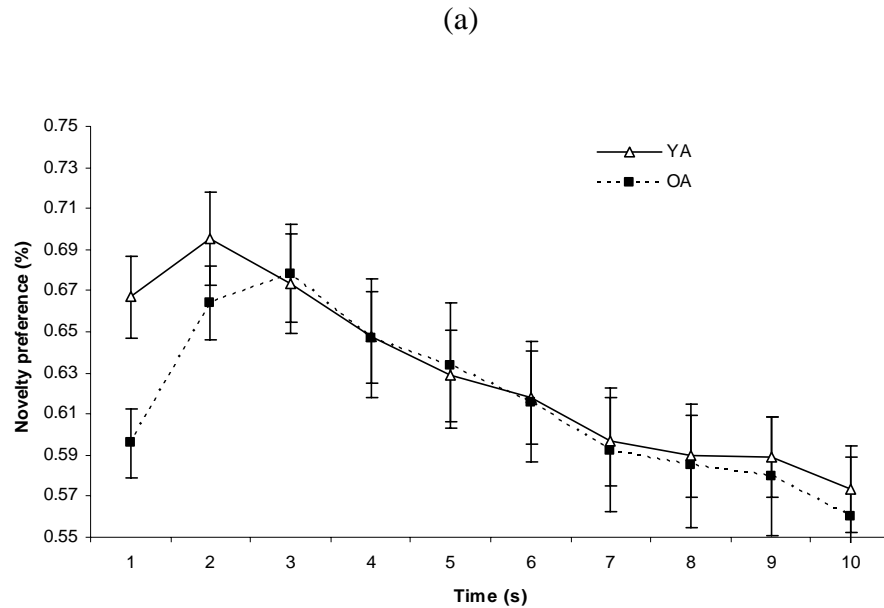
(b)

Figure 2. (a) Novelty preference by emotion. All conditions greater than 0.50; all YA emotional conditions greater than neutral; happy and angry OA conditions greater than neutral. (b) Novelty preference by time. All conditions greater than 0.50 until the 10th second for OA group. Error bars represent standard error of the means.

Collapsed across emotion, the two age groups looked very similar in novelty preference beginning in the 3rd second. Older and younger adults showed different novelty preferences in the very first second of the test phase ($t = 2.729$, $p < 0.01$), appeared to come together in the 2nd second, and are identical from the 3rd second on. However, even though the preference is similar in the 2nd second, the older adults' novelty preference is still rising, while younger adults' has peaked and is beginning to fall. Older adults' novelty preference scores peak in the 3rd second. See Figure 2(b).

Effects of emotion over time – interaction effects

Novelty preferences per emotion for each second of the test phase are shown for younger and older adults in Figure 1(a-b). A repeated measures ANOVA of the effects of emotion and time on novelty preference showed a significant emotion by time interaction for older adults ($F = 3.556$, $p < 0.05$) but not for younger adults ($F = 2.033$).

To break down the interaction effect in older adults, we compared the first and second halves of the 10-second test phase (see Figure 3). Figure 3 shows bias scores as well as novelty preference percentage scores. Bias scores are calculated as the average amount of time spent fixated on novel emotional faces minus the average amount of time fixated on novel neutral faces for the first five and last five seconds of the test phase separately. It is useful to show bias scores here because although preference scores show modulation with respect to preference for the novel face, given its emotion, bias scores show modulation with respect preference for the neutral face. This way we can view patterns of the effect of emotion separately from the joint effect with novelty. We believe novelty preference is a more sensitive measure than bias scores, and therefore ran all statistics using novelty preference. However, here we present bias scores in order to access between-trial preferences for emotional versus neutral faces, holding novelty constant. Additionally, previous literature (e.g., Isaacowitz et al., 2006a-b) has used bias scores to present results. It is useful for us to present bias scores as well as novelty preference to compare results with this literature.
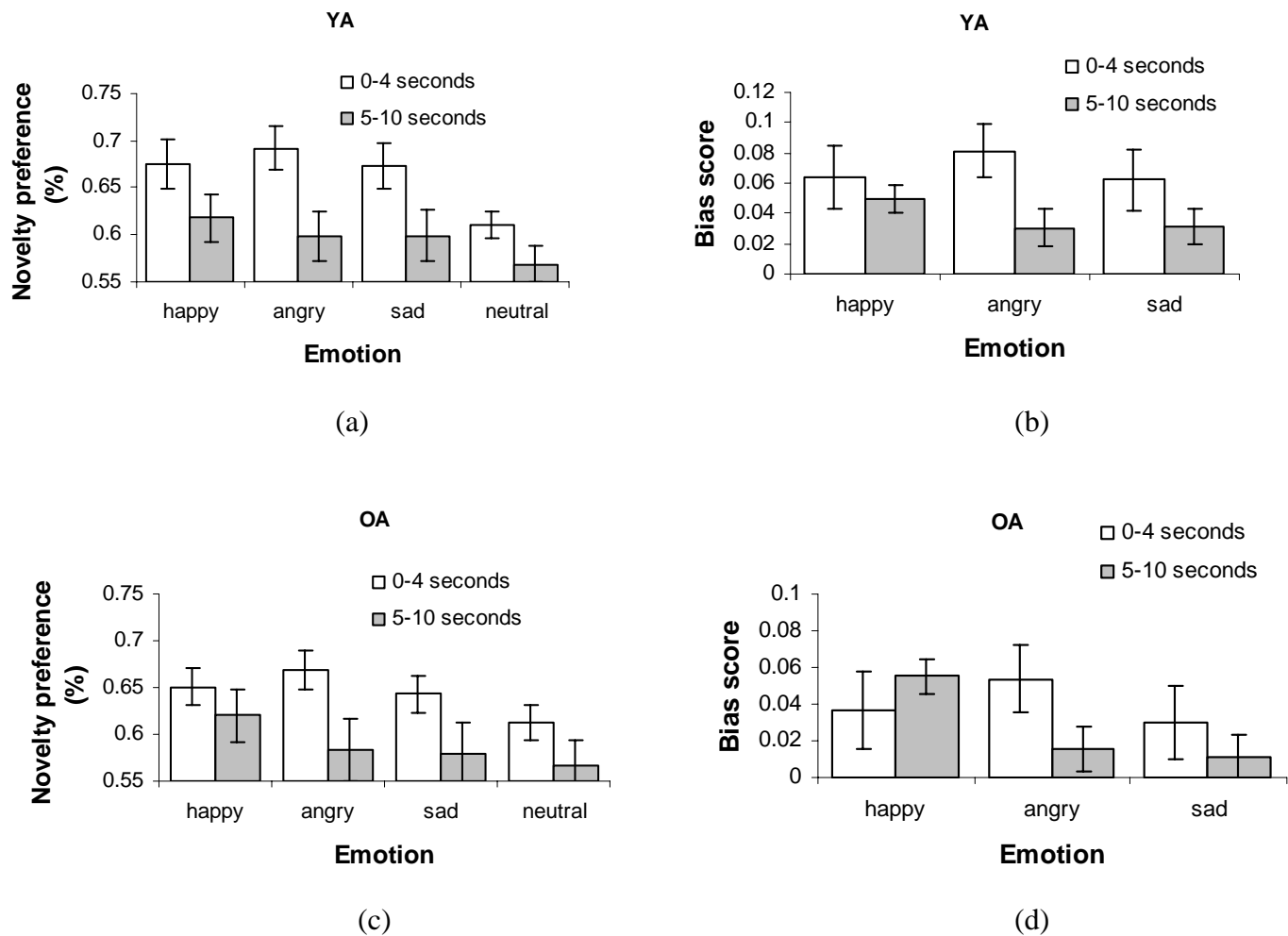
Figure 3. Using the novelty preference percentage, it is clear that overall preference for novel over familiar faces declines in the last five seconds of the test phase for both age groups (a,c). Differences in emotional preference change for older and younger adults are difficult to see. Using a bias score measure, one can see how older adults respond differently than younger adults in the last five seconds of the test phase (b,d). Younger adults showed less preference equally for all emotions, compared to neutral; older adults, however, demonstrate a positivity bias in the last five seconds. They respond much less to angry and sad emotional stimuli, and much more to happy emotional stimuli.

Younger adults. Younger adults showed a main effect of emotion in the first five seconds of the test phase ($F = 6.676$, $p = 0.001$), but not in the last five seconds. In the first five seconds

all emotional (happy, angry, sad) faces were preferred more than neutral faces were; in the last

five seconds no preferential differences emerged for any of the emotional over neutral faces.

Younger adults also did not differentiate preferential looking among the emotional faces in either

time period (Figure 3(a)). Bias scores (Figure 3(b)) shows an overall decrease in preferential

looking at the emotional faces, but again none of the emotions were preferred more or less

dramatically in either half of the test phase than the other emotions were. This is in contrast to

older adults, who showed a preference for angry faces in the first five seconds and a preference

for happy faces in the last five seconds, explained below.

Older adults. In the first five seconds of looking, older adults showed a significant

difference in preference for the emotional (angry, happy, sad) novel faces over the neutral novel

faces ($F = 10.627$, $p < 0.001$), similar to younger adults. Additionally during this time,

preference for angry was significantly higher than for the sad and neutral novel face conditions (t

$= 2.802$, $p < 0.01$; and $t = 5.314$, $p < 0.001$, respectively), and sad novel faces were significantly

preferred over neutral novel faces ($t = 2.910$, $p < 0.01$; see Figure 3(c)). Unlike younger adults,

however, older adults still showed a main effect of emotion during the last five seconds of the

test phase ($F = 3.525$; $p < 0.05$). However, the preferences for looking at angry and sad faces

were no longer significantly different than the preference for looking at neutral faces. Instead,

preference for looking at the happy novel face was now significantly higher than the angry and

neutral conditions ($t = 2.060$, $p < 0.05$; and $t = 3.992$, $p < 0.001$, respectively). Figure 3(c) shows

a nonsignificant difference in novelty preference for happy between the first and the last five

seconds. The differences in novelty preference for angry and sad are much more prominent. This

is clearer in Figure 3(d), which shows bias scores. Biases for angry and sad faces over neutral

novel faces completely disappear while the bias for happy novel faces over neutral novel faces increases.

Effects of emotion over time – pairwise comparisons

To understand the early preference for negative and late preference for positive novel faces, we compared responses to novel faces of each emotional expression on a second-by-second basis. This gave 10 separate analyses. The following within-subjects differences emerged after we implemented a conservative Bonferroni correction by dividing our alpha level by 10 and evaluating at $p = 0.005$. Figure 1(a-b) shows Novelty Preference by Emotion Type and Time separately for the younger and older adult Age Groups.

Younger adults. In younger adults, an early preference for emotion appeared. In the first 1000ms of the test phase, participants looked significantly more at all emotional novel stimuli than they looked at neutral novel stimuli. Between 1000 and 2000 ms, participants continued to look at angry novel stimuli more than neutral novel stimuli, but no longer showed significant preference for happy or sad stimuli over neutral ones. Using Tukey's HSD posthoc pairwise comparison test, the preference for one or more emotional stimuli over neutral persisted until the sixth second, with angry consistently preferred until the fifth second. After the emotional preferences disappeared, differences did not reappear in that test phase.

Older adults. The second-by-second analysis allowed us to pinpoint where the older adults' emotional preferences appeared, disappeared, and reappeared throughout the test phase. Older adults did not show a preference for any of the emotional stimuli in the first 1000ms. With a Bonferroni correction of $p = 0.05/10$, a preference for all emotional stimuli over neutral stimuli

existed between 1000 and 2000ms. Between 2000 and 3000ms, a preference for angry stimuli appeared, similar to the younger adults. Interestingly, though, although emotional preferences disappeared after 3000ms for a few seconds, in the sixth second a preference for happy novel stimuli appeared, and appeared again in the tenth second of the test phase. Using a less conservative correction, angry stimuli are preferred through the forth second, and happy stimuli are preferred over angry and sad in the ninth second and preferred over angry and neutral stimuli in the tenth second. This more detailed analysis explains the consistent main effect of emotion in both the first and second half of the test phase. In the first half, the main effect is driven by a consistent preference toward emotion (and especially toward angry). In the second half, the main effect is driven by the appearance of a preference toward happy, in particular, while angry, sad, and neutral decrease in preference.

Discussion

This study demonstrates three main results: first, it confirms the preference for attending to novel information over familiar information, and does so across two disparate age cohorts. Next it shows that this preference is modulated when the informational content is emotional. Third, it compares the effect of specific emotional valences on the direction and degree of attention modulation, and does so independently for younger and older adults.

In agreement with the literature on novelty preference, both age groups showed a strong and temporally-consistent preference for attending to the novel face, regardless of the emotion displayed. The visual paired-comparison task used in this study measured preference by comparing fixation durations on each of two visual stimuli. Though this measure has previously been used most consistently with infants and nonhuman primates in memory tasks, Richmond

and colleagues (2004) showed it to be an effective modulator of attention in young adults as well ($M = 21.11$ yrs, $SD = 3.57$). We were able to compare a younger adult population similar to theirs with an older adult population, and found no difference in preferential viewing to neutral novel faces in the base conditions. This indicates that the paired comparison task measures preference similarly in the two groups, and provides support for its use in assessing differences in attention allocation. Isaacowitz et al. (2006a, 2006b) used a similar looking-time paradigm to measure attention preferences. However, they did not establish a control condition that excluded emotion, thus making it difficult to argue that the emotional content of the stimuli affected viewing preferences differentially in the two groups while the overall experimental setting did not. Given the group similarities in the neutral novel condition in the present study, we were able to approach the question of differential modulation of attention by emotion based on a similar base preference for novelty between the groups when no emotion was involved.

The effect of emotion in addition to novelty was shown to the extent that the other three conditions (happy, angry, and sad) showed a larger novelty preference than the neutral condition did. Since the preference score for neutral novel stimuli was significantly greater than 50%, and the preference score for emotional novel stimuli was significantly greater than that for neutral novel, we conclude that not only is the novelty effect a valid measure of attentional preferences in older as well as younger adults, but it is also a measure that is sensitive to emotional effects on attention. These emotional effects were different among older and younger adults.

Younger adults. In adding emotion to the novelty preference paradigm, our results were consistent with our hypotheses, and with the literature on younger adult viewing preferences (Mather & Carstensen, 2003; Rösler et al., 2005; Knight et al., 2007). Younger adults preferred both negative and positive novel stimuli significantly more than they preferred neutral novel

stimuli. This heightened attention to emotional stimuli, regardless of emotional valence, was predicted in accordance to information-seeking motivational mechanisms in younger adults. We see no separate evidence of a positivity or a negativity bias; rather, *all* emotional stimuli – and hence, potentially more informative stimuli – seemed to attract attention. Additionally, there was a clear linear decrease in novelty preference across the 10-second test phase. This decrease never reached 0.50 (indicating the lack of novelty preference) for any of the valences tested, but it did differentiate between emotional and neutral stimuli through the sixth second, with emotional stimuli preferred. After six seconds the emotional stimuli were no longer significantly preferred over the neutral stimuli. This demonstrates a very robust emotion modulation effect of the novelty preference: the novelty effect diminishes but does not disappear by 10 seconds, and the modulation of novelty preference by emotion is apparent until 6 seconds, at which time emotion stimuli no longer appear to augment attention allocation.

    Older adults. Older adults showed similar novelty preferences in response to happy and angry emotions as younger adults did. Additionally, the sad condition approached a significant difference. By themselves, these results appear to refute previous findings of a positivity bias in older adults and of an active avoidance of negative information (Charles et al., 2003; Mather & Carstensen, 2005). According to these previous studies, novelty preference should be greater in response to the happy emotional novel face than to the neutral novel stimuli, and the angry and sad stimuli should receive either comparable preference to the neutral condition or less than both neutral and happy. However, although these differences did not appear in the overall Emotion x Time ANOVA, the differences emerge in the time-course evaluations, especially in the comparisons between the age groups.

The main differences between younger and older adult populations occurred in the first 3000ms (refer to Figure 2(b)). At the very beginning of the test phase, younger adults immediately showed a higher novelty preference across emotions. Preference peaked at 2000ms, and then dropped off steadily for the rest of the phase. Older adults' novelty preference in the first 1000ms was no higher than during the seventh second of viewing. It raised to peak at 3000ms (one second after the younger adults' preference peak), then fell off at almost the exact same rate as the younger adults. An interesting observation is the difference in peak looking time when split on emotional valence (Figure 1(a-b)). Younger adults showed peak preference at 2000ms for all four novel expressions. Older adults, on the other hand, showed a 2000ms peak for sad and happy conditions, while in the neutral and angry conditions preferential looking continued to increase significantly until 3000ms. When these dropped off – extremely rapidly for the angry condition, and relatively slowly for the neutral condition – the preference for happy remained relatively constant. Overall, preferences for happy and neutral stimuli decreased the least, whereas angry and sad decreased more sharply. In younger adults, preferential looking decreased at around the same rate for all of the emotional valences, with neutral remaining relatively stable and consistently below the others.

It seems unusual given socioemotional selectivity theory and other positivity bias explanations that older adults would spend so much additional time looking at the angry novel faces within the first few seconds. The work done by Ohman et al. (2001) and Mather and Knight (2006), discussed previously, indicate that angry faces get noticed quickly, and that this detection speed does not decrease significantly with age. Our results, however, support evidence that it takes up 2000-3000ms for older adults to process and identify angry faces. Thereafter, preference for the angry face faded dramatically, decreasing more rapidly than it did for any of

the other emotions, especially between three and six seconds. It was during this time, while angry preference declined, that the "positivity bias" identified consistently in Mather & Carstensen (2003; 2005), as well as Isaacowitz's (2006), work appeared. While younger adults continued to show equal preference for emotional and neutral novel faces throughout the test phase, older adults significantly preferred happy faces, starting in the sixth second, and again in the ninth and tenth second. It is plausible, then, that the positivity bias proposed by Mather and Carstensen (2003) comes out in an overt measure such as eye-tracking only after some evaluative time has passed. Rather than the preference for happy faces increasing in the latter half of the experiment, it remained relatively constant while preference for the other emotions dissipated. In this sense, our results support an eventual positivity bias rather than a suppression of negative emotion. After the first two seconds of decline, preference toward the angry face did not decrease significantly more quickly than that toward the neutral novel face does. Although those two seconds could be considered active suppression, by the fifth second the angry and neutral face novelty preferences were identical, and remained so throughout the test phase. Thus, it was only the sustained preference for attending to the positive faces that showed differentiation to the baseline novelty effect demonstrated by the neutral novel face condition.

In comparing our results with Isaacowitz et al.'s (2006a), we see evidence that using the novelty preference as an indicator of attention allocation, rather than (or in addition to) fixation duration ratios, is a sensitive measure that can distinguish between preferences for fixating on emotional stimuli differentially for various emotional valences. Isaacowitz and colleagues found significant differences in viewing preferences for older adults that favored positive and suppressed attention to negative stimuli. However, in younger adults they found trends of preferences toward all emotional (both positive and negative) stimuli that only became

significant for fearful stimuli (2006a). They subsequently found significant preference away from sad emotional stimuli (2006b). In the current study, we found evidence for a positivity bias similar to their older adult results using bias scores. Additionally, we found significant preference toward all emotional stimuli using novelty preference scores. This indicates that novelty preference can demonstrate preferential looking and attention modulation by emotional stimuli in a way that bias scores do not completely capture. One result we did not find was a sustained novelty preference to emotional stimuli when compared to neutral novel stimuli. All novel stimuli remained preferred across the entire testing period. Thus, because the novelty preference for neutral stimuli lasted beyond our test phase duration, we were unable to observe a modulation in the duration of attention allocation to emotional stimuli. However, modulation at the end of our test phase is currently not as meaningful as modulation at the beginning, because most of the conflicting literature concerns processes that occur within the first 500-4000ms after stimulus presentation.

This study is limited in that the familiarization phase always consists of familiarizing on a neutral emotional face. Thus, although the test phase includes a condition of comparing a familiar and a novel neutral stimulus, it does not include a comparison of a familiar and a novel emotional stimulus. Next steps for this study include familiarizing on emotional faces in order to consider novelty effects from removing emotion in the novel stimuli rather than only effects from adding emotion. These conditions would generalize the novelty preference effect for future use in studies of emotional effects on attention. Additionally, further analyses of the direction and duration of the first fixation in each test phase, or analyses on fixation duration means from shorter time periods (300 and 500ms rather than 1000, 2000, etc) could make comparisons with previous literature more precise by equating for presentation time.

Conclusions

The results of this experiment address many factors in the debate on emotional effects on attention allocation. It proposes a new methodology to use as a measure of attentional biases; it finds similar emotional effects (though slightly varying in emotional valence overlap) on attention using this measure as found in previous studies; and it finds to some extent similar positivity biases in older adults as found in previous studies (though with a very different and previously unexplored time-course effect on the appearance of this positivity bias). In adding the aspect of novelty and of time, it becomes advisable to (1) extend this type of methodology study to include familiarization periods using emotional stimuli; (2) consider removing the ecological photograph stimuli and attempting replication with synthetic stimuli (similar to Isaacowitz et al., 2006a, 2006b); and (3) break the time-course analysis down into more specific consideration for at least the first 3-4 seconds of the test phase, in order to more closely compare with previous studies of varying dependent variables (including reaction time, memory, and EEG studies). This study demonstrates many similarities and a few discrepancies between how older and younger adults respond to emotional stimuli. It supports main themes that do appear throughout all the literature: younger adults do show heightened attention (in many measures: RT, memory, preferential looking, P1 ERP components) in some capacity to almost all emotional stimuli. Older adults show a preference for positive emotional stimuli, even in self-reports of looking preferences. The older adult response to negative emotions remains the least clear. Here, perhaps, the novelty preference measure will be sensitive enough to present convincing results, as it has for younger adults, when given emotional familiarization periods and breaking the time-course evaluation down more precisely.

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