

Fox, C., Mather, M., & Kennedy, B.L. (in press). Age differences in rapid attention to emotional stimuli are driven more by valence than by discrete emotions. *Emotion*.

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Age Differences in Rapid Attention to Emotional Stimuli are Driven More by Valence than
by Discrete Emotions

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Correspondence concerning this article should be addressed to Briana L. Kennedy, School of Psychological Science, University of Western Australia (M304), 35 Stirling Highway, Crawley WA 6009 Australia, Email: briana.kennedy@uwa.edu.au. Additional materials are available at <https://osf.io/j2cpd/> (Fox et al., 2025), which includes a list of stimuli used in the experiment, experimental programs, analysis scripts, and raw and summarized data. The authors declare no conflicts of interest. This project was conducted in part for C.F.'s honours thesis at the University of Western Australia (UWA), the project was funded by UWA start-up funds to B.L.K., and M.M. was supported by National Institutes of Health grant R01AG082073. We wish to thank members of the Cognition Lab Group at UWA for helpful discussion about this project and those who participated in the study. Authors' contributions: C.F.: conceptualization (supporting), methodology, investigation, writing—original draft, writing—review/editing; M.M.: conceptualization, methodology, writing—review/editing; B.L.K.: conceptualization, methodology, software, investigation, formal analysis, writing—original draft, writing—review/editing, supervision.

Abstract

In a pattern known as the *positivity effect*, older adults tend to prioritize positive over negative information in attention and memory compared to younger adults. Traditional theories attribute this effect to age-related shifts toward positive emotions, and it is typically operationalized as a two-by-two interaction between age (younger versus older) and valence (negative versus positive). Alternative accounts, however, suggest that discrete emotions within valence categories may differentially drive the effect. To test this, from June to July 2023, younger adults ($n = 101$) and older adults ($n = 108$) completed an emotion-induced blindness task online. In each task trial, an emotional distractor image appeared shortly before a task-relevant target in a rapid stream of images. Emotional distractors depicted scenes of fear, disgust, excitement, contentment, or were emotionally neutral. We measured distraction from the emotional images and found minimal age-related differences between trials with different discrete emotion categories, but the positivity effect was evident when we compared across negative and positive valence categories. These findings suggest that valence, rather than discrete emotions, drives the positivity effect in attention. We discuss insights gained, limitations of our approach, and generalizability of our results to understand age-related changes in emotional prioritization.

Keywords: positivity effect, valence, discrete emotions, attention, aging

The positivity effect describes a pattern in which positive stimuli are prioritized over negative stimuli in attention and memory by older adults compared to younger adults (Carstensen & DeLiema, 2018; Charles et al., 2003; Mather & Carstensen, 2005; Reed & Carstensen, 2012). Although the mechanisms underlying the effect are not yet clear (Mather, 2024), the literature defines the effect as a two-by-two interaction between age (younger versus older) and valence (negative versus positive; Reed et al., 2014). The emotional stimuli used in positivity effect studies, however, are not simply negative versus positive. For example, using terms from a discrete emotions perspective, negatively valenced emotions can represent an array of distinct emotions such as fear, disgust, sadness, or anger, while positively valenced emotions can represent discrete emotions such as happiness, contentment, amusement, or excitement (e.g., Ekman, 1999; Ekman et al., 1983; Izard, 1992). Differences between discrete emotions within valence categories remain less explored in the positivity effect literature, despite their relevance for current theories.

The predominant account to explain the positivity effect is based on the socioemotional selectivity theory, which suggests that due to the limited time older adults have left to live, their goals change to derive more positive meaning out of life (Carstensen, 2006; Mather & Carstensen, 2005; Reed & Carstensen, 2012). However, aspects of this theory remain challenged (Barber & Kim, 2022), such as the role of motivational priorities related to limited time, and alternative theories consider other mechanisms. For example, the aging-brain model proposes the positivity effect is due to age-related neurodegeneration inhibiting responses to negative stimuli (Cacioppo et al., 2011), while the dynamic integration theory proposes older adults prioritize positive emotions as they tend to be less complex and easier to process than negative emotions (Labouvie-Vief et al., 2010). Others have suggested multiple processes; for example, Barber and Kim (2022) consider that the positivity effect may represent several mechanisms, given the way the effect seems to work differently across different tasks.

Theories tend to define the positivity effect as a pattern between negative and positive emotions. However, some theories consider differences between discrete emotions. For example, the discrete emotion theory posits that individuals prioritize different discrete emotions based on their relevance for navigating life stages (Kunzmann et al., 2014). This account focuses on differences between anger and sadness. Both are negative emotions but show different patterns with age – Kunzmann et al. argue that anger is more important to achieve goals in early life while sadness is more relevant in older age when dealing with loss and decline. The recently proposed autonomic compensation model considers age-related change in the sympathetic and parasympathetic nervous systems (Mather, 2024), which also considers emotions differently than simply negative versus positive. This model suggests that sympathetic activity increases as bodies age, and the brain compensates with increased parasympathetic activity from the ventromedial prefrontal cortex (Mather, 2024). In this instance, the positivity effect is a byproduct of the compensation from increased parasympathetic influence in the brain, whereby stimuli that activate parasympathetic activity are favored, with a bias against stimuli that activate sympathetic activity. While negative stimuli tend to be more sympathetic and positive stimuli tend to be more parasympathetic, there are exceptions: disgust, for example, is a negative emotion that promotes both sympathetic and parasympathetic activity (Kreibig, 2010).

Discrete emotions also differ along several other dimensions beyond valence. For example, anger is distinct from most other negative emotions in its motivational direction; whereas most negative emotions tend to be associated with avoidance, anger often activates approach/appetitive motivational systems more commonly seen in positive emotions (Carver & Harmon-Jones, 2009). Furthermore, emotions of similar valence can differ in the way they are appraised. According to the appraisal tendency framework, fear is associated with lower

certainty and lower levels of perceived control, whereas anger and disgust are associated with higher certainty and greater perceived control (Lerner & Keltner, 2000, 2001).

Limited research has investigated how discrete emotions contribute to the positivity effect, yet there are indications that discrete emotions with the same valence elicit different patterns across age. Research in this space tends to focus on anger and sadness (Kunzmann et al., 2014; also see reviews by Kim & Barber, 2022; Mather & Ponzio, 2016). Patterns indicate that general experiences of anger decrease with age, while general experiences of sadness either stay the same or increase with age (Kunzmann et al., 2013; Kunzmann & Thomas, 2014; but see Allard & Hamilton, 2019). In line with this pattern, some experimental work has indicated that older adults attend to anger and sadness stimuli differently (Isaacowitz et al., 2006). Recent work has also compared other discrete emotions (Boğa et al., 2021; Fernández-Aguilar et al., 2020). For example, Boğa et al. (2021) measured delayed recognition memory for fear, disgust, and happiness images and found age differences. Younger adults were more accurate in remembering disgust images than other image types, and showed a more liberal response bias for fear and disgust images. Older adults did not have better memory for disgust images than other image types, but did have an increased response bias for disgust images over other image types, meaning they were more likely to say they remembered a disgust image compared to images in other emotion categories (including fear; Boğa et al., 2021). These differences suggest that fear and disgust may operate differently with age, with some preservation of bias towards disgust but not fear, despite both being negative emotions.

Fear and disgust are both negative in valence and associated with avoidance (e.g., Harmon-Jones et al., 2013). However, relevant to positivity effect theory, particularly the autonomic compensation model, fear and disgust activate the autonomic nervous systems differently, with fear associated with promoting sympathetic activity and disgust associated

with promoting both sympathetic and parasympathetic systems (Kreibig, 2010). This suggests that disgust, despite being a negative emotion, could show patterns more similar to positive emotions due to its parasympathetic influences. Previous behavioral research also reveals age differences related to disgust that are different from other negative emotions. For example, older adults are often worse than younger adults at recognizing negative faces, but perform the same or better at recognizing disgust faces (Mather & Ponzio, 2016; Ruffman et al., 2008). Altogether, previous evidence and recent theory indicate that older adults may preserve biases for disgust stimuli but not fear stimuli.

Positive emotions are often captured under a single category of happiness, but can be categorized into several discrete emotions including amusement, awe, contentment, enthusiasm, excitement, joy, and pride (Fredrickson, 2013; Shiota et al., 2017). In the context of the positivity effect, amusement is a particularly interesting positive discrete emotion as it promotes both sympathetic and parasympathetic activity (Kreibig, 2010). However, amusement is somewhat difficult to study practically, due to limited stimuli identified as depicting amusement exclusive of other emotions. In the current study, we chose to focus on the positive emotions excitement and contentment. Both excitement and contentment are positive emotions, but excitement is typically a high arousal emotion while contentment is typically a low arousal emotion (Fredrickson, 1998). Arousal is related to autonomic nervous system activity (Kreibig, 2010), and research indicates that arousal can affect how positive emotions are experienced with age. For example, Bjälkebring et al. (2015) found that older adults rated their happiness lower when it was framed as high in arousal (such as ecstatic and bursting with positive emotions), but rated their happiness higher when it was framed as low in arousal (such as satisfied and filled with positive emotions). Examining age differences between excitement and contentment thus provides an opportunity to see if the attentional priority for these positive emotions shifts with age.

As theories of the positivity effect differ in their mechanistic assumptions, tasks that probe these distinctions serve as useful tools for distinguishing among accounts. In particular, the temporal dynamics of underlying mechanisms are at the heart of some theoretical differences. Whereas the socioemotional selectivity theory posits a goal-oriented, motivational change that may require time for regulatory processes to unfold, other theories suggest more automatic, immediate mechanisms. With the aim of probing mechanisms of the positivity effect in this study, we examined biases to discrete emotions at the level of attention.

Several studies have observed the positivity effect in attention (Barber et al., 2020; Gronchi et al., 2018; Isaacowitz et al., 2006; Kennedy et al., 2020; Kennedy & Mather, 2024; Knight et al., 2007; Mather & Carstensen, 2003; Zsoldos & Hot, 2023), but many attentional task designs still allow time for goal-directed strategies to be enacted. However, recent research revealed age differences consistent with the positivity effect for stimuli presented immediately after an emotional stimulus (Kennedy et al., 2020; Kennedy & Mather, 2024). Using an emotion-induced blindness task (e.g., Most et al., 2005), participants were shown a stream of images presented rapidly at a rate of ten images per second and asked to identify one target image rotated 90 degrees to the left or right. The rotated target picture sometimes appeared soon after an emotionally powerful distractor image that was negative or positive; poorer performance indicated greater distraction by the emotional images. Younger adults were consistently distracted by both negative and positive images, while older adults were distracted by positive images but less so by negative images. As the emotion-induced blindness task can measure age differences at a level of processing that is rapid and resistant to top-down control efforts (e.g., Kennedy et al., 2018; Kennedy & Most, 2015; Most et al., 2007; Zhao & Most, 2019), it is a quite interesting lens through which to examine differences in discrete emotions in the positivity effect.

In the current study, we used an emotion-induced blindness task to examine how younger and older adults attend to fearful, disgusting, exciting, contentment and emotionally neutral images. As in typical emotion-induced blindness designs (e.g., Most et al., 2005), we varied the temporal distance between the emotional distractor image and subsequent target image. This allowed us to examine the effects of discrete emotion images at different timepoints in attentional processing, as well as to vary participants' expectation of when the target image would appear. We chose to examine the distractor's influence when the target was presented at lag 2 (when the target appeared as the second image after the emotional distractor image) and lag 4 (when the target appeared as the fourth image after the emotional distractor image). Previous research indicates that the positivity effect is well-pronounced at lag 2 (Kennedy et al., 2020; Kennedy & Mather, 2024).

We chose to have participants complete the experiment across two days, as the greater number of distractor categories than typical emotion-induced blindness designs significantly increased the length of the experiment. A two-day design also provided an opportunity to examine the test-retest reliability. The emotion-induced blindness task has been shown to have low reliability yet has better reliability than other emotion-attention tasks (with intraclass correlation coefficients ranging from 0.33 to 0.91; Onie & Most, 2017). Although recent work has found that emotion-induced blindness differences between age groups appeared reliably (in a series of five experiments; Kennedy et al., 2020; Kennedy & Mather, 2024), some have questioned the reliability of the task as a measure of individual differences (Edwards et al., 2024). Therefore, the current study provided a design to both examine group differences for the image types and positivity effect, and measure reliability within-individuals across different timepoints.

In summary, in this study we aimed to better understand the mechanisms that drive the positivity effect by comparing discrete emotions within valence categories using an emotion-

induced blindness task (Most et al., 2005). In line with previous research (Kennedy et al., 2020; Kennedy & Mather, 2024), we predicted a positivity effect pattern with age differences overall between positive and negative trials. Additionally, we predicted there would be age differences between discrete emotion trials within valence categories. For negative distractors, we expected younger adults to be similarly distracted by fear and disgust images, but older adults to be more distracted by disgust images than fear images. For positive distractors, we expected younger adults to be more distracted by excitement images than contentment images, but older adults to be more distracted by contentment images than excitement images. We also expected the emotion-induced blindness task to show similar reliabilities to previous research, and to be a reliable measure of the positivity effect within participants.

Method

Participants

One hundred twenty younger adults and 120 older adults completed the study ($N = 240$). Data from 31 participants were removed from the final sample dataset; five participants (aged 34 to 47 years) for being aged far outside the target age ranges for younger adults (18 to 30 years) and older adults (over 60 years)¹, two for failing to complete the first day of the experiment (1 younger adult, 1 older adult), 11 for failing to complete the second day of the experiment (6 younger adults, 5 older adults), and an additional 13 participants for poor performance (8 younger adults, 5 older adults; see *Data Screening*). The final sample comprised 209 participants (101 younger adults, 108 older adults). The mean age of younger adults was 25.2 years ($SD = 3.0$ years, range: 19-30 years); 49 younger adults identified as female, 48 as male, two as non-binary, one as agender, and one as gender-fluid. The mean age

¹ We used the CloudResearch recruitment platform to target participants within specified age ranges and the study advertisement clearly outlined these age requirements. Nevertheless, some participants were aged outside of these ranges. We decided to retain data from participants whose ages were within five years of the target ranges but excluded data from participants whose ages exceeded that extended range.

of older adults was 66.6 years ($SD = 5.2$ years; range: 58-80 years); 66 older adults identified as female and 42 as male.

Younger adults described their highest level of education as a high school degree or equivalent ($n = 35$), some undergraduate work ($n = 15$), an associate's degree ($n = 7$), an undergraduate degree (e.g., Bachelor's; $n = 36$), a graduate degree (e.g., JD, Master's, or PhD; $n = 6$), or a vocational degree ($n = 2$). Older adults described their highest level of education as a high school degree or equivalent ($n = 20$), some undergraduate work ($n = 10$), an associate's degree ($n = 15$), an undergraduate degree (e.g., Bachelor's; $n = 32$), a graduate degree (e.g., JD, Master's, or PhD; $n = 27$), or a vocational degree ($n = 4$). One younger adult and 57 older adults self-reported being retired.

We aimed to recruit at least 100 participants in each group, to achieve a sample size capable of observing small-to-medium effects in our main comparisons of interest. The final sample of 209 participants was powered to observe a repeated measures within-between ANOVA interaction with effect sizes of $f = .12$, and Pearson correlations with effect sizes of $\rho = .19$, with $\alpha = .05$ and power $(1 - \beta) = 0.80$ (calculated with G*Power; Faul et al., 2007).

Participants were recruited from Australia and the United States via CloudResearch (Litman et al., 2017). Participants were eligible for the study if they were aged within the required age ranges (18-30 years or 60 years or older), had normal or corrected-to-normal vision, had the necessary technology (a computer with internet connection), were not taking beta-blocker medication, and could complete both Day 1 and Day 2 of the study.

Participants who completed Day 1 received \$5 USD. Those who completed all 200 trials on Day 1 were invited to participate in Day 2 via an email sent 12-24 hours later. Participants who completed Day 2 completed it on average 28.2 hours later ($SD = 11.43$, range: 14.6-94.3 hours) and received an additional \$7 USD for their participation. Each session took approximately 30 minutes to complete. Data were collected between June and

July 2023. Ethics was approved by the University of Western Australia Human Research Ethics Committee (2023/ET000257; “Discrete Emotions in Attention”).

Materials

Participants completed the experiment on their own computer via the Internet. The experiment was programmed using custom scripts in Inquisit (*Inquisit 6*, 2021) and Qualtrics software.

Stimuli

Stimuli were colored 320-pixel $\times$ 240-pixel images presented against a white background. Images were used as either distractor, target, or filler images in the emotion-induced blindness task. Distractor images depicted fear, disgust, excitement, contentment, or neutral content. Two hundred distractor images (40 images per distractor type) were selected from the International Affective Pictures System (IAPS; Lang et al., 2008), Nencki Affective Picture System (NAPS; Marchewka et al., 2014), and Disgust-Related-Images (DIRTI; Haberkamp et al., 2017).

Distractor images were chosen based on the databases’ normative ratings of valence and arousal, as well as previous research ratings of discrete emotion categories (Haberkamp et al., 2017; Mikels et al., 2005; Riegel et al., 2016) and also from some unpublished ratings from a clinical trial (Nashiro et al., 2024). Haberkamp et al (2017) provided a database consisting primarily of disgust-eliciting images, and ratings from this database were used to choose disgust images rated high in disgust and low in fear. Mikels et al. (2005) and Riegel et al. (2016) had participants rate images from the IAPS and NAPS databases respectively across discrete categories and additionally assigned discrete emotion category labels for each image, and Nashiro et al. (2024) similarly had participants categorize IAPS, NAPS, and DIRTI images with discrete emotion category labels. We chose images for our four emotion categories based on category assignments from these previous studies to ensure that they

were previously confirmed as depicting the targeted emotion over other emotions. The only exception was in the excitement image set; there were few images that were labelled as uniquely depicting excitement over all other emotions, so we also included images that were categorised as both excitement and awe. When there were insufficient images from previous research for a discrete emotion category, images depicting similar content were supplemented with images from the Open Affective Standardized Image Set (OASIS; Kurdi et al., 2017) based on the judgement and agreement of authors BLK and CF.

From the sets of discrete emotion images, we further eliminated images that were inappropriate for the emotion-induced blindness design. These were images that depicted scenes without clear people, animals, or prominent objects visible, which would make them difficult to serve as distractors amongst other landscape images in the task trials. Finally, we used ratings of arousal and valence to best match between the final sets of images and also establish a set of “neutral” category images. Neutral images were chosen to resemble images used in previous emotion-induced blindness experiments clearly depicting people, animals, or prominent objects, and were rated as low in arousal and neither negatively nor positively valenced.

All of the databases that we used to collect images (i.e., IAPS, NAPS, DIRT1, and OASIS) provided normative ratings of valence and arousal on scales from 1 (negative valence; low arousal) to 9 (positive valence; high arousal). A list of the specific images used in the experiment is provided on the Open Science Framework at <https://osf.io/j2cpd> (Fox et al., 2025), and descriptive statistics, including average valence and arousal ratings for each image category, are provided in the *Supplementary Material*.

In our final set of distractor images, there was no significant difference between fear and disgust images in valence, $t(78) = 0.97, p = .335, d = 0.22$, or arousal, $t(78) = 0.69, p = .495, d = 0.15$, ratings. By their nature, excitement images are more arousing than

contentment images, so unlike the negative emotion categories, we chose not to match them on valence or arousal ratings. This allowed us to prioritize images that best represented the discrete categories as well as specifically disconnect the positive categories by high arousal and high valence ratings. Excitement images were higher in arousal, $t(78) = 4.63, p < .001, d = 1.03$, and less positive, $t(78) = 5.06, p < .001, d = 1.12$, than contentment images. Both contentment and excitement image sets were rated as more positively valenced than disgust and fear image sets ($ts \geq 12.80, ps \leq .001$). Excitement images were significantly more arousing than fear and disgust images ($ts \geq 2.15, ps \leq .035$), while contentment images were less arousing than fear images, $t(78) = 2.62, p = .011, d = 0.59$, but not less arousing than disgust images, $t(78) = 1.88, p = .064, d = 0.42$. Compared to neutral, fear and disgust images were significantly more negative in valence ($ts \geq 9.70, ps \leq .001$) whereas excitement and contentment images were significantly more positive ($ts \geq 5.96, ps \leq .001$). Fear, disgust, excitement, and contentment images were all significantly higher in arousal than neutral images ($ts \geq 3.15, ps \leq .002$).

Similar image themes were evident within the final discrete emotion subsets of distractor images. Fear images included scenes of threatening animals, weapons, or violent acts. Disgust images included scenes of medical injuries, vomit, or rotting food. Excitement images included images of people playing extreme sports, such as motocross or skiing. Contentment images included images such as smiling babies or kittens. Neutral images included people with neutral facial expressions or engaging in passive activities, such as supermarket shopping.

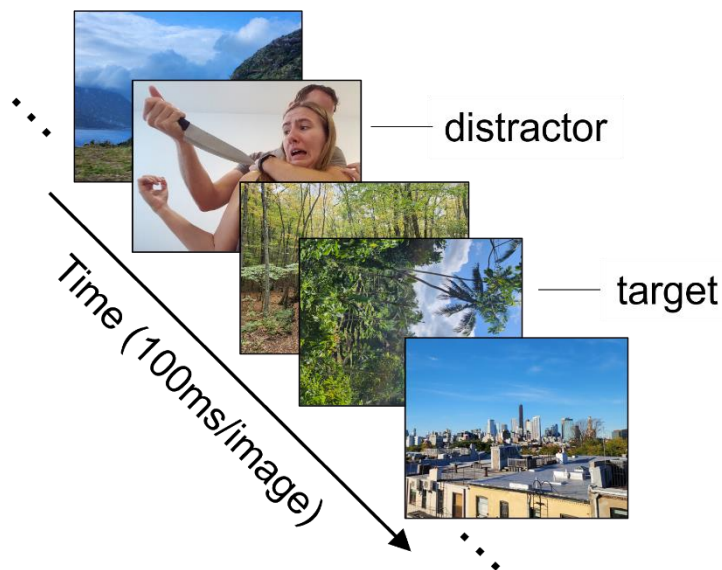
Target images depicted landscape or architectural scenes, but did not include people or animals, and were rotated 90 degrees to the left or 90 degrees to the right. These were comprised of 52 images rotated 90 degrees to the left and 90 degrees to the right (104 images total). An additional 204 filler images depicted landscape or architectural scenes and did not

include people or animals but were not rotated. Target and filler images were the same as those used in previous emotion-induced blindness research (Kennedy et al., 2020; Kennedy & Most, 2015; Most et al., 2005).

All image types were divided into two sets (Set A and Set B). Each set had 100 distractor type images (20 images per distractor type); both sets were balanced for content, valence, and arousal of each distractor type so there was no significant difference between Set A and Set B image sets on these measures. Similarly, target and filler images were split across the two sets and had similar images on both. Each set included 26 of the 52 target images, and 102 of the 204 filler images, so that no target or filler images appeared on both days. The sets were counterbalanced so that approximately half of participants viewed Set A on Day 1 ($n = 107$) and the other participants viewed Set B on Day 1 ($n = 102$).

Emotion-Induced Blindness Task

Each experimental session consisted of 200 trials divided into four blocks (50 trials per block; 400 trials across both days). Each trial contained 15 images: one target (rotated) image, one distractor (emotional) image, and 13 filler (unrotated) images. Images were presented in a rapid serial visual presentation and were shown one at a time in the center of the screen for 100 milliseconds before being rapidly replaced by the following image (see *Figure 1*).

Figure 1*Schematic of a Partial Trial in the Emotion-Induced Blindness Task*

Note. Participants searched for a single target image rotated to the left or to the right. A distractor that depicted either fear, disgust, excitement, contentment, or emotionally neutral scenes appeared either two or four items before the target in each trial. The images depicted here serve as examples of the types of images that appeared in the experiment but were not part of the stimulus set.

The target image always appeared sometime after the distractor image. In half of the trials, the target appeared as the second image after the distractor image (lag 2) or as the fourth image after the distractor image (lag 4). Previous research indicates that effects of distractor images are particularly strong at early lags, such as lag 2, and weaken with later lags, such as lag 4 (e.g., Kennedy & Most, 2015; Most et al., 2005). Distractor images and lags were quasi-randomised from trial to trial to reduce participant anticipation of a particular emotional distractor appearing.

At the beginning of each trial, participants viewed a fixation cross for 500 milliseconds before the rapid stream of images. After all 15 images for the trial were presented, there was a screen with text (“Rotated left (F) or right (J)?”) prompting the participant’s response. There was no time limit for responding. Once participants entered their response, the program provided feedback (“Correct!” or “Incorrect.”). The subsequent trial began 500 milliseconds after participants submitted their response. Participants were notified when they had completed a block of trials and pressed Enter (or equivalent) on their computer keyboard when ready to commence the next block.

Before the task, participants completed six practice trials. The initial three practice trials presented images at 200 milliseconds per image and the final three practice trials presented images at the experiment speed of 100 milliseconds per image. All practice trials had a filler image instead of a distractor image, such that no emotional images were shown during practice.

Questionnaires

Participants completed a demographic questionnaire, which included questions regarding the participants’ age, gender, education, profession, retirement status, and whether their vision was normal or corrected-to-normal. We also administered five additional questionnaires: The Depression Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995), a subset of the World Health Organization Quality of Life Scale -- Brief Version (WHOQOL-BREF; World Health Organization, 2004), the Disgust Propensity and Sensitivity Scale-Revised (DPSS-R; Fergus & Valentiner, 2009), the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), and the Cognitive Emotional Regulation Questionnaire (CERQ; Garnefski et al., 2001). These questionnaires were included for secondary exploratory analyses outside of the main scope of the experiment, but we report these analyses in the *Supplemental Material* for interested readers.

Procedure

Participants registered for the study online through CloudResearch. On Day 1 of the study, participants clicked a link redirecting them to Qualtrics, where they were presented with information about the study and shown examples of emotional images to ensure they were comfortable with the experiment. Participants read the consent form and after providing consent completed demographic questionnaires, the DASS-21, and PANAS. Participants were automatically redirected to the emotion-induced blindness task. After the emotion-induced blindness task, participants were thanked and given information about how to complete Day 2: that it would take approximately 30 minutes to complete, that they would be sent an invitation for Day 2 within 12-24 hours, and that they should complete Day 2 within 48 hours of receiving the invitation. Participants were also given information about psychological support if needed, contact information if they had questions, and received compensation for completing Day 1.

After 12-24 hours, participants received an email invitation for Day 2 to complete the emotion-induced blindness task within 48 hours of receiving the invitation. This period was chosen to allow enough time between sessions and reduce participant attrition. Participants clicked on the link provided, where they were welcomed back to the experiment and automatically redirected to the emotion-induced blindness task. The main experiment ran the same way as Day 1. After completing the task, participants were redirected to complete the WHOQOL-BREF, DPSS-R, and CERQ questionnaires. At the end of the experiment, participants were thanked, debriefed about the study's aims, and received compensation for Day 2. It took approximately one hour total to complete the task across both days.

Transparency and Openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. The experimental materials, including custom code,

anonymized data, and summarized results are available on the Open Science Framework and can be accessed at <https://osf.io/j2cpd/> (Fox et al., 2025). Data were analyzed using R (version 4.3.1; *psych* package) and SPSS (version 29). Figures were made with *ggplot2* and tables were formatted using *gt* in R. The experiment was not preregistered.

Results

Data Screening

Full datasets from participants with an overall performance accuracy of less than 55% on either session were excluded from the final dataset ($n = 13$). The 55% threshold was the same as that used in previous emotion-induced blindness research (Kennedy et al., 2020; Kennedy & Most, 2015). Variables met satisfactory levels of normality, making them suitable for statistical parametric analyses, with skewness $< |2.0|$ and kurtosis $< |9.0|$ (Gignac, 2023). Bonferroni correction was applied in post-hoc analyses to accommodate multiple comparisons. When sphericity assumptions were violated, Greenhouse-Geisser corrected values were reported. Bonferroni corrections were applied to t -tests to account for multiple comparisons unless otherwise noted.

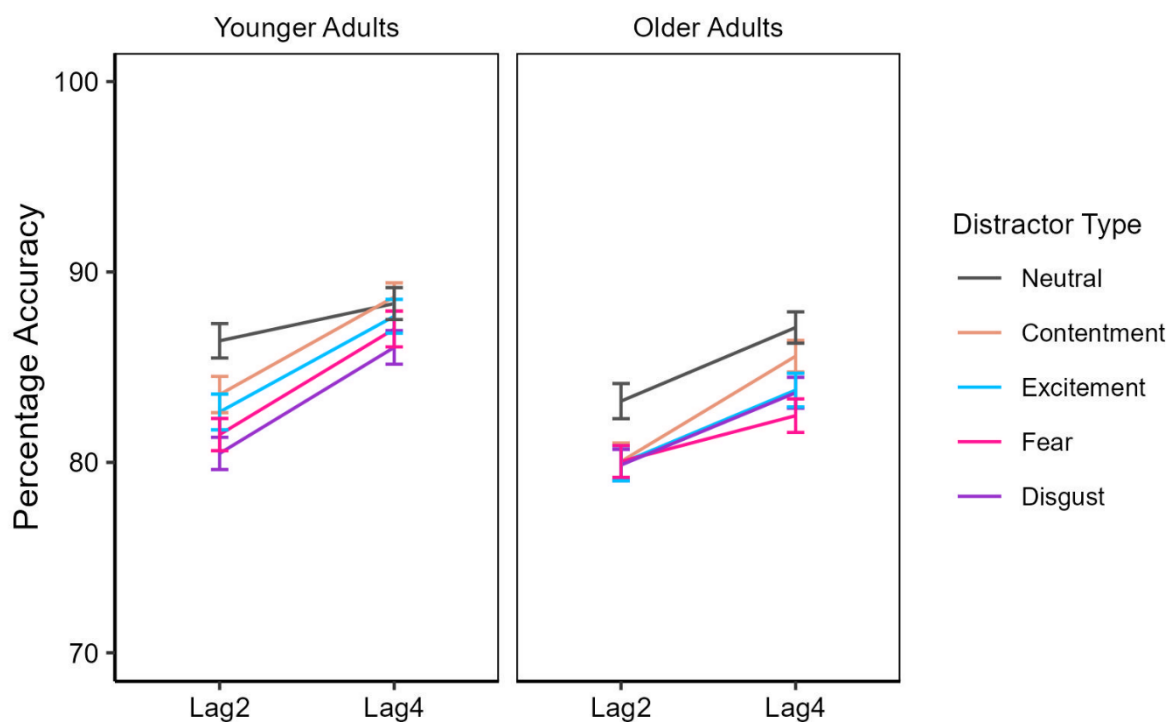
Emotion-Induced Blindness Performance

To assess emotion-induced blindness performance, we used percentage accuracy as the main dependent variable; lower mean percentage accuracy scores reflected greater levels of distraction. Before combining data across days of the experiment, we conducted a 2 (age: younger adults and older adults) $\times$ 5 (distractor type: fear, disgust, excitement, contentment, neutral) $\times$ 2 (lag: lag 2 and lag 4) $\times$ 2 (day: Day 1 and Day 2) mixed-design ANOVA to see if day impacted performance. Data from this analysis are available in our *Supplemental Material*. Importantly, we found no significant age $\times$ distractor type $\times$ lag $\times$ day interaction, $F(3.96, 820.29) = 0.70, p = .594, \eta^2_p < 0.01$, and therefore collapsed across day for

subsequent analyses related to emotion-induced blindness performance. *Figure 2* displays mean percentage accuracies on the emotion-induced blindness task collapsed across day.

Figure 2

Younger and Older Adult Performance on Discrete Emotion Trials Combined Across Days



Note. Error bars represent between-subjects standard error.

For our main analysis, to compare across all discrete emotion categories we performed a $2 \text{ (age)} \times 5 \text{ (distractor type)} \times 2 \text{ (lag)}$ mixed-design ANOVA on target performance. There was a main effect of distractor type, $F(3.93, 813.31) = 30.77, p < .001, \eta^2_p = .13$, indicating that performance differed across distractor types overall, as well as a main effect of lag, such that performance was generally poorer on lag 2 trials than lag 4 trials, $F(1, 207) = 236.74, p < .001, \eta^2_p = .53$. A main effect of age also indicated that older adults performed significantly worse overall than younger adults, $F(1, 207) = 7.49, p = .007, \eta^2_p = .03$. With corrections for

sphericity, there was no significant distractor type $\times$ lag interaction, $F(3.82, 790.83) = 2.39, p = .052, \eta^2_p = .01$, which was unlike most emotion-induced blindness patterns (e.g., Kennedy & Most, 2015; Most et al., 2005). This was perhaps due to the lowered arousal levels of most distractor type images compared to typical experiments. There was also no significant age $\times$ distractor type interaction, $F(3.93, 813.31) = 2.05, p = .087, \eta^2_p < .01$, or age $\times$ lag interaction, $F(1, 207) = 1.85, p = .175, \eta^2_p < .01$. However, there was a three-way age $\times$ distractor type $\times$ lag interaction, $F(3.82, 790.83) = 2.82, p = .026, \eta^2_p = .01$, indicating that the pattern of distraction for different distractor types across lags was different in younger and older adults.

To follow up on the three-way interaction, we examined the age $\times$ distractor type interaction at each lag separately. At lag 2 there were significant main effects of distractor type, $F(3.91, 808.88) = 18.36, p < .001, \eta^2_p = .08$, and age, $F(1, 207) = 4.98, p = .027, \eta^2_p = .02$, but no significant age $\times$ distractor type interaction, $F(3.91, 808.88) = 2.13, p = .077, \eta^2_p = .01$. At lag 4 there were also significant main effects of distractor type, $F(3.89, 805.31) = 12.54, p < .001, \eta^2_p = .06$, and age, $F(1, 207) = 9.25, p = .003, \eta^2_p = .04$, as well as a significant age $\times$ distractor type interaction, $F(3.89, 805.31) = 2.86, p = .024, \eta^2_p = .01$. Thus, age differences in distraction for different discrete emotion categories were pronounced at lag 4 but not at lag 2.

Fear versus Disgust

We compared fear versus disgust distractor types to determine if there were age differences in distraction for these discrete emotions in the negative valence category. We originally planned to conduct a 2 (age) $\times$ 2 (distractor type) ANOVA on only lag 2 data for this comparison, since emotion-induced blindness tends to be most pronounced at lag 2. This planned comparison revealed no main effect of distractor type, $F(1, 207) = 0.91, p = .341, \eta^2_p < .01$, age, $F(1, 207) = 1.00, p = .318, \eta^2_p < .01$, or interaction between them, $F(1, 207) =$

0.43, $p = .514$, $\eta^2_p < .01$. However, given that lag 4 was most pronounced for age differences in the overall ANOVA results with all distractor types, we decided to also run a 2 (age) $\times$ 2 (distractor type: fear vs. disgust) ANOVA of only lag 4 data. This revealed no significant main effect of distractor type, $F(1, 207) = 0.05$, $p = .825$, $\eta^2_p < .01$, but there was a significant effect of age, $F(1, 207) = 9.59$, $p = .002$, $\eta^2_p = .04$, as well as a significant distractor type $\times$ age interaction, $F(1, 207) = 4.06$, $p = .045$, $\eta^2_p = .02$. In the context of the pattern of results, this indicated that younger adults compared to older adults were more distracted by disgust than fear distractor images at lag 4. Nevertheless, subsequent paired samples t -tests revealed that neither younger or older adults demonstrated a difference in fear versus disgust distractor images at lag 2 or lag 4 (with Bonferroni corrections, $ps \geq .569$, $d_{zs} \leq .15$). Thus, there was no significant difference in distraction for fear- versus disgust- images in either younger or older adults, with differences arising only when comparing age groups. This was contrary to our hypothesis that older adults would be more distracted by disgust images than fear images, although it was consistent with our prediction that younger adults would be similarly distracted by fear and disgust images.

Excitement versus Contentment

We next compared excitement versus contentment conditions to see if there were age differences in distraction in the positive valence category. Like the comparisons between fear and disgust, we originally planned to conduct a 2 (age) $\times$ 2 (distractor type: excitement vs. contentment) ANOVA of lag 2 data only. This revealed no main effect of distractor type, $F(1, 207) = 0.75$, $p = .388$, $\eta^2_p < .01$, or age $\times$ distractor type interaction, $F(1, 207) = 0.50$, $p = .481$, $\eta^2_p < .01$, but did reveal a main effect of age, $F(1, 207) = 6.64$, $p = .011$, $\eta^2_p = .03$; older adults were more distracted than younger adults at lag 2. When we ran the same comparisons for lag 4 trials, there was still no age $\times$ distractor type interaction, $F(1, 207) = 0.53$, $p = .468$, $\eta^2_p < .01$, but there were main effects of distractor type, $F(1, 207) = 7.04$, $p = .009$, $\eta^2_p = .03$,

and age, $F(1, 207) = 10.79, p < .001, \eta^2_p = .05$. This indicated that, at lag 2 and lag 4, older adults performed worse than younger adults overall, and at lag 4 older adults compared to younger adults were more distracted by excitement than contentment overall. Subsequent paired samples t -tests between excitement and contentment conditions with Bonferroni correction showed that at both lags there were no significant differences in distraction by excitement images compared to contentment images in either younger adults or older adults ($ps \geq .139, d_{zs} \leq .21$). This was not consistent with our hypothesis for positive images; we expected younger adults to be more distracted by excitement images than contentment images and older adults to be more distracted by contentment images than excitement images. Instead, we found no differences between positive emotion categories in either age group.

Negative versus Positive

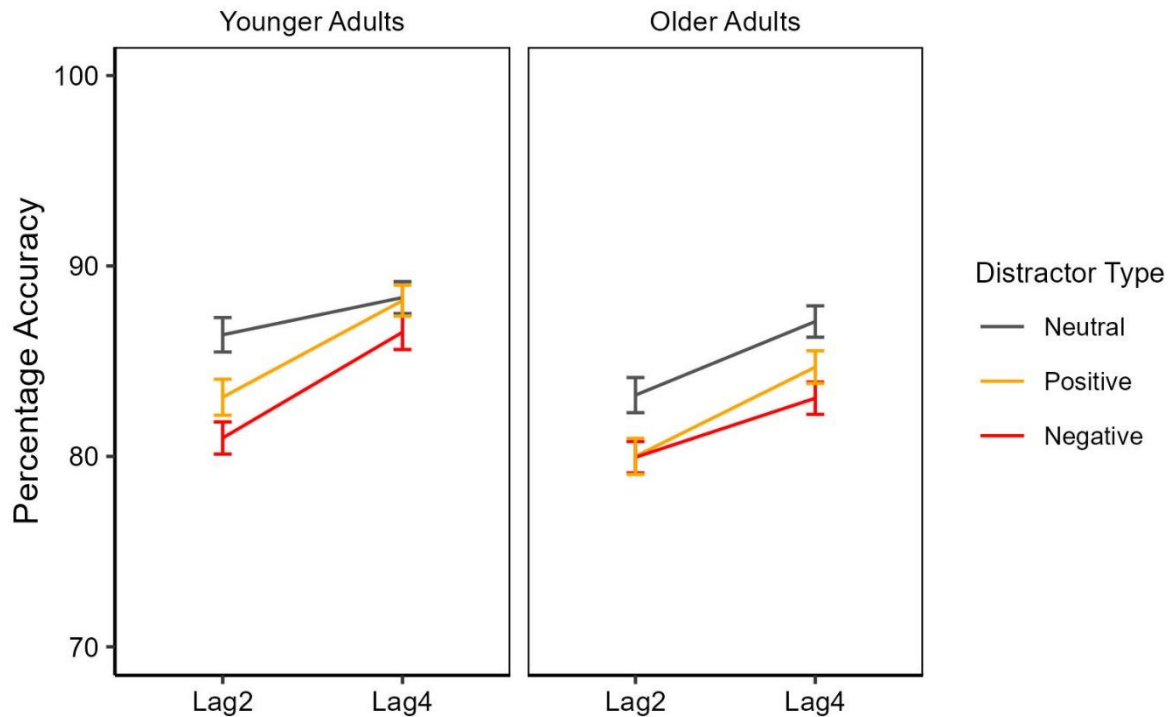
We next wanted to examine whether younger and older adults differed in the way they were distracted by negative versus positive images, as the positivity effect is typically defined. To do this, we collapsed across fear and disgust trials to create a negative valence category, and across excitement and contentment to create a positive valence category (see Figure 3). Because we were collapsing across conditions, for this comparison we ran a 2 (distractor type: negative vs. positive) $\times$ 2 (age) $\times$ 2 (lag) ANOVA. Notably, there was a significant lag $\times$ age interaction, $F(1, 207) = 5.34, p = .022, \eta^2_p = .03$, but no significant distractor type $\times$ age $\times$ lag interaction, $F(1, 207) = 2.95, p = .088, \eta^2_p = .01$, nor distractor type $\times$ age interaction overall, $F(1, 207) = 3.14, p = .078, \eta^2_p = .02$.

We originally planned to conduct a 2 (age) $\times$ 2 (valence category: negative vs. positive) mixed-design ANOVA of only lag 2 data to examine the presence of the positivity effect in the lag that typically shows this pattern. This revealed a significant main effect of valence category, $F(1, 207) = 5.83, p = .017, \eta^2_p = .03$, age, $F(1, 207) = 4.11, p = .044, \eta^2_p = .02$, and age $\times$ valence category interaction, $F(1, 207) = 5.35, p = .022, \eta^2_p = .03$, consistent with the

positivity effect. This differed from lag 4 data, which also showed a significant main effect of valence category, $F(1, 207) = 17.41, p < .001, \eta^2_p = .08$, and age, $F(1, 207) = 11.69, p < .001, \eta^2_p = .05$, but no age $\times$ valence category interaction, $F(1, 207) < .01, p = .973, \eta^2_p < .01$. Subsequent paired t -tests revealed that younger adults were more distracted by negative than positive distractors at lag 2, $t(100) = 3.30, p = .005, d_z = .33$, and lag 4, $t(100) = 2.86, p = .021, d_z = .28$. Older adults showed no difference between negative and positive distractors at lag 2, $t(107) = .07, p = 1.00, d_z = .01$, but, like younger adults, were more distracted by negative than positive distractors at lag 4, $t(107) = 3.05, p = .012, d_z = .29$. Thus, when categorizing images by valence, patterns consistent with the positivity effect were evident when data were restricted to lag 2, but not lag 4. This confirmed our hypothesis that there would be a positivity effect pattern overall, with predicted age differences between positive and negative distractor conditions.

Figure 3

Younger and Older Adults Performance on Positive and Negative Trials Combined Across Days



Note. Error bars represent between-subjects standard error.

Reliability

Having participants complete two days of the experiment allowed us to estimate the reliability of the task conditions across the sessions. We calculated intraclass correlation coefficients (ICC) using a two-way mixed model with absolute agreement for each of the distractor types as well as composite negative and positive scores and a negative-minus-positive performance at both lags separately (i.e., negative minus positive performance at lag 2 and lag 4 separately). Across all participants, the ICC reliability estimates ranged from .138 to .601 (see Table 1). According to common conventions, these reliabilities ranged between poor (less than .5) and moderate (between .5 and .75; Koo & Li, 2016). Separate estimates for younger and older adults are available in our *Supplemental Material*; younger adults' ICC estimates ranged from .206 to .628, while older adults' ICC estimates ranged from -.126 to .632. Altogether, these estimates resemble reliabilities previously reported in emotion-

induced blindness research, however they suggest that this task is unlikely to be well-suited for providing a trait measure of the positivity effect, especially when the positivity effect is assessed at the individual level as a subtraction of negative minus positive. Indeed, many classic behavioral tasks show low within-subject reliability (Enkavi et al., 2019). However, our findings suggest that positive and negative distractor scores considered separately yield better reliability.

Table 1

Intraclass Correlation Coefficients Comparing Day 1 and Day 2 Performance in All Participants ($N = 209$).

<i>Distractor Type</i>	<i>Lag</i>	<i>ICC</i>	<i>95% CI Lower</i>	<i>95% CI Upper</i>
Contentment	Lag 2	0.473	0.309	0.598
	Lag 4	0.458	0.290	0.586
Disgust	Lag 2	0.324	0.117	0.483
	Lag 4	0.379	0.189	0.525
Excitement	Lag 2	0.479	0.317	0.603
	Lag 4	0.581	0.451	0.681
Fear	Lag 2	0.347	0.148	0.500
	Lag 4	0.519	0.369	0.633
Neutral	Lag 2	0.539	0.395	0.648
	Lag 4	0.426	0.248	0.562
Negative	Lag 2	0.419	0.239	0.557
	Lag 4	0.576	0.436	0.680
Positive	Lag 2	0.587	0.449	0.690
	Lag 4	0.601	0.475	0.697
Negative Minus	Lag 2	0.250	0.014	0.430
Positive	Lag 4	0.138	-0.132	0.343

Discussion

We sought to understand the role of discrete emotions in the positivity effect. We used an emotion-induced blindness task to determine how younger and older adults attended to images depicting fear, disgust, excitement, contentment, or emotionally neutral scenes. We

predicted that younger and older adults would demonstrate a positivity effect overall, but that there may be differences in performance between discrete emotion categories beyond valence. In both younger and older adults, we found no difference in performance between fear and disgust images nor between excitement versus contentment images in the way they were attended at lag 2. We did find minimal differences at lag 4 in how younger and older adults attended to discrete emotion images, but not in the directions we predicted. In fact, the pattern at lag 4 suggested fear images were somewhat more distracting than disgust images to older adults, which was the opposite of our predictions. While the effects of discrete emotions were minimal, we did find a positivity effect pattern consistent with our prior findings (Kennedy et al., 2020; Kennedy & Mather, 2024) when images were combined into negative and positive valence categories. Whereas younger adults were distracted by negative images more than positive images, older adults showed no such difference, and this age difference was pronounced at lag 2 but not lag 4. We discuss these results in the context of the different test-retest reliabilities of the task measurements.

We observed the positivity effect as predicted in a 2 (age: younger versus older) $\times$ 2 (valence: negative versus positive) interaction. Younger adults were generally more distracted by negative than positive images, whereas older adults were similarly distracted by negative and positive images. This is consistent with previous research, and indicates that in emotion-induced blindness the positivity effect tends to be evident through older adults being less distracted by negative images but similarly distracted by positive images, compared to younger adults (Kennedy et al., 2020; Kennedy & Mather, 2024). In some ways, these results align with previous research that questions whether the effect is better considered as an age-related reduction in negativity (i.e., less attention toward negative stimuli) than an age-related increase in positivity (Barber et al., 2020; Gronchi et al., 2018). It is also noteworthy that the

positivity effect was most pronounced at lag 2, whereas the few effects of discrete emotions that we observed emerged at lag 4.

Using discrete emotions allowed us to investigate whether there might be factors other than valence that drive the age-by-valence interaction within the emotion-induced blindness task. There was good reason to suspect differences between discrete emotions, including different influences from autonomic nervous systems (Kreibig, 2010), different motivational tendencies (Carver & Harmon-Jones, 2009), different appraisal tendencies (Lerner & Keltner, 2000, 2001), and even different arousal levels within the positive emotions that we chose. We were especially interested in stimuli depicting disgusting scenes, as disgust promotes both sympathetic and parasympathetic activity, unlike most other negative emotions which do not promote parasympathetic activity (Kreibig, 2010). However, the age-by-valence interaction at lag 2 within our task was better aligned with valence than with discrete emotions. One possibility is that the positivity effect can occur early, but discrete emotions involve mechanisms that take more time to unfold. While speculative, previous research indicates that discrete emotions take more time to decode in neuroimaging data than valence and arousal, and that fear especially can be decoded faster than other discrete emotions like disgust (Grootswagers et al., 2017). The effects of discrete emotions may therefore take more time to eventuate than valence in the positivity effect, particularly in older adults with slower processing speeds (Salthouse, 2010). It is also notable that we found no difference between high and low arousal positive emotions in either younger or older adults, despite prior claims that arousal drives emotion-induced blindness patterns (Singh & Sunny, 2017) or that the age-related positivity effect is seen only with low-arousal stimuli (Kensinger, 2008). The current patterns in positive emotions instead suggest that, while arousal is likely an important factor, it is unlikely to be the sole driver of the effects.

In some ways, these results are consistent with the limited previous research exploring discrete emotions in younger and older adults. While Boğa et al. (2021) found that older adults showed a more liberal response bias to disgust images over other emotions, they also found no difference in older adult memory accuracy for disgust images over other image categories, including fear. Our results match their memory accuracy results in older adults, suggesting that discrete emotion differences either are not present or do not eventuate to biases that are easily measured. However, unlike their study, which showed more accurate memory in younger adults for disgust images over other image types (Boğa et al., 2021), we found that younger adults attended to all emotion categories similarly. While speculative, these differences could be driven by the stimuli classes used (landscapes versus faces) or cognitive task types (attention versus memory). Further research in this space could explore the role of these differences as they play out in positivity effect patterns.

Our results support the theoretical understanding that the positivity effect is driven by valence and not by discrete emotions, at least at an early lag. In the context of positivity effect theories, this pattern does not clearly support one account over others, nor does it rule any out. For instance, the socioemotional selectivity theory attributes the positivity effect to age-related changes in emotion regulation (Mather & Carstensen, 2005). While the rapid signature of the positivity effect in the emotion-induced blindness task raises questions about how such processes could operate at such speeds, it does not preclude their involvement, particularly given prior evidence that taxing working memory can disrupt the effect at these speeds (Kennedy et al., 2020). Additionally, although the autonomic compensation model was a strong motivator for our design, our findings neither support nor refute the mechanisms it proposes. Disgust, an emotion involving both sympathetic and parasympathetic activation (Kreibig, 2010) was expected to differ from fear based on these distinctions in autonomic influences. However, it is possible that the absence of a difference between them may be due

to shared sympathetic activation across both emotions, or that our greater set of stimuli did not induce autonomic activity as predicted.

One of the most important considerations for this experiment were the stimuli that we used. We intentionally chose images carefully based on previous research in defining which images represented each of the four discrete emotions (Haberkamp et al., 2017; Mikels et al., 2005; Riegel et al., 2016). We also matched fear and disgust images on both valence and arousal measures to compare between the discrete emotions, rather than valence or arousal levels. This process resulted in images being included that were less arousing and less extreme in valence than typical emotion-induced blindness experiments. Performance accuracy was higher for both younger and older adults compared to previous studies (Kennedy et al., 2020; Kennedy & Most, 2015; Most et al., 2005), which was likely due to these less powerful emotional images. Unlike previous studies, younger adults in the current experiment were less distracted by positive stimuli compared to negative stimuli. This pattern was likely due to the use of less emotionally intense images and content than typical stimuli – particularly the limit of highly arousing positive images, such as erotica, which are often used in prior research. Despite these differences, the two-by-two positivity effect remained evident in performance. That said, although choosing images to represent specific discrete emotions can be challenging, future researchers may curate additional and more powerful image sets to represent discrete emotion categories. This may reveal effects between discrete emotions that may have been difficult to observe with the images that we used in this study. In particular, if performance accuracy were lower overall with images higher in arousal levels, effects such as the impact of distractors at later lags, may be easier to further investigate. In a similar way, future research could more directly measure parasympathetic and sympathetic activity, for example by measuring skin conductance, to further probe and potentially disentangle their distinct contributions.

We used a two-day experimental design in this study, which allowed us to examine the reliability of the positivity effect and emotion-induced blindness patterns generally. The test-retest reliabilities ranged from relatively moderate reliability (e.g., the composite negative and positive distractor type measurements) to poor reliability (e.g., lag 4 negative-minus-positive). It is worth noting that our negative-minus-positive lag 2 performance measurement had an ICC of .250, which we used to estimate each individual's positivity bias and to examine relationships with individual differences measurements. According to common conventions, this is a poor reliability measurement (Koo & Li, 2016), although some work indicates that individual differences measures tend to have smaller reliabilities than conventions suggest (Gignac & Szodorai, 2016) and that dichotomously scored measurements can produce poor reliability estimates (Gignac, 2025). Our reliability estimates of the task were similar to other emotion-induced blindness findings (see Onie & Most, 2017), and some measures in commonly used visual cognition research (Clark et al., 2022).

Due to low test-retest reliabilities, recent work has questioned the role of using emotion-induced blindness as a tool to examine individual differences (Edwards et al., 2024). However, importantly, ICCs are informative about the stability of a measure over time within individuals, rather than as a way to characterize how different groups of people perform (Clark et al., 2022). The group differences between younger and older adults were evident in this study as well as in previous research (e.g., Kennedy et al., 2020). The reliable across-experiment age-by-valence interaction with a task that has relatively low individual reliability may relate to what has been called the “reliability paradox”, in which classic behavioral tasks that reliably elicit certain effects across participants show low within-participant reliability (e.g., stop signal, task switching, go/no-go; Enkavi et al., 2019; Hedge et al., 2018). We take this to indicate that the emotion-induced blindness task is an effective task to reveal the age-

related positivity effect, but that individual difference measures derived from this task are likely to have low power to reveal individual difference associations with other measures.

Constraints on Generality

Collecting data online allowed us to conveniently recruit a large sample of younger and older adults to participate in this study. We recruited participants via CloudResearch from Australia and the United States to target large samples of participants who were engaged with the online research platform, who were in primarily English-speaking countries with similar cultures, and to match similar research samples in previous research (Kennedy et al., 2020; Kennedy & Mather, 2024). However, this naturally limited the diversity of our sample. Some evidence suggests that the positivity effect differs across cultural groups (Fung et al., 2008; but see Ko et al., 2011), particularly in the way emotional stimuli are interpreted (Kwon et al., 2009; see also Reed & Carstensen, 2012). Additionally, aspects of our study could not be controlled because we ran our experiment online (see Grootswagers, 2020). To accommodate for this, we used millisecond sensitive software (*Inquisit 6*, 2021). We were encouraged that performance accuracy was high (indicating that participants were engaged with the experiment and understood instructions) and the results replicated previous positivity effect patterns using the same task (indicating that participants were performing similarly to participants in the laboratory; Kennedy et al., 2020). Nevertheless, our results should be interpreted with the consideration that there are limitations in generality from our results due to the way that we sampled our participants and ran our study.

Conclusion

Overall, this study revealed that age differences were apparent in attention when comparing effects of negative versus positive valence, rather than driven by certain discrete emotion categories. This was particularly the case at lag 2, although patterns suggested that discrete emotions may play a larger role at later lags. Future research should continue to

incorporate emotional categories beyond negative and positive categories to enhance theoretical understanding, however this evidence supports theories that consider the positivity effect an age-by-valence effect.

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