Emotion

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Don't Like What You See? Give It Time: Longer Reaction Times Associated With Increased Positive Affect

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Images with an ambiguous valence (e.g., surprised facial expressions) are interpreted by some people as having a negative valence, and by others, as having a more positive valence. Despite these individual differences in valence bias, the more automatic interpretation is negative, and positivity appears to require regulation. Interestingly, extant research has shown that there is an age-related positivity effect such that relative to young adults, older adults attend to and remember positive more than negative information. In this report, the authors show that this positivity effect extends to emotional ambiguity (Experiment 1). Eighty participants (aged 19–71, 42 females) rated the valence of images with a clear or ambiguous valence. They found that age correlated with valence bias, such that older adults showed a more positive bias, and they took longer to rate images, than younger adults. They also found that this increase in reaction times was sufficient to bias positivity (Experiment 2). Thirty-four participants (aged 18–28, 24 females) rated ambiguous and clear images, before and after an instruction to delay their RTs. They also found that although ratings among individuals with a positive bias did not change, those with a negative bias became more positive when encouraged to delay. Indeed, participants with the strongest negativity bias showed the greatest increase in RTs. Taken together, this work demonstrates that the valence bias, which represents a stable, trait-like difference across people, can be moved in the positive direction, at least temporarily, when participants are encouraged to take their time and consider alternatives.

Keywords: emotional ambiguity, individual differences, negativity bias, aging, reaction time (RT)

Facial expressions are important social cues as they help predict information about the emotions and intentions of other people, as well as information about our environment. Although some expressions provide clear predictive information that something good (e.g., happy) or bad (e.g., angry) will happen; other expressions, like surprise, have predicted both positive (e.g., birthday party) and negative (e.g., car accident) events for us in the past. When presented without clarifying contextual information, these ambiguously valenced expressions can be used to delineate a *valence bias*, which is defined as the tendency to interpret ambiguity as positive or negative (Kim, Somerville, Johnstone, Alexander, & Whalen, 2003; Kim et al., 2004; Neta, Kelley, & Whalen, 2013; Neta, Norris, & Whalen, 2009). This valence bias seems to be a trait-like difference across people that is stable across time (Neta et al., 2009) and generalizes across stimuli (Neta et al., 2013). Such studies can be informative for studying psychiatric disorders (e.g., anxiety, depression) where a negativity bias may be at the heart of the psychopathology (Williams et al., 2007).

Despite these individual differences in the interpretation of surprised faces, the "initial, more automatic" interpretation is consistently negative (i.e., even for those people who eventually interpret the expression as positive; Neta et al., 2009; Neta, Davis, & Whalen, 2011; Neta & Whalen, 2010). This early negative assessment is thought to recruit the amygdala (Kim et al., 2003; Neta & Whalen, 2010). Positive interpretations may then require an additional regulatory process—one that only some individuals adopt naturally.

Consistent with this working hypothesis, children show a more negative bias in response to surprise (Tottenham, Phuong, Flannery, Gabard-Durnam, & Goff, 2013). This negativity comes at a time before control networks in the brain have fully developed (Casey, Tottenham, Liston, & Durston, 2005; Luna et al., 2001). Thus, one potential explanation for their negativity is that regulatory mechanisms responsible for producing a positive bias are weaker in children.

Age-Related Positivity Bias

On the other end of the life span, an age-related positivity effect has been frequently observed among older adults. For instance, it has been shown that older adults attend more to positive than negative information (e.g., Mather & Carstensen, 2003, 2005; Mather, Knight, & McCaffrey, 2005) and they remember more positive than negative information (e.g., Charles, Mather, & Carstensen, 2003; Kennedy, Mather, & Carstensen, 2004; Mather & Carstensen, 2003). This positivity effect was identified by

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testing hypotheses grounded in the socioemotional selectivity theory of motivation (Carstensen, 1992), which posits that, as time horizons shrink, as they do in older age, people became more invested in emotionally meaningful goals (Carstensen, 1992, 1995; Carstensen, Isaacowitz, & Charles, 1999). This shift in motivation promotes emotion regulation, which might be the cause of older adults' cognitive bias toward positivity (Carstensen & Mikels, 2005; Mather & Carstensen, 2005; Urry & Gross, 2010). Indeed, a depletion in cognitive resources that would diminish emotion regulation abilities can be restored via strategies of selection and optimization (e.g., situation selection) used by older adults to bolster emotion regulation (Urry & Gross, 2010). Mather and colleagues (2004) also found neural correlates of this motivational switch in older age. In particular, although both older and younger adults showed increased amygdala activation for emotional compared to neutral images, only older adults showed greater amygdala activation for positive compared to negative images (Mather et al., 2004). Moreover, this motivational shift favoring emotionally satisfying goals is consistent with findings that reported that, compared to younger adults, older adults exert greater emotional control (Gross et al., 1997; Mather & Carstensen, 2005) and experience less negative emotions (Charles, Reynolds, & Gatz, 2001; Gross et al., 1997). Although the positivity bias in older adults has been shown in other aspects of cognition (e.g., attention, memory), to our knowledge, no previous study has shown age-related effect in resolving valence ambiguity. Therefore, our first goal in the present work is to extend previous work comparing clear positivity and negativity in aging to examine age-related changes in response to ambiguous valence, predicting that older adults would show a more positive bias than younger adults.

Finally, we have found that, when rating surprised faces, people take longer to make a positive rating than a negative rating (Neta et al., 2009). We also know that older adults take longer to make motor responses than younger adults (e.g., Stelmach & Nahom, 1992). If we predict that negativity is more automatic, and that positivity is related to an additional process (also supported by RT differences), the second goal of the present work is to determine whether or not we can shift the valence bias in the positive direction simply by encouraging people to take longer when evaluating each item.

Experiment 1

Method

Participants. Eighty participants (ages 19–71, $M = 44.95$, $SD = 15.39$; 42 females) were recruited through Amazon Mechanical Turk. None of the participants were aware of the purpose of the experiment, and they were all compensated for their participation through monetary payment. Informed consent was obtained electronically from each participant before the session, and all procedures were exempted by New York University Committee for the Protection of Human Subjects.

Stimuli. The stimuli were taken from previous work (Neta et al., 2013). This included a set of 48 faces, 24 with an ambiguous valence (surprised expression), and 24 with a clear valence (12 angry and 12 happy expressions). Of the 48 faces, 34 discrete face identities were used (17 males, 17 females) posing angry, happy, and surprised expressions. Fourteen identities (seven males, age 21–30 years old) were taken from the NimStim standardized facial expression stimulus set (Tottenham et al., 2009), another 20 identities (10 males, age 20–30 years old) were taken from the averaged Karolinska Directed Emotional Faces database (Lundqvist, Flykt, & Öhman, 1998). In addition, we used a set of 48 scenes taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), 24 with an ambiguous valence, and 24 with a clear valence (12 clearly negative and 12 clearly positive).

Procedure. Participants were asked to complete an online experiment, which consisted of 16 alternating blocks of faces and IAPS (eight faces, eight IAPS). Each block consisted of 24 trials (12 clear valence, 12 ambiguous). The order of the images within a block was randomized across all participants.

For each trial, participants first saw a fixation cross (500 ms), followed by an image (500 ms). Participants used their computer mouse to rate the image as positive or negative. They were instructed to rate as fast as possible, based on a gut reaction. There was no time limit for the responses. However, if they took longer than 1 s to initiate their mouse movement, they would see a message encouraging them to start moving their mouse faster, even if they weren't sure of their decision. This was to ensure that the mouse movements reflected the real-time decision making process from the participants. The mouse trajectory for each trial was recorded (sampling rate = 70Hz), processed, and analyzed with the MouseTracker software (Freeman & Ambady, 2010).

Results

Valence Ratings. Participants rated clear items accurately (average accuracy for faces: angry = 98.86%, happy = 98.28%; IAPS: negative = 93.12%, positive = 98.22%). However, there were individual differences in ratings for ambiguous faces (surprised expression) and IAPS, consistent with previous work (Neta et al., 2009, 2013). For each participant, we calculated a valence bias (i.e., tendency to interpret ambiguity as positive or negative) using their percent negative ratings, which is calculated as the percent of trials they rate an item as negative, out of the total number of ratings made per condition. For example, a participant with a 77% for surprise rated surprised faces as negative on 77% of the trials in which they made a rating about a surprised face. This valence bias was consistent across faces and IAPS, $r(78) = 0.31$, $p = .005$, replicating previous work (Neta et al., 2013). In other words, those individuals who rated surprised faces as positive also rated ambiguous IAPS as positive.

To test our first hypothesis, we examined the effect of age on valence ratings. As predicted, age significantly correlated with the valence bias for both faces, $r(78) = -0.28$, $p = .01$, and IAPS, $r(78) = -0.29$, $p = .008$, such that older adults showed a more positive bias than younger adults (Figure 1a). When collapsing valence ratings across stimulus types, the result was still significant, $r(78) = -0.34$, $p = .002$.

Moreover, previous work has demonstrated an age-related impairment in recognizing negative emotions (Ruffman, Henry, Livingstone, & Phillips, 2008) that may be associated with age-related regulatory decline (e.g., Krendl & Ambady, 2010). However, in the current study, we found that age was not significantly correlated with accuracy for clearly negative images, $r(78) = -0.17$, $p > .1$, or clearly positive images, $r(78) = -0.10$, $p > .4$.

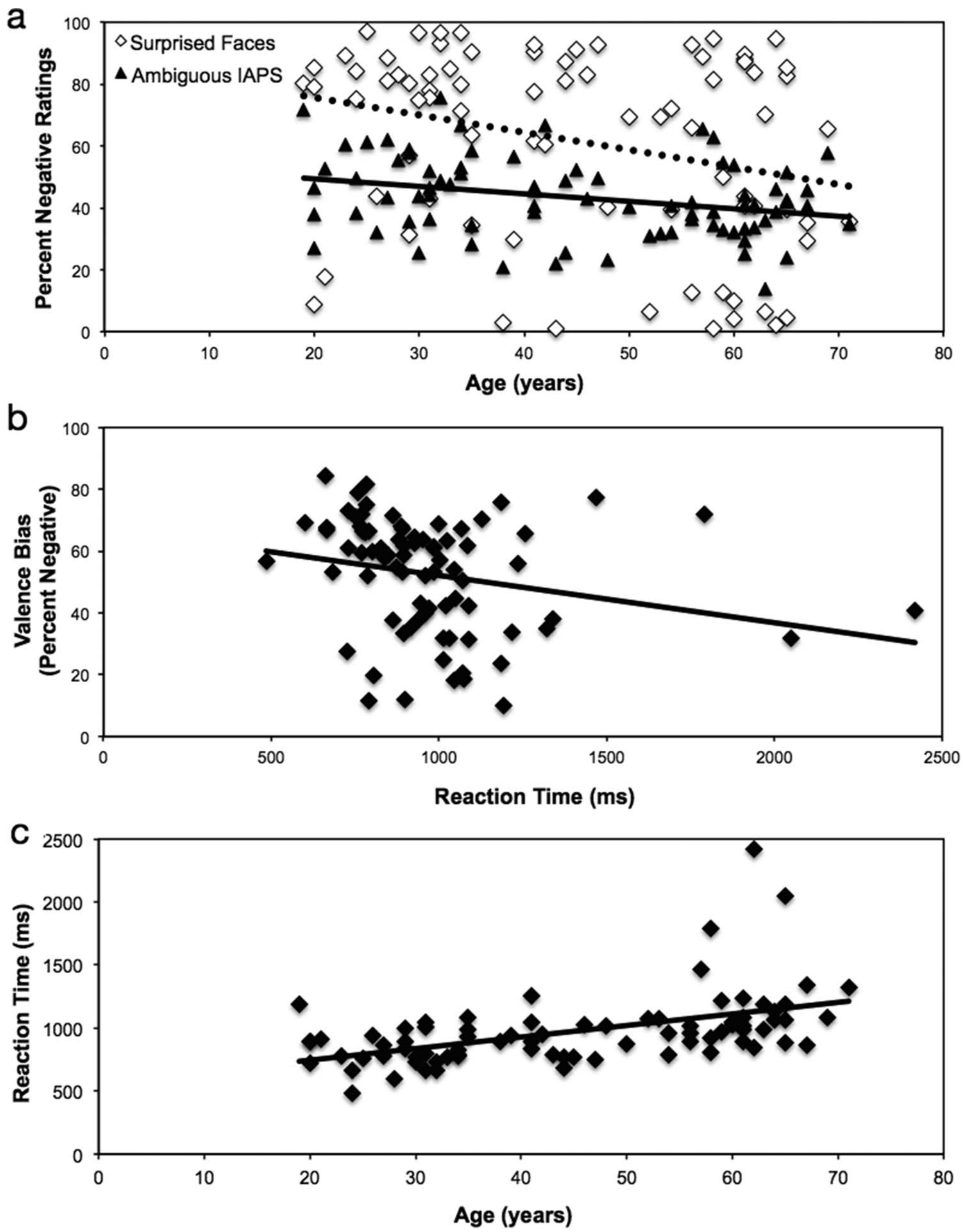

Figure 1. a: Age was correlated with valence ratings of surprised faces and ambiguous IAPS such that older adults were more positive than younger adults in rating ambiguity. When combining ambiguous images across stimulus types, those with a more positive bias (b) and older adults (c) responded significantly slower. All p's $<$ 0.05.

Reaction Time. We focused these analyses on the ambiguous items of interest, collapsing across stimulus types. There was a significant correlation between reaction time (RT) and valence bias, such that individuals with a more negative bias responded faster, $r(78) = -0.24$, $p = .03$ (Figure 1b). When the three outliers were removed (RTs were greater than 2 *SD*s from the mean), the effect was still significant, $r(75) = -0.30$, $p = .008$. In contrast, there was no significant correlation between valence ratings and RT for the clearly negative items, $r(78) = -0.02$, $p = .9$, or the clearly positive items, $r(78) = 0.15$, $p = .2$.

RT also correlated with age, $r(78) = 0.49$, $p < .001$, such that older adults took longer to rate ambiguous images than younger adults (Figure 1c). Again, when the three outliers were removed, this effect was still significant, $r(75) = 0.54$, $p < .001$.

Discussion

As predicted, the positivity effect in aging was found to extend to emotional ambiguity, such that older adults showed a more positive bias when ratings the valence of surprised faces and ambiguous IAPS as compared with younger adults. Not surprisingly, older adults also took longer to make their ratings than younger adults across all conditions. However, the age-related effect here is specific to the ambiguous condition because (a) as older adults did not rate clearly valenced items differently from younger adults, and (b) greater positivity was only associated with longer RTs for the ambiguous condition.

We studied a group of participants that we predicted would naturally show a more positive valence bias (older adults). Although some work has suggested that older adults are more positive because of an attentional bias whereby both older and younger adults initially orient to negative stimuli, and only older people subsequently refocus on the positive, other work found that older adults initially avoid negative information (Mather & Carstensen, 2003), and will go so far as to scan the image more, looking particularly at the least relevant parts of an image to decrease attention to negative information (van Reekum et al., 2007). Indeed, although threat detection is intact among older adults (Mather & Knight, 2006), they display an attentional and memory bias against negative faces (Mather & Carstensen, 2003), and an attentional preference toward happy and away from angry faces (Isaacowitz, Wadlinger, Goren, & Wilson, 2006). Moreover, when young adults were instructed to focus on emotion regulation (a motivation system that presumably mimics older adults), they showed decreased attention to negative compared to positive images—a pattern similar to older adults (Xing & Isaacowitz, 2006). In other words, older adults use gaze as a regulatory tool because it requires less cognitive effort than many other regulation strategies (Isaacowitz, Toner, Goren, & Wilson, 2008; Knight et al., 2007; Mauss, Cook, & Gross, 2007; Washburn & Putney, 2001). Here, we found that older adults showed a more positive bias when rating ambiguously valenced images, and that they take longer to make these ratings than younger adults. As such, our data are consistent with previous work studying the positivity effect in attention and memory, and go a step further to suggest that this dispositional age-related positivity generalizes to ambiguity resolution. Taken together, our findings might be the results of a deliberate allocation of attention toward positivity and away from negativity. However, both positive and negative information are available in the same (ambiguous) images. Future work using eye-tracking methodologies could help determine whether attentional deployment is associated with this difference in valence bias, particularly in older adults. Finally, although some work has suggested that this age-related positivity is associated with cognitive control broadly (Mather & Carstensen, 2005), we propose that, within this domain of cognitive control, perhaps emotion regulation is the type of control that allows for more positive ratings of valence ambiguity. Future work will be needed to test this specific relationship.

Next, based on previous work, we proposed that the negative interpretation of ambiguity is more automatic, and that positivity may require some additional, perhaps regulatory, mechanism—one that only some individuals adopt naturally (Kim et al., 2003, 2004; Neta & Whalen, 2010). Consistent with this, RTs were found to be faster for negative ratings of ambiguous items than for positive ratings. Given our hypothesis that positivity may require some additional regulation process, and that older adults showed both a more positive valence bias and longer RTs, the next study set out to determine whether we could drive individuals with a negative bias (an effect primarily evident in young adults) to show a more positive bias simply by instructing them to behave more like individuals with a positive bias (i.e., slowed RT). We predict that this additional RT will afford these negatively biased individuals a greater opportunity to consider alternative (positive) interpretations that may be less automatic.

Experiment 2

Method

Participants. Forty-four participants were recruited, although six were excluded due to high error rate ($>$40%) for clear valence faces and IAPS (e.g., rating negative images as positive), and four more were excluded due to recent psychoactive medication treatment. The final sample included 34 participants (ages 18–28, M = 19.68, SD = 1.79; 24 females, all White). All participants had normal or corrected-to-normal vision. None were aware of the purpose of the experiment, and they were all compensated for their participation through monetary payment or course credit. Written informed consent was obtained from each participant before the session, and all procedures were approved by the University of Nebraska Committee for the Protection of Human Subjects.

Stimuli. The stimuli used in Experiment 2 were the same as in Experiment 1.

Procedure. There were three parts to the experimental session. First, participants performed a valence rating task similar to Experiment 1 ("Rate 1"), where they were asked to rate faces and IAPS as positive or negative; however, this time, they used a two alternative-choice button response, consistent with previous work (Neta et al., 2009; Neta & Whalen, 2010; Neta et al., 2011; Neta et al., 2013). Participants saw each image for 500 ms, which was followed by an interstimulus interval (ISI) presented for 1,500 ms. Participants were able to make a response starting at the stimulus onset, and throughout the ISI period (total available response time = 2,000 ms) and, as in Experiment 1, they were asked to respond as quickly and accurately as possible.

Second, participants were given the delay instruction (details below), which served to encourage participants to take longer when making their ratings of each item. Third, they completed another valence ratings task on a different set of faces and IAPS ("Rate 2"). Importantly, unlike the first rating task, participants were instructed to take their time, to think more about alternative contexts of the ambiguous images, and make their best guess regarding the valence of the images. Participants had unlimited time to respond: Images were presented on the screen until participants made a response, which was followed by an ISI for 500 ms before starting the next trial.

Based on the results from Experiment 1, the face stimuli were split into two subsets (24 images each) that were not significantly different from each other in terms of valence ratings, based on data from Experiment 1 ($p > .05$). The same was done for the IAPS set. One subset of 24 faces and 24 IAPS was used in Rate 1 (before the delay instruction), and the other subset was used in Rate 2 (after the delay instruction). In terms of the design structure, both Rate 1 and Rate 2 contained four blocks (two face blocks, two IAPS blocks), each block consisted of 24 trials (twelve ambiguous, six positive, and six negative). The order in which each face and IAPS subset was used in Rate 1 or Rate 2, and the order of face blocks and IAPS blocks within Rate 1 and Rate 2 were counterbalanced across all participants.

We predicted that the delay manipulation would have a differential effect on ambiguity ratings, depending on the individual's valence bias (i.e., people with a negative bias will shift ratings in the positive direction, whereas people with a positive bias might already see ambiguity as both positive and negative). Therefore, we analyze valence bias as a categorical variable to examine separately how each group was affected by the manipulation. In addition, we provide an analysis with valence bias as a continuous variable, consistent with the methods from Experiment 1.

Delay instruction. In between Rate 1 and Rate 2, participants were given instructions to encourage longer RTs when making their ratings of each item. Specifically, they were told:

> You might have noticed that some of those images [seen in Rate 1] were clearly negative or clearly positive, but other images were more difficult to define. For example, you might have thought that some of the facial expressions could be either positive or negative. Surprised expressions are a good example of this because you might make that expression when you walk into a surprise birthday party, or when you witness a car accident. The facial expression is pretty much the same, but the meaning is very different, depending on what just happened in your environment. Another example of a picture that is not clearly positive or clearly negative is a scene in which people are crying. You may not know if they are crying tears of happiness or tears of grief. Therefore, when we show you some of these types of images, we expect that it might be more difficult to make decisions about these ones that are not so clear, and the meaning depends on the environment. Now we're going to ask you to look at some similar images and make the same decision, which is to rate the images you see as either positive or negative. But this time, for each image, we want you to try to take your time and consider the alternatives before making your decision.

Results

Valence Ratings.

Valence bias as a categorical variable—comparing groups. Similar to Experiment 1, participants' valence bias was calculated using their percent negative ratings. Because we predicted that the delay manipulation would make individuals with a negative bias interpret ambiguity more positively, we divided our participants into two groups based on a median split of their combined valence bias for surprised faces and ambiguous IAPS from Rate 1, as in previous work (Neta et al., 2009; Neta & Whalen, 2010): 17 participants showing a greater tendency to interpret these ambiguous images as having a negative valence (Bias_{neg} group; 12 females; $M \pm SE = 67.34\% \pm 1.39$, range: 57.50–81.85%), and the other 17 subjects showing a greater tendency to interpret these ambiguous images as having a more positive valence (Bias_{pos} group; 12 females; $M \pm SE = 43.35\% \pm 2.59$, range: 23.33–56.58%).

An Order (Rate 1, Rate 2) × Stimulus (Faces, IAPS) × Valence (Negative, Positive, Ambiguous) × Group (Bias_{neg}, Bias_{pos}) repeated measures analysis of variance (ANOVA) revealed a significant Order × Valence interaction, $F(2, 64) = 24.39$, $p < .001$, partial $\eta^2 = 0.43$, such that clear items were rated more accurately in Rate 2 (after the delay instruction) than in Rate 1 ($ps < .001$; $M \pm SE$: clearly negative: Rate 1 = 84.75% ± 1.59, Rate 2 = 95.96% ± 0.87; clearly positive: Rate 1 = 9.94% ± 1.54, Rate 2 = 2.45% ± 0.59). As predicted, ambiguous items were rated more positively in Rate 2 than in Rate 1 ($p < .05$; $M \pm SE$: Rate 1 = 55.35% ± 2.54, Rate 2 = 50.65% ± 2.18). There was also a significant Order × Valence × Group interaction ($F(2, 64) = 5.64$, $p < .01$, partial $\eta^2 = 0.15$), such that these effects were significant for the Bias_{neg} group (clear items were rated more accurately, and ambiguous items were rated more positively in Rate 2 as compared to Rate 1; $ps < 0.05$; Figure 2a). In contrast, the Bias_{pos} group rated clear items more accurately in Rate 2 as compared to Rate 1 ($ps < 0.001$), but there was no significant difference in their ratings of ambiguous items from Rate 1 to Rate 2 ($p > .3$; Figure 2a).

Valence as a continuous variable. We calculated a difference score for ambiguity ratings from Rate 1 to Rate 2, where a greater value denotes a greater shift toward positivity (i.e., high percent negativity at Rate 1 to low percent negativity at Rate 2). There was a significant correlation between valence bias at Rate 1 and the change in ambiguity ratings, $r(32) = 0.63$, $p < .001$, such that people with a more negative bias at Rate 1 showed the greatest change toward positive ratings of ambiguous items in Rate (Figure 2b).

RT. We collapsed RT across conditions of clear valence for each stimulus type (angry and happy faces; negative and positive IAPS), to allow direct comparison of clear versus ambiguous items. An Order (Rate 1, Rate 2) × Stimulus (Faces, IAPS) × Valence (Clear, Ambiguous) × Group (Bias_{neg}, Bias_{pos}) repeated measures ANOVA revealed a significant main effect of Order, $F(1, 32) = 181.41$, $p < .001$, partial $\eta^2 = 0.85$, such that RTs were slower after the delay instruction than before, which simply served as a manipulation check ($M \pm SE$: Rate 1 = 654.63 ± 24.53, Rate 2 = 1643.54 ± 86.88). Interestingly, there was a significant Order × Group interaction, $F(1, 32) = 6.73$, $p = .01$, partial $\eta^2 = 0.17$, such that, at Rate 1, there was no significant difference in RTs between groups ($p > .2$; Figure 2c), but at Rate 2, the Bias_{neg} group showed significantly longer RTs than the Bias_{pos} group ($p < .01$; Figure 2c).

Again, we calculated a difference score for RT on ambiguous trials from Rate 1 to Rate 2, and compared this RT change to valence bias in Rate 1. There was a positive correlation, such that people that showed the greatest change in RT had a more negative bias at Rate 1, $r(32) = 0.46$, $p = .006$.

Discussion

In this experiment, we introduced participants to alternative interpretations of ambiguous items and encouraged them to try to take their time and consider these alternatives before making a valence rating. The delay manipulation was effective; people took significantly longer to make valence ratings after given this instruction (Rate 2), as compared to before they were given this instruction (Rate 1). As predicted, ratings of ambiguous items became more positive after the instruction to delay. In contrast, clear items were rated more accurately after the delay instruction (negative items were rated more negatively, and positive items more positively), suggesting that this delay manipulation did not bias all responses in the positive direction; only ambiguous items were rated more positively at Rate 2. This provides support for the notion that negative ratings are more automatic, and that an addi-

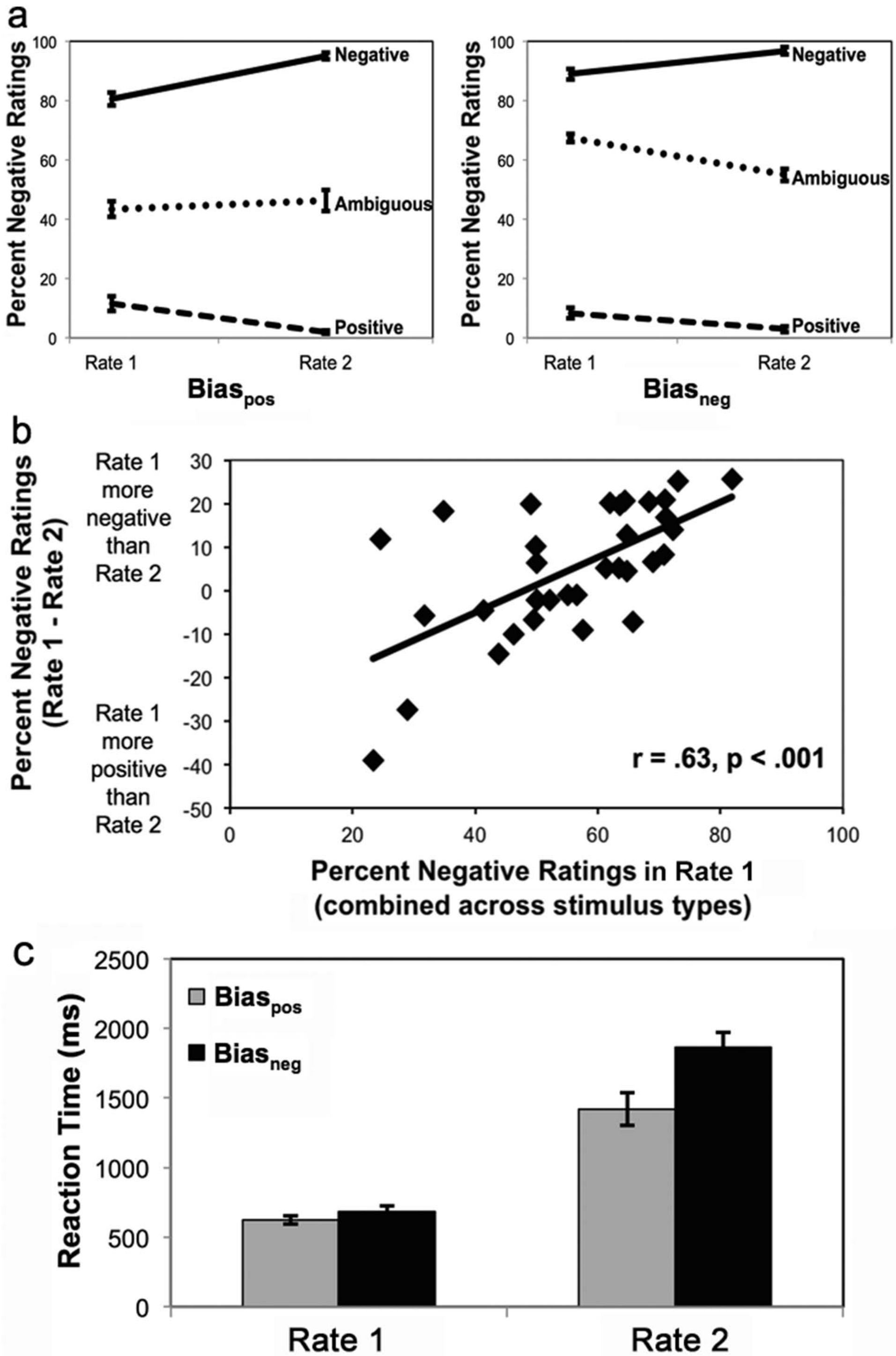

Figure 2. a: For both groups with positive and negative bias, ratings of clearly valenced images became more accurate (p's < 0.05). For ambiguously valenced images, the Bias$_{neg}$ group became more positive ($p < .05$), but the Bias$_{pos}$ group did not change their ratings ($p > .3$). b: This is the same effect as (a) but treating valence bias as a continuous variable. We calculated a difference score for ambiguity ratings from Rate 1 to Rate 2, where a greater value denotes a greater shift toward positivity (i.e., high percent negativity at Rate 1 to low percent negativity at Rate 2). There was a significant correlation between valence bias at Rate 1 and the change in ambiguity ratings, $r(32) = 0.63$, $p < .001$), such that people with a more negative bias at Rate 1 showed the greatest change toward positive ratings of ambiguous items in Rate 2. c: Before the delay instruction (Rate 1), there was no group difference in RT ($p > .2$), but after the instruction (Rate 2), the Bias$_{neg}$ group had significantly longer RT ($p < .01$). Error bars represent standard errors.

tional, perhaps regulatory, step is required for arriving at a positive rating.

Interestingly, this shift toward rating ambiguous items more positively was only significant for people that initially showed a negative valence bias. In other words, individuals that spontaneously show a more positive bias did not change their ratings of ambiguity upon being encouraged to take their time and consider alternative interpretations. This suggests that these positive individuals may already be more flexibly aware of these alternative explanations, which allows them to arrive at a positive interpretation more frequently. Consistent with this, although the groups did not have significantly different RTs at Rate 1, at Rate 2, people with a negative valence bias showed longer RTs than those with a positive bias, suggesting that individuals with a negative bias required additional time to adopt a positive interpretation. Indeed, the most negative participants at Rate 1 showed the greatest change in both valence ratings and RT after being given the delay instruction.

Finally, these data suggest that regulatory effort (as the presumed underlying mechanism employed here) may only be able to shift valence bias so far, to the level of positivity naturally displayed by individuals with a positive bias. In other words, we do not expect that a simple delay manipulation is salient or robust enough to shift ratings to be extremely positive (more positive than the natural positive bias represented in other subjects). As such, the group with a negative bias showed ratings shifted in the positive direction, but only to the extent that is naturally shown by the group with a positive bias.

General Discussion

Extant research has shown that there are individual differences in valence interpretations of ambiguously valenced faces (surprised expression) and scenes (IAPS) in young adults (Neta et al., 2009; Neta & Whalen, 2010; Neta et al., 2013). In the present study, we set out to determine if the age-related positivity effect extended to these interpretations of ambiguity, and if the individual differences in valence bias could be manipulated. Specifically, we predicted that we could encourage individuals with a negative bias to see ambiguity in a more positive light.

Our findings are consistent with the postulation that the age-related positivity effect is a result of a top-down, motivational shift promoting emotionally gratifying experiences, rather than cognitive or neurological decline in old age (see Reed & Carstensen, 2012). Isaacowitz, Allard, Murphy, and Schlangel (2009) found that an attentional bias toward posivity emerged at least 500 ms after stimulus onset, supporting the hypothesis that the positivity effect is a controlled (slower) process. Here, we found that longer RTs were associated with a positive bias, which provides additional evidence for this view. Second, compared to younger adults, older adults recruit medial prefrontal regions to a greater extent when processing negative as opposed to positive images (Williams et al., 2006; Leclerc & Kensinger, 2011). Given that these regions are implicated in emotion regulation, those findings are consistent with a controlled mechanism for down-regulating negative information in older adults. This also fits nicely with work in younger adults showing that a more positive interpretation of surprised faces is associated with greater medial prefrontal activity (Kim et al., 2003).

Next, given that older adults showed a more positive bias and were also slower to make valence decisions (Experiment 1), we predicted that perhaps simply encouraging young adults to take longer when making their valence ratings might be sufficient to bias their interpretations in the positive direction. In Experiment 2, we found that individuals with a negative bias showed the greatest increase in RTs after being instructed to take their time and consider alternative interpretations. Importantly, these individuals showed a concomitant shift in the positive direction, specifically for ratings of ambiguous items (ratings of clearly negative items, e.g., shifted in the negative—more accurate—direction). As such, our data suggest that the valence bias, which represents a trait-life difference across people (Neta et al., 2009), can be shifted. In particular, this positivity shift occurs simply by taking longer to make an evaluation for each item. This is consistent with work in other domains that found that mindfulness training, including focused breathing, is associated with increased positive and decreased negative emotions (Davidson et al., 2003; Brown & Ryan, 2003; Arch & Craske, 2006). Interestingly, mindfulness involves a process of enabling alternate appraisals of life events (Teasdale, Segal, & Williams, 1995), which is likely associated with increased processing time, and is thought to play a causal role in positive reappraisal (Garland, Gaylord, & Park, 2009). The corresponding increase in even momentary positive affect is associated with increased resilience (Cohn, Fredrickson, Brown, Mikels, & Conway, 2009). Indeed, for participants with a lifetime history of depression, scoring only one standard deviation higher on the ability to generate positive affect from pleasant daily life events was associated with a threefold reduction in risk to experience a future episode (Wichers et al., 2010). As such, we are hopeful that these results in psychiatrically healthy participants may ultimately provide tools and insights for the future study of psychopathological groups with known negativity biases (e.g., depression, anxiety).

Effects of Constrained Processing

Experiment 1 represents a more unconstrained task, where participants were simply asked to rate each image as positive or negative based on a gut reaction. These data revealed an age-related positivity effect such that older adults rated ambiguous items as more positive than younger adults. This is consistent with the notion that the positivity effect is strongest in tasks that do not constrain information processing (e.g., tasks that encourage naturalistic viewing or allow participants to attend to vs. ignore whichever information they pleased; Reed, Chan, & Mikels, 2014).

In contrast, Experiment 2 (which was conducted only on younger adults) was more constrained, instructing people to consider the alternatives before selecting a response. In this study, we found that participants that initially had a negative bias showed a shift toward positive ratings upon deliberation. Because previous work has shown that the processing constraints do not significantly change the negative bias in younger adults (Reed et al., 2014), we suggest that this shift was not attributable to the processing constraints. Instead, when instructed to consider the alternatives and spend more time on the decision, the younger adults were more able to see the potential positive interpretation of ambiguity.

Having said that, we do not mean to suggest that slowed speed is the mechanism underlying positivity, per se. It could be that the slowed speed allowed for greater deliberation or other processing that represents the underlying mechanisms for positivity. In other words, it could be that the delay instruction not only emphasized slower RTs, but also encouraged a shift in goals such that participants rated images as more positive because of an increase in emotional reflection. Such a change in goals has been previously shown to eliminate the age-related positivity effect, encouraging younger adult responses to reflect more older adult-like responses (Lockenhoff & Carstensen, 2007). Therefore, it is possible that the positivity effect is not driven by the slower responses, but by a change in the goals and approach taken by each participant. Future work including both older and younger adult populations would be needed to tease apart these alternative explanations.

Limitations

Although we did not find clear evidence from our results of an age-related impairment in recognizing negative emotions (see Ruffman et al., 2008), it could be that older adults showed a greater positivity bias in response to ambiguous images because they have more difficulty detecting negative emotions, not because they exert regulatory effort to be more positive. In other words, we do not have evidence that the positivity bias specifically results from a regulatory effort to be more positive, per se. It could be that the positivity bias results from an effort to be less negative, or even if ratings were converging to 50/50 (no bias). As mentioned above, it appears that regulatory effort is only able to shift valence bias so far (to the level of positivity naturally displayed by individuals with a positive bias). So it could be that (a) the negative group shifted to the same level of positivity as the positive group, whereas the positive group showed no change, or (b) it could be that the ratings were converging to the middle of the scale (50/50). However, we do believe that this mechanism is related in some way to a regulatory effort to be more positive because, in younger adults, negativity is more automatic (Neta & Whalen, 2010; Neta et al., 2011) and positivity takes longer (Neta et al., 2009). Future work would be needed to explicitly disentangle these potential explanations.

Finally, previous work has shown that the highest functioning older adults show the positivity effect the most (Mather & Carstensen, 2005). This finding is consistent with our hypothesis that positive valence bias is associated with regulatory capacity, but it is not consistent with the hypothesis that the regulatory mechanisms underlying positive bias require longer RTs (as higher functioning older adults would have faster RTs than lower functioning older adults). This inconsistency could be a result of differences between rating clearly versus ambiguously valenced images. In other words, it could be that the cognitive resources required for reallocating attentional resources away from clearly negative information and toward clearly positive information is greater than the attentional resources required to find the positivity that is available in an ambiguously valenced images (i.e., images that can naturally have both positive and negative interpretations). Indeed, in response to ambiguity, it appears that, at least for young adults, the negative interpretation is faster and more automatic, and the positivity is slower (see data in the present study as well as previous work with young adults; Neta et al., 2009). Therefore, perhaps there is no effect of cognitive impairment on responses to ambiguity, and we do not have the data here to address this directly. However, given previous work and our initial negativity hypothesis, we would predict that positivity would be associated with longer RTs, and that older adults (who show longer RTs than younger adults) might then show a more positive bias. Future work could address these findings with respect to regulatory ability and cognitive impairment in aging.

Conclusions

Previous studies support the proposal that there is a trait-like individual difference in ascribing ambiguous images with a positive or negative valence (Kim et al., 2003, 2004; Neta et al., 2009, 2013). Moreover, this tendency toward a more positive or negative interpretation (i.e., valence bias) is stable across time (Neta et al., 2009) and generalizes across stimuli (Neta et al., 2013). The present work has shown, however, that there are age-related changes in the valence bias, such that as age increases, the bias becomes more positive. As such, the current study showed that the age-related positivity effect for attention and memory extends to ambiguity resolution. This age-related positivity effect, along with previous work demonstrating that children have a more negative valence bias (Tottenham et al., 2013) suggests a longitudinal change of valence bias across the life span, from an early negativity to gradually more positivity in later adulthood.

Moreover, these data suggest that the negative valence bias can be moved in the positive direction, at least temporarily. This work may help inform research of psychiatric disorders (e.g., anxiety, depression) where a negativity bias may be at the heart of the psychopathology (Williams et al., 2007). These data further complement previous research suggesting that negativity is more automatic and that positivity requires an additional, presumably regulatory, mechanism. In future studies, we will specifically test the relationship between the positivity bias and emotion regulation, predicting that those individuals that naturally adopt a more positive bias show better emotion regulation abilities.

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