Negative images, regardless of task relevance, distract younger more than older adults

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Abstract

Older adults, compared to younger adults, tend to prioritize positive information more and negative information less. We recently observed this “positivity effect” pattern in an emotion-induced blindness task, which measures attention allocated to task-irrelevant emotional stimuli in the way participants are distracted by them. Older adults were less distracted by negative images compared to younger adults. This could represent an age-related priority shift away from negative emotions. However, it could also be that older adults simply do not see negative images presented at a fast rate. A similar possibility is that older adults to fail to engage with negative stimuli because of their complex nature, rather than due to age-related changes in emotional preference per se. In the present study, we tested this possibility by manipulating the required degree of engagement with emotional distractors. Participants completed a modified emotion-induced blindness task, with emotional distractors that were either task irrelevant (younger: n=48; older: n=46) or task relevant (younger: n=48; older: n=45). The task relevance of distractors did not affect performance. Even though older adults could quickly perceive the negative images, they were less distracted by them compared to younger adults. Current theories of the positivity effect fail to fully account for these positivity effect patterns in attention, especially those that propose mechanisms requiring a substantial time to enact. The current results may require rethinking previous accounts of the positivity effect and highlight the benefits of probing the positivity effect in early cognitive processing stages.

Keywords*:* positivity effect, emotion, attention, aging, task relevance

Public Significance Statement

The well-being of older adults is increasingly important in an aging society. Our research reveals that the positivity effect – an age-related shift toward positive and away from negative information – is not merely a visual processing limitation in older adults, nor due to a slow cognitive process. Instead, the findings suggest the need to revaluate theories to improve understanding of age differences in attention preferences and their implications for future well-being interventions.

Emotional information tends to be attended to and remembered better than information that lacks emotional significance (e.g., Mather & Sutherland, 2011; Mathewson et al., 2008; Most et al., 2005). Some factors, such as age, can affect the way emotional information is prioritized. This is demonstrated in a pattern known as the *positivity effect*, which describes a tendency for older adults, compared to younger adults, to favor negative information less and positive information more in both attention and memory (Carstensen & DeLiema, 2018; Charles et al., 2003; Mather & Carstensen, 2005; Reed & Carstensen, 2012). The pattern is conceptualized as an age-by-valence interaction and has been observed in a variety of tasks; for instance, if a neutral and an emotional picture of scenes or faces are shown side by side, older adults tend to avoid looking at negative pictures but look at positive pictures as much or more than neutral pictures (e.g., Isaacowitz et al., 2006; Knight et al., 2007; Zsoldos & Hot, 2023). The mechanisms responsible for the positivity effect remain under investigation.

One of the most prominent theories that may explain the positivity effect is the socioemotional selectivity theory (Carstensen, 2006; Mather & Carstensen, 2005; Reed & Carstensen, 2012). This theory suggests that as end of life approaches, older adults prioritize positive experiences more and negative experiences less. While the original theory did not specify how older adults would implement these emotional priorities, subsequent theorizing proposed that older adults have chronic goals to optimize emotional well-being that require cognitive control; this proposed regulation mechanism helps older adults prioritize positive experiences and diminish the impact of negative experiences (Knight et al., 2007; Kryla-Lighthall & Mather, 2009; Mather & Carstensen, 2005; Mather & Knight, 2005; Reed et al., 2014; Reed & Carstensen, 2012). While this cognitive control model can account for a variety of positivity effect patterns (see Reed & Carstensen, 2012), the goal-directed mechanism is difficult to reconcile with findings that the positivity effect can occur quickly and that individual differences in the positivity effect are not reliably associated with executive function (Barber & Kim, 2022; Mather, 2024; see also Buecker et al., 2023). Alternative accounts of the positivity effect often consider more automatic, rather than strategic, processing (Barber & Kim, 2022; Gronchi et al., 2018; Labouvie-Vief et al., 2010; Mather, 2024). For example, the dynamic integration theory considers older adults to process negative information less than younger adults because the emotional content is more complex and difficult to process, so older adults automatically deprioritize negative information that would otherwise disrupt their limited cognitive capacity (Labouvie-Vief et al., 2010).

In a recent study, we observed the positivity effect manifesting in a way that is difficult to reconcile in the context of current theory (Kennedy et al., 2020). Using an emotion-induced blindness task (Most et al., 2005), we had younger and older adult participants search for task-relevant targets in trials with rapidly presented images (Kennedy et al., 2020). Task-irrelevant emotionally negative, positive, or neutral distractors appeared shortly before the targets, and worse performance accuracy reporting the target was interpreted to indicate greater distraction from distractors. We found a positivity effect across four experiments; in every experiment, there was an age by valence interaction in which the relative distractibility of positive compared with negative images was higher among older than among younger adults, even only 100ms after the emotional distractors appeared.

Observing the positivity effect in a fast attention task challenges a strategic cognitive control mechanism. However, before ruling out this possibility, an alternative explanation would first need to be considered. Due to the nature of the emotion-induced blindness task, our results could simply be because older adults failed to process the content of complex negative images when they were shown so quickly and therefore remained undistracted by them. In this scenario, older adults may not have fully seen the task-irrelevant negative distractors in the task or given them much attentional weight because they were task-irrelevant. In fact, this possibility could be consistent with the dynamic integration account

(Labouvie-Vief et al., 2010): older adults may not prioritize negative stimuli in this task and automatically discount them because of their complexity. Note, however, that such an explanation is not restricted to the dynamic integration theory account – negative emotional stimuli may be less attended by older adults for several reasons (e.g., low level visual features or complex visual scenes separable from emotion necessarily).

In the current study, we examined the possibility that our previous results were due to older adults failing to see negative emotional stimuli. We modified an emotion-induced blindness task by manipulating the task relevance of emotional distractors. One half of participants were assigned to a *task-irrelevant condition*, which was similar to traditional emotion-induced blindness designs (e.g., Most et al., 2005): participants were instructed to ignore an emotional image but report about a non-emotional target image. The other half of participants were assigned to a *task-relevant condition*, and instead had to report about both the emotional image *and* the non-emotional target. In many ways, this emulated a typical attentional blink design, whereby participants have to report about two targets (T1 and T2) in a rapid stream (e.g., Chun & Potter, 1995).

By requiring some participants to respond about emotional images shown at fast rates, we could determine (1) if older adults *could* process the negative images when asked to do so, and (2) if being required to report about these images made any difference in the bias from emotional images in younger and older adults. We hypothesised that task relevance would make no difference to the effect. This would support a mechanism of the positivity effect that penetrates early cognitive processing, challenging theoretical accounts that implicate a slow, cognitive control mechanism, while also ruling out the possibility that our previous results were due to older adults failing to engage with negative images when they were task irrelevant. Alternatively, if instead the patterns of our previous work were simply because older adults were not processing the negative emotional stimuli, then task relevance should disrupt this pattern; in this case, older adults should be distracted by negative emotional stimuli in the task-relevant, but not task-irrelevant, condition.

Methods

Transparency and Openness

The experimental material, code, and data are available on the Open Science Framework (Kennedy & Mather, 2023). We report how we determined our sample size, any data exclusions, all manipulations, and all measures. Data were preprocessed using custom R scripts (version 4.3.1) and analyses were conducted using SPSS (version 29). The experiment was not preregistered.

Participants

In total, 225 participants took part in the experiment. All participants were recruited online via CloudResearch TurkPrime and Amazon MTurk in November-December 2019. We aimed to recruit at least 184 participants with at least 45 participants in each age × task relevance group, based on a priori power analyses of within-between repeated measures interactions using data from our previous research (α = .05, power (1 – β) = 0.8, using age × distractor interactions from Kennedy et al., 2020, Experiments 1 and 2; and age × distractor × lag × group comparisons from Kennedy et al., 2020, Experiment 4; calculated with G*Power; Faul et al., 2007). A sensitivity analysis indicated that our final sample (N = 187) was powered to observe an age × T1/distractor type interaction with effect sizes as small as f = .12, with α = .05 and power (1 – β) = 0.8 (calculated with G*Power; Faul et al., 2007). Participants' data were removed from the final dataset if they did not complete all trials in the experiment (N = 3), reported an age outside of the age ranges for younger or older adults (N = 3), or performed poorly on the task (N = 32; see *Data Screening*). The final sample was comprised of 187 participants; 96 younger adults (aged M = 28.5 years, SD = 3.7 years, range: 20-35 years old) and 91 older adults (aged M = 65.9 years, SD = 4.3 years, range: 58-

78 years). We used NIH recommended categories to gather race and ethnicity data for our participants: younger adults self-identified as 75 White/Caucasian, 11 Black/African American, 4 Asian, 1 Pacific Islander/Native Hawaiian, 2 Bi-racial, 2 stated “other,” and 1 declined to state; 15 identified as Hispanic. Older adults self-identified as 86 White/Caucasian, 2 Black/African American, 2 Asian, and 1 stated “other”; 2 identified as Hispanic. Younger and older adults reported a similar number of years of education (younger: M = 14.7 years, SD = 2.1 years, 11-25 years; older: M = 15.5 years, SD = 2.1 years, 12-21 years). The University of Southern California Institutional Review Board approved the study, “Emotion and Cognition,” protocol UP-12-00019. Participants received compensation (US$4) for their participation, which took approximately 30 minutes to complete.

Materials

The online experiment was programmed with Inquisit (*Inquisit 5*, 2016) and participants completed the experiment on their own computers.

Stimuli

Stimuli in the experiment were 320×240 colored images. T1/distractor[1] images were collected from the International Affective Picture System (IAPS; Lang et al., 2008). We chose 27 negative, 27 positive, and 27 neutral T1/distractor images that clearly depicted people or animals. To choose images, we used normative emotion ratings from the IAPS related to valence on a scale of 1 (very negative) to 9 (very positive), and arousal, on a scale of 1 (low arousal) to 9 (high arousal). An additional six images were used as T1/distractor images in practice trials, which were emotionally neutral. More information about the T1/distractor images is available in *Supplemental Material 1*.

[1] We adopted labels of “T1/distractor” and “T2/target” to mimic terms used in the attentional blink and emotion-induced blindness literatures.

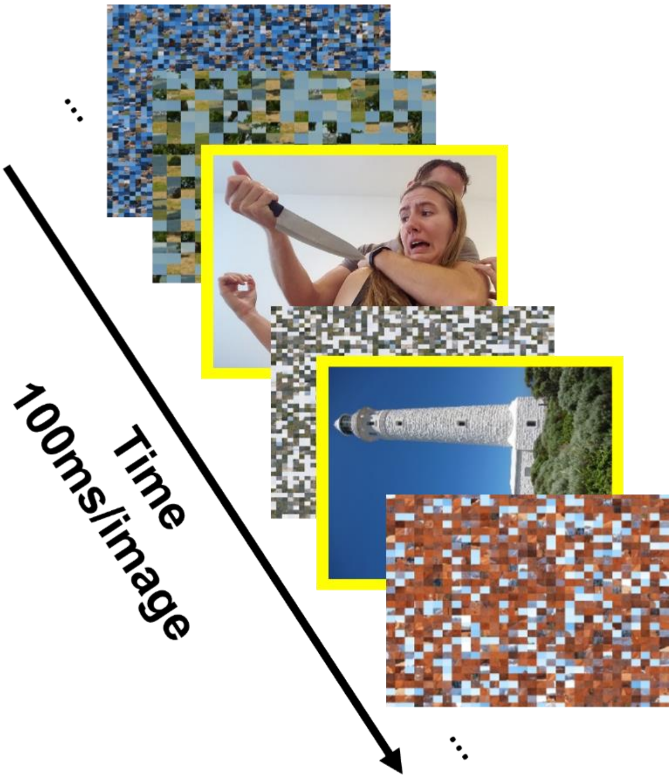
T2/target images were from a set of 52 landscape images rotated 90-degrees to the left and 90-degrees to the right (104 images total) and an additional 80 landscape images were used to create “scrambled/filler” images. Images of both types were sourced from previous emotion-induced blindness experiments (Most et al., 2005), and the scrambled/filler images were created by submitting landscape images to the Matlab JigSaw function (Ouseph, 2020). These were segmented into either 20×20, 30×30, 40×40, or 50×50 equal parts and scrambled randomly, with 20 images per segmentation size. Since the images used by Most et al., 2005 were sourced with attributions unknown, we cannot share the images, however, examples of similar images are depicted in Figure 1.

All images (T1/distractors, T2/targets, and scrambled/filler images) were submitted to the SHINE Toolbox on Matlab to normalise levels of luminance (Willenbockel et al., 2010).

Modified emotion-induced blindness task

The experiment included four blocks of 30 trials; 120 trials total. On every trial of the experiment, participants viewed a rapid serial visual presentation of 17 images presented at a rate of 100ms per image in the center of the screen against a white background. Each trial contained 15 scrambled/filler images in addition to one T1/distractor image and one T2/target image. Both the T1/distractor image and T2/target image appeared with a 20px yellow border surrounding it. All other scrambled/filler images appeared with no border (see Figure 1).

Figure 1. Example trial structure



Note. Depending on their random group assignment, participants were instructed to either report about only the second bordered image (task-irrelevant condition) or about both yellow bordered images (task-relevant condition). The trial structure was otherwise the same for all participants. Images depicted in this figure are examples only and were not used in the experiment.

The T2/target image appeared either two (lag 2) or five (lag 5) images after the T1/distractor image; previous emotion-induced blindness studies indicate that impairment from emotional T1/distractors is robust at lag 2 and less pronounced by lag 5 (e.g., Kennedy et al., 2020; Most et al., 2005), and by including both lag conditions, participants would not feel sure about when the T2/target would appear after seeing the T1/distractor. T1/distractor images were presented so that there was an equal number of each type on each block, but no constraints otherwise. Unlike most emotion-induced blindness studies, we chose not to include additional “baseline” trials with no distractor present, because this could not accommodate a task-relevant condition. Scrambled/filler images were presented such that no segmentation size would follow an image with the same segmentation size.

Participants’ tasks varied based on their randomly assigned condition. We chose to manipulate task relevance between participants to minimise demand effects and to ensure that participants in the task-irrelevant condition would always disregard the T1/distractors as task irrelevant. Half of participants (*task-irrelevant condition;* 48 younger and 46 older) were told that their task was to ignore the first bordered image and to indicate the direction the second bordered image was rotated. They made this response via keypress at the end of each trial, to a screen that read “Rotated left(F) or right(J)?”. The other half of participants (*task-relevant condition;* 48 younger and 45 older) were told that their task was to identify the number of people in the first bordered image *and then* indicate the direction the second bordered image was rotated. To make their responses, these participants first responded to a screen that read, “No people(0), One person(1), or Two people(2)” and then to a screen that read, “Rotated left(F) or right(J)?”. The trials were otherwise the same for all participants. Participants’ responses were self-paced. After participants made a response, a screen appeared for 1000ms to indicate if they answered correctly or not. The next trial started after a 1000ms fixation cross.

Procedure

Participants were invited to the complete the study via CloudResearch services. After reading the consent form, and indicating that they were comfortable with graphic images, participants continued to the Inquisit program to read the task instructions. Participants completed six practice trials, in the way that they would complete the rest of the experiment (i.e., either the task-irrelevant or task-relevant condition instructions). Participants were told that they could take a break between blocks. After the task, participants indicated their demographic information, were debriefed, and provided the code to enter into MTurk for compensation.

Results

Data Screening

Performance accuracy served as the main dependent variable, with worse accuracy reporting the T2/target indicating more distraction from the T1/distractor. Using the same criteria for T2/target performance as in our previous research (Kennedy et al., 2020), 28 participants (11 younger, 17 older) had data removed for poor performance (<55%). Although chance responses to the T1/distractor would yield 33.3% accuracy, we used a 50% criterion for T1/distractor performance so that participants were correct on at least half of trials; using this criterion we removed data from another 4 participants (3 younger, 1 older) for poor performance (<50%) in reporting the T1/distractor.

T1/distractor performance accuracy

We first examined T1/distractor performance accuracy in the task-relevant condition (participants in the task-irrelevant condition did not report about the T1/distractor). Overall accuracy was high for both younger (M = 89.3%, 95% CI = [86.5%, 92.0%]) and older (M = 83.7%, 95% CI = [81.0%, 86.3%]) adults. There was a group difference; older adults were worse at identifying the T1/distractor images than younger adults, $t(91) = 2.95$, $p = .004$, $d = .61$. For more details about T1/distractor accuracy, see *Supplemental Material 2*. Importantly, we were satisfied that participants of both age groups were following instructions in the task-relevant condition.

T2/target performance accuracy

In our main analysis, we examined T2/target performance accuracy (see Figure 2). A 2 (age: younger vs older) × 2 (task relevance: irrelevant vs relevant) × 3 (T1/distractor type: negative vs neutral vs positive) × 2 (lag: 2 vs 5) ANOVA revealed a significant main effect of

T1/distractor type, $F(2,366) = 33.62$, $p < .001$, $\eta^2_p = .15$, with worse performance overall on negative and positive trials compared to neutral. There was also a significant effect of lag, $F(1,183) = 329.44$, $p < .001$, $\eta^2_p = .64$, with worse performance at lag 2 compared to lag 5 overall, and a significant effect of task relevance, $F(1,183) = 57.71$, $p < .001$, $\eta^2_p = .24$; performance was better when the T1/distractor was task-irrelevant compared to task-relevant. There was, however, no significant main effect of age, $F(1,183) = 2.99$, $p = .086$, $\eta^2_p = .02$; overall, younger and older adults identified the T2/target with similar performance accuracies.

Unlike most emotion-induced blindness experiments, there was no significant T1/distractor type × lag interaction, $F(2,366) = 0.20$, $p = .823$, $\eta^2_p = .001$; this was likely because of two reasons: we did not have a "control" baseline condition in this experiment (which can often drive the interaction) and because neutral distractors in this experiment were more distracting than usual because of the yellow border. Most important to our hypothesis, there was a significant age × T1/distractor type interaction, $F(2,366) = 5.18$, $p = .006$, $\eta^2_p = .03$, indicating that younger and older adults differed in how much different emotions distracted them. Neither the age × lag interaction, nor age × T1/distractor type × lag interaction, were significant ($Fs \leq .58$, $ps \geq .555$). Additionally, task relevance had minimal impact on performance. There was a significant interaction between lag and task relevance, $F(1,183) = 22.30$, $p < .001$, $\eta^2_p = .11$, but no T1/distractor type × task relevance, lag × age × task relevance, T1/distractor type × lag × task relevance, or T1/distractor type × lag × age × task relevance interactions ($Fs \leq 2.73$, $ps \geq .067$).

To decompose the age × T1/distractor type interaction, post-hoc pairwise comparisons confirmed a pattern consistent with the positivity effect and our previous research (Kennedy et al., 2020): overall, younger adults' performance was worse on negative and positive T1/distractor trials compared to neutral T1/distractor trials ($ps < .001$), with no difference between negative and positive T1/distractor trials overall (*p* = .976), whereas older adults' performance was worse overall on positive compared to negative (*p* = .006) and neutral (*p* < .001) T1/distractor trials, with no difference between negative and neutral T1/distractor trials (*p* = .059) overall. Similar post-hoc comparisons to decompose the T1/distractor type × lag interaction revealed that task relevance had a significant effect at both lags, with worse performance on relevant compared to irrelevant trials overall (*ps* < .001).

To probe our specific hypotheses, we collapsed across lag conditions to see if, overall, younger and older adults were distracted by negative and positive images compared to neutral T1/distractors in the different task relevance conditions. Using averages across lag conditions, task relevance made no difference to the pattern; younger adults were distracted by both negative (irrelevant: $t(47) = 3.47$, $p = .001$, $d = .50$; relevant: $t(47) = 4.76$, $p < .001$, $d = .69$) and positive (irrelevant: $t(47) = 3.05$, $p = .004$, $d = .49$; relevant: $t(47) = 5.23$, $p < .001$, $d = .75$) compared to neutral T1/distractors, whereas older adults were not distracted by negative (irrelevant: $t(45) = 1.53$, $p = .133$, $d = .23$; relevant: $t(44) = 1.62$, $p = .113$, $d = .24$) but were distracted by positive (irrelevant: $t(45) = 2.90$, $p = .006$, $d = .43$; relevant: $t(44) = 4.09$, $p < .001$, $d = .61$) compared to neutral T1/distractors.[2]

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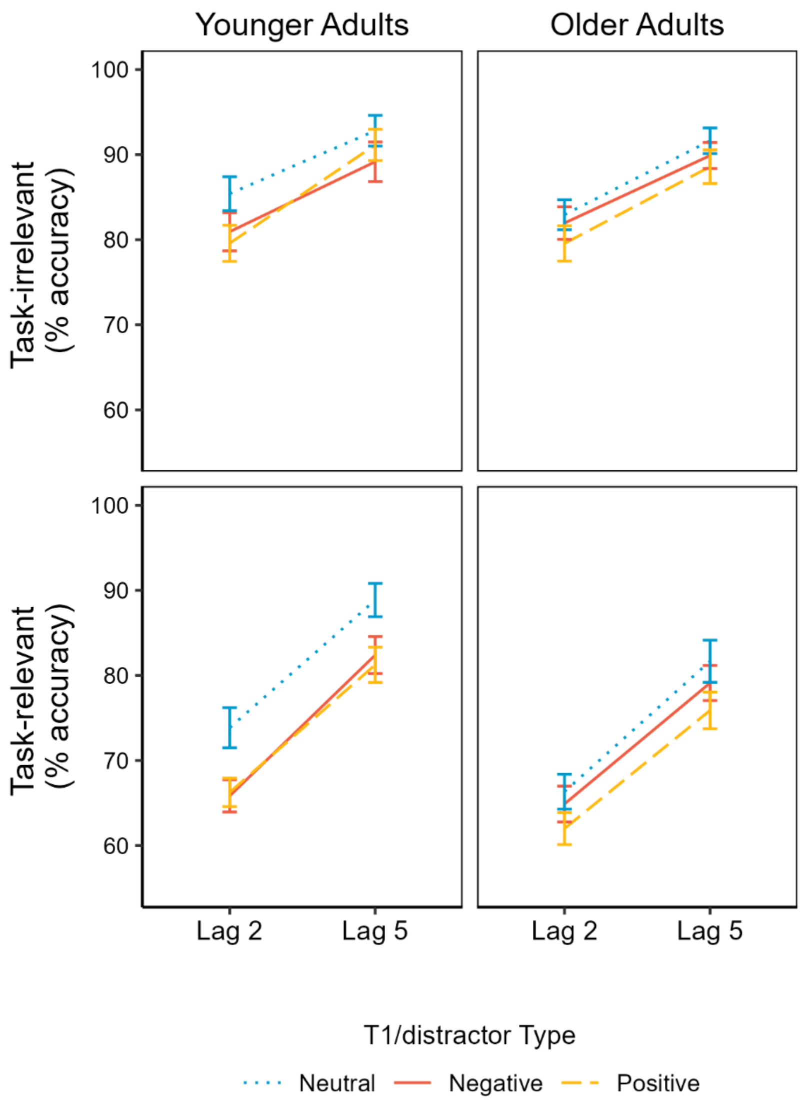
[2] We originally planned contrasts with lag 2 data to determine the effect of distractor types, since both emotion-induced blindness and attentional blink effects tend to be most pronounced at lag 2 and because our previous research indicated differences between younger and older adults at lag 2 (Kennedy et al., 2020). However, we did not observe a typical T1/distractor type × lag interaction, so report those planned comparisons here. At lag 2, younger adults showed emotion-induced blindness in both relevance conditions – both negative (irrelevant: $t(47) = 2.76$, $p = .008$, $d = .40$; relevant: $t(47) = 3.64$, $p < .001$, $d = .53$), and positive (irrelevant: $t(47) = 3.10$, $p = .003$, $d = .45$; relevant: $t(47) = 3.06$, $p = .004$, $d = .44$) T1/distractors led to impairment compared to neutral T1/distractors. Older adults showed emotion-induced blindness in neither relevance conditions from negative (irrelevant: $t(45) = 0.58$, $p = .568$, $d = .09$; relevant: $t(44) = 0.68$, $p = .500$, $d = .10$) or positive (irrelevant: $t(45) = 1.93$, $p = .060$, $d = .29$; relevant: $t(44) = 1.80$, $p = .079$, $d = .27$) T1/distractors. Thus, older adults were not more distracted by either negative or positive images compared to neutral when data were restricted to lag 2 trials only. Similarly, for T2/target|T1/distractor comparisons, when limited to lag 2 performance only, younger adults in the task-relevant condition were distracted by negative, $t(47) = 3.38$, $p = .001$, $d = .50$, and positive, $t(47) = 3.26$, $p = .002$, $d = .47$, T1/distractors compared to neutral, but older adults in the task-

Figure 2. T2/target performance accuracy results



Note. Error bars depict between-subject standard error. For reference, means and 95% confidence intervals are also available in table format in *Supplemental Material 3*.

T2/target given T1/distractor type accuracy

In an additional analysis, we examined only trials when participants in the task-relevant condition correctly identified the number of people in the T1/distractor image (commonly

relevant condition were not distracted by negative, $t(44) = 0.54$, $p = .589$, $d = .08$, nor positive, $t(44) = 1.39$, $p = .173$, $d = .09$, images compared to neutral.

referred to as T2|T1 in the attentional blink literature; e.g., Chun & Potter, 1995). If the positivity effect changed when older adults were required to see negative stimuli, correctly responding to T1/distractors could serve as a proxy for “seeing” it. This analysis revealed similar results as when we did not consider T1/distractor performance.

Means for T2/target|T1/distractor performance for participants in the task-relevant condition are reported in *Supplemental Material 4*. A 2 (age: younger vs older) × 3 (T1/distractor type: negative vs neutral vs positive) × 2 (lag: 2 vs 5) ANOVA revealed significant main effects of T1/distractor type, lag, and age (*Fs* > 5.39; *ps* < .022), however the T1/distractor type × age interaction failed to reach significance for these data, $F(2,182) = 2.80$, $p = .063$, $\eta^2_p = .030$. Nevertheless, our planned contrasts revealed that, when averaged across lags, younger adults were distracted by both negative, $t(47) = 4.35$, $p < .001$, $d = .63$, and positive, $t(47) = 4.61$, $p < .001$, $d = .67$, T1/distractors, whereas older adults were distracted by positive, $t(44) = 3.53$, $p < .001$, $d = .52$, but not negative, $t(44) = 0.89$, $p = .380$, $d = .13$, T1/distractors compared to neutral. This confirmed a general pattern whereby, regardless of task-relevance condition, younger adults were distracted by both negative and positive T1/distractors, whereas older adults were distracted by positive but not negative T1/distractors.

Discussion

In a recent emotion-induced blindness study, we found that older adults were similarly distracted by positive images but less distracted by negative images compared to younger adults (Kennedy et al., 2020). To determine whether older adults simply failed to see the negative images, we manipulated the task relevance of emotional distractors in the current study using a modified emotion-induced blindness task. We found that when we made participants report about the emotional images it had no effect on the patterns of distraction. Younger and older adults were more distracted by positive T1/distractors than neutral

T1/distractors regardless of task relevance. Task relevance also made no difference for negative effects: older adults were no more distracted by negative T1/distractors than neutral T1/distractors, whereas younger adults were more distracted by negative T1/distractors than neutral T1/distractors. Altogether, this evidence indicates that the age-related change in negative distraction (1) is not due to older adults' missed awareness/processing of negative stimuli and (2) that task relevance makes no difference in the bias from emotional images in younger and older adults. Instead, these results indicate that older adults can engage with negative images but remain less affected by them than younger adults.

Performance was worse overall when the T1/distractor was task relevant. This is consistent with previous research that tends to reveal additive effects of task relevance and emotion-induced blindness (e.g., Chen et al., 2020; Kennedy et al., 2018; Mathewson et al., 2008; Santacroce et al., 2023); task relevance tends to worsen performance overall, but not alter the impact of emotional images. The concept of "relevance" is particularly important in emotion work: some argue that it is the biological relevance that makes emotional stimuli so powerful (e.g., Ferrari et al., 2013; Sakaki et al., 2012). We chose to use a task-relevance manipulation that would force participants to pay attention to the T1/distractor images but in a manner distinct from their emotionality. We did this to limit post-perceptual emotional processing – if participants had to report about the emotion, then later cognitive processing stages related to emotion could defeat the purpose of using a fast-paced task. Nevertheless, while emotional relevance goes beyond the goals of the current study, future research could further examine whether older adults similarly show a similar positivity bias when having to identify the emotionality of images at fast speeds.

The mechanisms of the positivity effect remain under investigation. Previous theories tend to suggest a mechanism that is either more strategic or more automatic in nature (Barber & Kim, 2022; Carstensen, 2006; Gronchi et al., 2018; Kryla-Lighthall & Mather, 2009;

Labouvie-Vief et al., 2010; Reed & Carstensen, 2012). Aspects of both classes of theories are inconsistent with these data. The traditional socioemotional selectivity account proposes the effect to be a goal-directed mechanism. The way in which younger adults but not older adults were distracted by negative images in this fast attention task indicates that the effect is more "automatic" than traditionally discussed (e.g., Reed & Carstensen, 2012). However, accounts that negative images make less impact because they are more complex (e.g., Labouvie-Vief et al., 2010) are also difficult to reconcile with these findings. Task relevance made no difference in the bias away from negative stimuli; when older adults had to attend to the complex negative images, they could extract the necessary information and still were less distracted by them. These results do not rule out the dynamic integration theory necessarily, but do indicate that older adults can at least prioritize negative images enough to respond to them when shown at rapid speeds and remain less affected by them than younger adults. Altogether, our results support recent calls to re-examine mechanisms as they relate to the positivity effect (e.g., Barber & Kim, 2022; Mather, 2024). While our results do not pinpoint a particular mechanism, they do indicate that the positivity effect can occur early in cognitive processing and goes beyond age-related stimulus perception differences. Several existing theories can accommodate these findings, including less traditional accounts. For example, some recent accounts suggest the positivity effect to be driven by multiple pathways (Barber & Kim, 2022; Gronchi et al., 2018), while another proposes it to be a byproduct of age-related changes in autonomic and noradrenergic systems (Mather, 2024).

Future research in this space should continue to take advantage of attention tasks that limit time for strategic processing, since they are well-positioned to probe the contested mechanisms of the positivity effect. Other studies that have examined the positivity effect in attention tend to use the dot probe task (Barber et al., 2020; Gronchi et al., 2018; Isaacowitz et al., 2006; Knight et al., 2007; Mather & Carstensen, 2003; Zsoldos & Hot, 2023), sometimes with findings that differ from our results. For example, Gronchi and colleagues recently reported dot probe findings that suggested aspects of the effect to occur at different timepoints; they found that positive stimuli were preferred at 100ms, whereas negative stimuli were avoided only when more time was available at 500ms (Gronchi et al., 2018). Their results are not consistent with ours in that they did not find the effect of negative stimuli at an early time point, whereas we did. We view these varying findings as motivation to continue to use complementary methods to gain a deeper understanding of mechanisms. The dot probe and emotion-induced blindness have been proposed to operate via different attentional mechanisms (Onie & Most, 2017), and each task paradigm has benefits and limitations. Taken together, we argue that future studies should draw from visual cognition literatures to better understand the underlying pathways of this effect.

This study was not without limitations. Performance accuracy was particularly high for both younger and older adults – this was likely due to the changes we made to the design by using scrambled images rather than landscape images to make up the rapid streams, which likely made the T2/targets easier to see. The patterns between conditions were still apparent despite this, but the size of these effects may be larger in another design that makes it more difficult to report the T2/target. It is also worth noting that participants completed this experiment on their own devices in their own spaces, rather than in a laboratory. To circumvent this decreased experimental control, we used Inquisit (*Inquisit 5*, 2016) to allow for millisecond accuracy in stimulus presentation and CloudResearch services to recruit participants of each age group. Our research questions focused on interactions between ages and emotion conditions rather than general performance. We saw high performance accuracies on our task indicating that participants were following instructions and completing the task as expected, and our results strongly replicated results from our previous laboratory-based studies. Thus, although participants' environments were less controlled, concerns about this limitation were minimal due to the nature of our design and pattern of results.

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Supplemental Material

Supplemental Material 1

The full list of T1/distractor images used in this experiment is available on the Open Science Framework (Kennedy & Mather, 2023; https://osf.io/75swn). Negative images were rated as high in arousal (*M* = 6.60, 95% CI [6.43, 6.77]) and negative valence (*M* = 2.54, 95% CI [2.21, 2.86]) and depicted images of threatening animals, injured bodies, and violence. Positive images were also rated high in arousal (*M* = 5.94, 95% CI [5.62, 6.26]) and in positive valence (*M* = 7.14, 95% CI [6.92, 7.37]) and depicted images of happy couples, sweet animals, and erotica. Neutral images were rated as low in arousal (*M* = 3.32, 95% CI [3.15, 3.50]) and of neither negative or positive valence (*M* = 5.25, 95% CI [4.99, 5.50]) and depicted images such as unremarkable animals or people with neutral facial expressions. Negative images were more arousing than both neutral, $t(52) = 27.86$, $p < .001$, $d = 7.58$, and positive images, $t(52) = 3.75$, $p < .001$, $d = 1.02$. Negative images and positive images differed in valence ratings from each other, $t(52) = 23.93$, $p < .001$, $d = 6.51$, and both also from neutral images, *ps* < .001, *ds* ≥ 3.10.

The six images used as T1/distractor images in practice trials included three images that depicted neutral content collected from the IAPS database (valence: *M* = 4.87, 95% CI [4.14, 5.60]; arousal: *M* = 3.44, 95% CI [1.68, 5.21]) and three images of landscape scenes collected from Google Images, which were not rated but depicted neutral content with no people or animals presented. We indicate the IAPS images used on our OSF, however cannot share the three landscape images sourced from Google Images, since their attributions are unknown.

Supplemental Material 2

For participants in the task-relevant condition, means and 95% confidence intervals of T1/distractor accuracy for each T1/distractor type × age × lag condition are available in Table S1. To determine if these factors affected their ability to identify the T1/distractor, we conducted a 2 (age: younger vs older) × 3 (T1/distractor type: negative vs neutral vs positive) × 2 (lag: 2 vs 5) ANOVA on T1/distractor accuracy. This revealed a significant main effect of T1/distractor type, $F(2,182) = 203.50$, $p < .001$, $\eta^2_p = .69$, such that T1/distractor performance was worse for negative images and best for neutral images. There was also a significant main effect of age, $F(1,91) = 8.71$, $p = .004$, $\eta^2_p = .09$, and a significant T1/distractor type × age interaction, $F(2,182) = 18.53$, $p < .001$, $\eta^2_p = .17$, indicating that older adults were worse overall in identifying the number of people in T1/distractor images compared to younger adults, and especially on emotional trials compared to neutral. There was no main effect, nor any significant interaction, with lag (*Fs* < 2.30, *ps* > .133).

Table S1. T1/distractor mean accuracy and 95% confidence intervals on task-relevant trials

		Younger		Older	
		M	*95% CIs*	*M*	*95% CIs*
Negative	Lag 2	82.92	[79.74, 86.10]	72.89	[69.27, 76.51]
	Lag 5	80.52	[76.87, 84.17]	72.67	[68.67, 76.66]
Neutral	Lag 2	95.00	[92.16, 97.84]	95.56	[93.26, 97.85]
	Lag 5	94.79	[91.80, 97.79]	95.56	[93.35, 97.76]
Positive	Lag 2	91.15	[87.85, 94.44]	81.11	[76.52, 85.71]
	Lag 5	91.15	[88.03, 94.26]	84.11	[79.94, 88.28]

Supplemental Material 3

The means of T2/target accuracies for each 2 (age: younger vs older) × 2 (task relevance: irrelevant vs relevant) × 3 (T1/distractor type: negative vs neutral vs positive) × 2 (lag: 2 vs 5) condition are depicted in Figure 2 of our manuscript. We also provide them here in table format (Table S2).

Table S2. T2/target mean accuracy and 95% confidence intervals

		Task irrelevant				Task relevant			
		Younger		Older		Younger		Older	
		M	*95% CIs*	*M*	*95% CIs*	*M*	*95% CIs*	*M*	*95% CIs*
Negative	Lag 2	80.94	[76.42, 85.46]	81.96	[78.12, 85.80]	65.83	[62.03, 69.64]	64.89	[60.65, 69.13]
	Lag 5	89.17	[84.49, 93.84]	89.89	[86.80, 92.98]	82.40	[78.04, 86.76]	79.11	[74.96, 83.27]
Neutral	Lag 2	85.42	[81.41, 89.42]	82.93	[79.40, 86.47]	73.85	[69.12, 78.59]	66.33	[62.19, 70.48]
	Lag 5	92.81	[89.19, 96.43]	91.63	[88.59, 94.67]	88.85	[84.92, 92.78]	81.67	[76.66, 86.67]
Positive	Lag 2	79.58	[75.31, 83.86]	79.57	[75.39, 83.74]	66.25	[62.88, 69.62]	62.00	[58.21, 65.79]
	Lag 5	91.15	[87.44, 94.85]	88.59	[84.59, 92.58]	81.25	[77.07, 85.43]	75.89	[71.56, 80.21]

Supplemental Material 4

Table S3 reports the means and 95% confidence intervals on task-relevant trials when we examined only T2/target trials when the T1/distractor was correctly (T2/target|T1/distractor).

Table S3. T2/target|T1/distractor mean accuracy and 95% confidence intervals

		Younger		Older	
		M	*95% CIs*	*M*	*95% CIs*
Negative	Lag 2	66.34	[62.35, 70.33]	64.76	[60.40, 69.11]
	Lag 5	84.11	[79.67, 88.54]	80.37	[76.06, 84.68]
Neutral	Lag 2	74.47	[69.38, 79.56]	66.04	[61.62, 70.45]
	Lag 5	89.07	[85.06, 93.07]	81.80	[76.86, 86.74]
Positive	Lag 2	65.36	[61.62, 69.09]	62.51	[58.40, 66.63]
	Lag 5	82.03	[77.75, 86.32]	75.51	[70.80, 80.22]