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When does the positivity effect emerge? : age-related emotional biases at encoding and retrieval

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When does the Positivity Effect Emerge? Age-Related Emotional Biases at Encoding and

Retrieval

by

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Abstract:

The Socioemotional Selectivity Theory (SST) posits that as their future time perspective shrinks, older adults tend to be more motivated by emotionally meaningful goals and therefore experience what is called the "positivity effect" with age (Carstensen, 2006). The positivity effect had been studied in both attention biases (Isaacowitz *et al.*, 2006a) and memory biases (Kensinger, 2008), with older adults dwelling longer on and better remembering the positive stimuli over the negative. Yet, few studies have measured emotional biases at both the encoding *and* retrieval phases, which is why this study uses eye-tracking to determine whether any biases in gaze patterns map directly onto memory biases. 41 younger adults and 41 older adults participated in this "linguistic processing" study, where they completed measures of mood and emotion regulation strategies, were instructed to view 31 mixed-valence triplets of words, completed an incidental yes/no item recognition task, and finally rated each word they had viewed during the study on scales of valence and arousal. Surprisingly, older adults tended to show a negativity bias in gaze patterns. Yet, younger adults showed a negativity bias in memory and older adults tended to make an equal number of recognition hits across the three valence categories. Interestingly, the proportional dwell time on negative words was significantly positively correlated with the number of negative hits mad, but only for older adults, suggesting that prioritizing negative stimuli during encoding facilitated better recognition ability. Finally, we propose a conceptual model of the relationships between age, memory, emotion regulation, mood, and gaze time. Structural equation modeling indicated a good fit of data to the model. Altogether, the results of this study suggest that the relationship between age and memory are complex and cannot be fully explained by gaze patterns alone.

Keywords: older adults, positivity effect, attention, memory, eye-tracking

When does the Positivity Effect Emerge? Age-Related Emotional Biases at Encoding and

Retrieval

The Socioemotional Selectivity Theory (SST) posits that as their future time perspective

shrinks, older adults tend to be more motivated by emotionally meaningful goals and therefore

experience what is called the "positivity effect" with age (Carstensen, 2006). In one study by

Fung and Carstensen (2003), older adults not only *preferred* emotionally meaningful

advertisements to knowledge-based advertisements, but also better *remembered* the emotional

content, demonstrating the implications of the SST on attention and memory. As older adults

pursue more emotionally meaningful goals and consequently invest more in regulating their

emotional state, they may do so by prioritizing, attending to, and better remembering positive

information over negative.

This shift in emotional experiences across the lifespan is not only due to changes in

motivation, but also the fact that older adults regulate their emotional state using different

strategies. Gross' (1998) model of emotional regulation explains that the early strategy of

situation selection requires less cognitive resources than downstream strategies such as cognitive

reappraisal (reinterpreting the situation to change its meaning, altering the resulting emotional

response; Urry & Gross, 2010). This difference in cognitive demands leads to differences in

strategy type utilization for younger versus older adults. Due to reduced cognitive resources,

older adults tend to be less successful at cognitive reappraisal (Opitz et al., 2012). Therefore, as

suggested by a theory of selection, optimization, and compensation applied to emotion regulation

(Urry & Gross, 2010), older adults must select and optimize less-demanding strategies such as

situation selection. For instance, older adults generally prefer and rely on smaller, more intimate

friend groups, who can help guide them in utilizing situation selection more frequently and

successfully than younger adults through encouraging engagement in positive activities within close friendship circles (Urry & Gross, 2010).

This strategy preference, in addition to the high importance placed on emotion regulation, suggests that attentional biases are a form of situation selection used by older adults to attend to positive information and avoid negative information (Isaacowitz *et al.*, 2006a). Evidence for attention as a form of emotion regulation has been shown in the goal-congruent gaze patterns exhibited by two different groups possessing similar affective goals: older adults and optimists. In fact, both optimists and older adults have shown selective inattention for negative images and a preference towards positive images (Isaacowitz, 2005; Isaacowitz, *et al.*, 2006a, 2006b). These findings suggest that motivation is a key factor in attentional biases. When younger adults adopt similar motivational strategies as older adults (e.g., in motivation manipulations with the goal of regulating emotions rather than acquiring information), they also exhibit a positivity effect in attention, whereby they avoid focusing on negative images (Wadlinger & Isaacowitz, 2011).

Attentional biases may include not only duration of encoding but also depth of encoding. Mather *et al.* (2004) found that when presented with differently valenced images at study, younger adults showed significantly increased amygdalar activation in response to both positive and negative images, while older adults showed increased activation for only positive images. A similar pattern was later found in prefrontal cortex activation for words rather than pictures (Leclerc & Kensinger, 2011). These findings suggest that older adults relegate less attention to encoding of negative material at early stages of processing, and not just at recall (Mather *et al.*, 2004).

The positivity effect has been supported in research demonstrating attentional biases at encoding as well as in research showing better memory for positive stimuli over neutral and

negative stimuli. For instance, when younger and older adults were presented with emotionally-valenced and neutral images, the age difference in recall ability was greatest for the negative images and smallest for positive images due. This finding was attributed to a positivity bias in older adults (Charles, Mather, & Carstensen, 2003). Furthermore, a positivity bias was replicated in older adults' memory for word stimuli, though the trend was limited to non-arousing words (Kensinger, 2008), suggesting the positivity effect can be generalized to words.

A current controversy at the intersection of research on emotion and memory revolves around whether memory deficits and emotional biases occur during encoding (when a word is first put into memory) or at retrieval (when the word is recalled), or both. Studying gaze patterns through eye-tracking techniques provides a methodological tool that allows for teasing apart these two processes. If age differences in emotional biases of gaze patterns are present during the viewing phase, this would suggest that utilization of emotional regulation strategies leads to preferential encoding. However, if emotional biases are only present during the recall phase, this would suggest a retrieval deficit. Few studies have measured emotional biases at both the encoding *and* retrieval phases and, importantly, tracking preferential gaze patterns at encoding would allow mapping of biases that operate at this early stage onto biases that operate at the retrieval stage. Furthermore, understanding when the positivity bias occurs – that is, at viewing, encoding, and retrieval stages, or some combination therein, would help pinpoint whether negative information is avoided from the start, degrades in storage, or is irretrievable at test.

Eye-tracking methodology has been used to investigate the age-related positivity effect, yet the stimuli for these studies have been limited to images of scenes or faces. In fact, a systematic meta-analysis of the positivity effect (Reed, Chan, & Mikels, 2014) examined 100 empirical studies and of the 12 studies that used eye-tracking methods, none used words as the

stimuli. Understanding how stimuli are processed as basic, singular words has implications for how we comprehend and use information on an everyday basis. Much of the way we communicate important information to each other is through written words, which makes investigating the sources of an age-related positivity effect for words even more compelling.

This study employed a novel stimulus configuration presentation to study the effect of word valence on the positivity bias. Word triplets comprised of differently-valenced words should provide a direct test of the hypothesis that attentional biases function as a form of situation selection in older adults. Specifically, triplets consisting of words of different valences may elicit unequal attention across the three words, which would imply the use of attentional deployment as a form of emotion regulation. Attention can be measured with fixation duration times to various stimuli as representations of degree of attention paid to different stimuli. Longer fixation times can be taken to mean greater intentional focus on a stimulus (Li, Fung, & Isaacowitz, 2010). The present study compared fixation durations across three valence categories in order to investigate whether a positivity bias drives older adults' attentional gaze patterns across stimulus types.

If gaze patterns are a form of emotion regulation at an attentional level, whereby older adults may avoid negative information to maintain emotional well-being, then mood prior to the presentation of stimuli must also be taken into account. Previous research has shown that an individual's mood can affect attentional biases during the viewing of stimuli. Isaacowitz et. al (2008) found that when viewing differently emotionally-valenced faces (angry, afraid, sad, and happy) paired with a neutral face, younger adults exhibited mood-congruent fixation patterns while older adults exhibited mood-incongruent patterns. Consequently, older adults in a negative mood may show a stronger positivity bias (see Demeyer, Sanchez, & Raedt, 2017). Due to this

potential moderating effect of mood on the relationship between age and gaze biases, the current emotional state of the participant will be assessed prior to the encoding phase.

Furthermore, individual differences in the use of specific emotion regulation strategies, including dispositional cognitive reappraisal and expressive suppression, can also impact gaze patterns during encoding of emotionally-valenced stimuli. In particular, cognitive reappraisal, which involves reinterpreting a situation to make it less negative, occurs after attention has been focused (Gross & John, 2003). In fact, Li *et. al* (2012) found that self-rated dispositional cognitive reappraisal (M+1SD) moderated the inverse relationship between age and pupil dilation for negative images. Specifically, among participants high in cognitive reappraisal, the negative correlation between age and pupil dilation increased, suggesting these older adult participants experienced less cognitive effort and arousal for the negative images. However, this relationship became nonsignificant for participants in the medium and low reappraisal groups (Li, Fung, & Isaacowitz, 2010). Only those with a greater disposition to use cognitive reappraisal exhibited a positivity effect at encoding, suggesting the importance of dispositional emotion regulation as a moderator for attentional biases with age.

In sum, I hypothesized different age-related differences for gaze patterns and memory. First, I predicted a positive age-related positivity effect in dwell durations such that negative words would be fixated on for shorter durations than positive and neutral words among older adults. I also predicted a positivity effect in memory, with older adults making the least hits for the negative valence category compared to the neutral and positive categories. Taken together, these predictions led to a third prediction: Gaze patterns in older adults should map directly onto their recognition ability, with reduced dwell time on negative words leading to worse memory for those words. For younger adults, I expected to find a valence bias in gaze patterns because

valenced words tend to be more highly arousing and therefore would equally grab their attention. However, I expected to see an age-related negativity bias in memory such that younger adults would make more negative hits than neutral and positive. The analyses focused on within-age-group trends because of greater interest in the different effects of *valence* of stimuli on encoding and retrieval for younger adults and older adults. I also hypothesized that positive affect and dispositional cognitive reappraisal would mediate the relationship between age, gaze patterns, and memory patterns. Consequently, I propose a mediation model that incorporates all these measures (as seen in Figure 3).

Method

Participants

Participants included 41 younger adults (age 18-22; N females) and 41 older adults (age 65-88; N females). A total of 96 participants participated in this study, however 3 younger adults and 1 older adult were excluded due to computer problems, 4 younger adults and 5 older adults were excluded due to high eye-tracking error rates, and 1 older adult was excluded due to early signs of dementia. All further analyses will only include the remaining 82 participants. Of these, 14.6% had 5 or fewer trials with missing dwell time data due to recording equipment failure. To make up for these missing data, I used the age group's average dwell time on those words and imputed those values. A total of 31 dwell times on individual words were imputed using this method.

Of the 82 participants, 76.8% identified as Caucasian, 3.7% as African American, 15.9% as Asian American, 0% Hispanic, 1.2% Latino/Latina, and 1.2% as other. Younger adults and were recruited through University of Richmond Introductory Psychology SONA or volunteer participation and older adults were recruited through advertisements in the Richmond Times

Dispatch or the Osher Lifelong Learning Institute. All older adult participants received $20.00 compensation.

Stimuli

Stimuli were selected from a list created by Wolfe, Sanders, Zakrzewski, and Berry (2017). All words were drawn from the Affective Norms for English Words database (Bradley & Lang, 1999) and consisted only of nouns. In Wolfe et al., each of the initially selected 204 words were rated by both younger and older adults, through Amazon Mechanical Turk, on subjective arousal and valence (each a 9-point Likert Scale). These data were used to eliminate any words ($N= 24$) rated significantly different on valence and/or arousal between the two age groups.

Stimuli for this study were organized into 2 lists of triplets. Half the participants in each age group received List 1 and half received List 2. Each list contained 31 triplets of words for a total of 93 words; there were 28 positive (valence rating of 7-9 on 9-point Likert Scale), 28 negative (valence rating of 1-3), and 34 neutral (valence rating of 4-6) words. There were 6 different within-subjects triplet types that varied by valence composition (see Table 1).

Each triplet was presented in 1 of 2 different configurations (left-heavy or right-heavy triangular format) and within each triplet type, the word valence was rotated through the three locations in the triangular configuration. All triplets of each triplet type were presented equally in the two different orientations (see Figure 4). The presentation order of the triplets was randomized for each participant except for the neutral-neutral-neutral triplets which served as buffers to mitigate primacy and recency effects.

To ensure the creation of 3 distinct valence categories, mean scores on valence and arousal for the words were analyzed as a function of assigned valence group. The negative words had the lowest mean valence *(M= 2.22)*, the positive words had the highest mean valence *(M=*

7.69), with the neutral group falling between the two extremes *(M= 5.20)*, all p's < .001. As

expected, mean arousal scores did not significantly differ between negative (*M*= 5.39) and

positive (*M*= 5.76) word groups but were both significantly greater than the neutral group (*M*=

3.60), both p's < .001.

Eye-tracking Procedure

Gaze patterns were tracked by the EyeLink 1000 Plus (SR Research). The first 10

participants (all younger adults) were tracked via remote mode (the chin rest is replaced by a

target sticker on the participant's forehead, allowing for their head to move more freely). All

other participants were tracked using the chin rest to improve calibration efficiency and quality.

Dwell Time

Interest area (IA) boxes were drawn around each word to capture all fixations on the

individual words. Buffer triplets 1, 2, and 31 (the first two and the last one presented) were

excluded from further analyses so that the total number of neutral words (30) was equal to that of

positive (30) and negative (30) words. Average dwell times by valence were calculated by

summing the duration of all the fixations within an IA and then averaging these totals for all

words of one valence category. Proportional dwell times were also calculated as a measure of

relative attention allocated to the individual words in a triplet by dividing the total time spent on

one word by the total dwell time in all IAs of a triplet. These proportions were then averaged

across all words of a valence category.

Measures derived from fixation duration and pupil dilation can be used as representations

of distinct emotion regulation strategies, specifically, attentional change and cognitive change,

respectively (Li, Fung, & Isaacowitz, 2010). Longer fixation implies greater attentional focus on

a stimulus. Pupil dilation relates to increased cognitive effort used to process a stimulus,

including greater emotional arousal and rumination. Consequently, both total dwell time (fixation duration) and pupil dilation will be used to assess positivity bias in attention.

Memory

Participants were given a 90-item yes/no recognition test. Single words were presented in each trial; 45 of these words had been viewed previously in the triplet presentations and 45 of these words were novel (not viewed previously). Within each group of 45 words, there were 15 items of each valence. The presentation of the items was randomized for each participant.

Afterwards, participants also completed a free-recall task, which was included as an exploratory measure. In this task, participants were asked to recall any pairings or individual words they had previously viewed. Analyses of these data are not reported here.

Emotion Regulation

The 10-item Emotion Regulation Questionnaire (Gross & John, 2003) was analyzed as a measure of dispositional tendency to regulate emotions using two different strategies using two subscales. The first subscale is cognitive reappraisal, or altering the way in which one thinks about a situation, thereby altering his/her resulting emotions. The second subscale is expressive suppression, or hiding one's emotions during social interactions. Participants rated each item on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree) and the two subscales are analyzed separately.

Dispositional Positivity

The 20-item Positive and Negative Affect Schedule (Watson et al., 1988) was used to measure current mood at the time of the experiment. The questionnaire describes 20 different emotions (10 positive and 10 negative). Participants are asked to rate the degree to which they are currently feeling each emotion on a 5-point Likert-type scale ranging from 1 (very slightly or

not at all) to 5 (extremely). The positive emotions are averaged together to produce a positive affect score and the negative emotions are averaged to produce a negative affect score for each participant.

Other Cognitive Measures

Participants completed measures of vocabulary ability (Ekstrom, French, Harman, Dermen Synonym Test, 1976), speed of processing (WAIS-R Digit-Symbol Substitution Task; DSST; Wechsler, 1981), and short-term memory (Wechsler Memory Scale- Revised; WMS-R; Wechsler, 1981).

Procedure

Participants were tested individually by an experimenter in a quiet room for one session each of approximately 1.5 hours. After consenting to participate in the experiment, participants completed the PANAS for current mood, followed by the vocabulary task. After this, the eye-tracker was calibrated to the participant's eyes using a 13-point calibration display.

The "viewing phase" was programmed and run on Experiment Builder (https://www.sr-research.com/). Participants were given an overview of the experiment and then instructed to view the word triplets "as naturally as possible." This was meant to promote unconstrained cognitive processing and prevent effortful studying, which has been shown to elicit a stronger positivity effect (Reed et al., 2014). Each triplet was presented one-by-one for 6 seconds. In between the presentation of each triplet, a cross flashed quickly in the center of the screen to re-center visual attention.

After the participants viewed the word triplets and completed the 20-second distractor task (a simple picture-matching task meant to prevent rehearsal of the stimuli), they were given instructions on how to complete the yes/no item recognition task (referred to as a "reflection

phase" to avoid eliciting the negative age stereotypes associated with memory tests). These instructions included the prompt, "do you remember viewing this word in one of the previous triplets," followed by 45 words from the stimuli list participants did in fact view (responding yes corresponded to making a "hit") and 45 novel items (responding yes corresponded to making a "false alarm"). Items of the recognition test were presented one at a time and the order of old and novel words was randomized. Response times were recorded.

Next, experimenters described the free-recall test ("pairings task"). A blank of paper with instructions at the top was given to the participant and he or she was asked to write down any triplets, pairs, or individual words they could remember. They were encouraged to guess and were allotted as much time as requested.

After these two memory tasks, participants completed a short post-test questionnaire related to study strategies and effort and, importantly, whether or not they anticipated a memory test. Next, participants completed the ERQ, followed by the DSST, a demographic questionnaire, and the WSM-R (see Table 2).

All participants of the current study also engaged in an identical rating task to that used for the original selection of word stimuli (Wolfe et al., 2017). At the end of the testing session, participants were asked to rate each word on its subjective valence and arousal using the same 9-point Likert Scales. Finally, participants were debriefed and received partial course credit (younger adults) or monetary compensation (older adults) for their time.

Results

Manipulation Checks

Total Dwell Time on Interest Areas

Between-subjects *t* tests for total dwell time on all interest areas (IAs) were conducted to investigate age-related differences in looking on or off the stimuli to determine whether one age group looked away from the words and at the blank space more frequently than the other. This comparison may have implications for memory ability (i.e., less time spent effortfully encoding). Younger adults (*M*= 137.86 seconds, *SD*= 17.25) and older adults (*M*= 130.17 seconds, *SD*= 27.05), spent equivalent amounts of time looking within the IAs *p* > .05.

Neutral Triplets

A 2 (age group: young and old) x 3 (word: neutral word 1, neutral word 2, neutral word 3) mixed ANOVA for proportional dwell time on the three different words in the neutral-neutral-neutral triplets was conducted to confirm these triplets as a control, supporting the notion that biases in attention may be due to differing emotion valence of the words in other triplet conditions. Total view time on IAs across all stimuli was covaried. Results indicated a nonsignificant main effect of age, $F(1,79) = .31$, $p > .05$, and, importantly, no main effect of word, $F(2,158) = 1.48$, $p > .05$. As expected, none of the neutral words in this triplet type drew greater attention as measured by dwell time.

Anticipation of Memory Test and Studying Effort

42.5% of younger adults and 46.3% of older adults anticipated taking a memory test in this experiment. Analysis of responses, where 1 = "did anticipate" and 2 = "did not anticipate," revealed nonsignificant age differences in the anticipation of taking a memory task (younger adults: *M*= 1.58, *SD*= .50; older adults: *M*= 1.54, *SD*= .51), $t(79)= .34$, $p > .05$. Importantly, the analysis of reported effort produced a nonsignificant difference between age groups: younger (*M*= 2.76, *SD*= 1.18) and older adults (*M*= 2.98, *SD*= 1.44) reported equivalent effort studying the individual words, $t(80)= -.76$, $p > .05$.

Disposition

Mood

Two between-subjects *t* tests of scores on the PANAS were conducted to investigate age-related differences in self-rated mood. Analyses revealed that older adults rated themselves significantly higher on positive emotions (*M*= 37.41, *SD*= 5.99) than younger adults (*M*= 25.57, *SD*= 6.59), *t*(81) = -8.56, *p* < .001. Furthermore, older adults rated themselves significantly lower on negative emotions (*M*= 11.32, *SD*= 2.48) than younger adults (*M*= 13.36, *SD*= 3.25), *t*(81) = 3.21, *p* < .05.

Emotion Regulation

A between-subjects *t* test for scores on the ERQ was conducted to investigate age-related differences in self-rated use of cognitive reappraisal and emotional suppression as emotion regulation strategies. Analyses revealed that older adults did not rate themselves significantly higher (*M*= 30.37, *SD*= 5.00) than younger adults (*M*= 29.12, *SD*= 6.77) on cognitive reappraisal, *t*(81) = -.95, *p* > .05. Interestingly, younger adults rated themselves significantly higher (*M*= 15.62, *SD*= 4.54) than older adults (*M*= 11.02, *SD*= 3.69) on emotional suppression, *p* < .001.

Gaze Pattern Analyses

A 2 (age group) x 3 (valence category: positive, neutral, negative) mixed ANOVA was conducted to analyze age differences in emotion-related attentional biases using the average time spent on all words of a valence category for the three categories. Total view time on IAs of all stimuli across all valence categories was covaried out to control for individual differences in the amount of view time spent on the stimuli or off the stimuli in the blank white space. Results indicated a main effect of age, *F*(1,78) = .79 *p* < .05, and a nonsignificant main effect of valence,

$F(2,156) = .49$ $p > .05$. Importantly, there was a marginally significant interaction between age group and valence, $F(2,156) = 2.82$, $p < .10$.

As seen in Figure 1, post-hoc analyses revealed equivalent average view times across the three valences for younger adults, all p's $> .05$, but older adults tended to spend significantly more time, on average, viewing negative words ($M= 1492.32$, $SEM= 19.04$) than both positive ($M= 1412.27$, $SEM= 23.91$) and neutral words ($M= 1451.23$, $SEM= 18.63$), both p's $< .05$. Furthermore, a one-way ANOVA revealed that older adults spent significantly more time viewing the negative stimuli than younger adults ($M= 1435.57$, $SEM= 18.80$), $F(1,78) = 4.43$, $p < .05$.

Altogether these results suggest a gaze-pattern bias away from positive words and an inclination towards negative words in older adults relative to younger adults.

Memory

Overall (Collapsed Across Valence)

A between-subjects t test for scores on the memory task was conducted to investigate age-related differences in overall item recognition ability. younger adults tended to have significantly greater overall recognition ability, as measured by hits + correct rejections, ($M= 62.51$, $SD= 9.20$) than older adults ($M= 57.50$, $SD= 6.86$), $t(79) = 2.774$, $p < .05$. Similarly, younger adults tended to have significantly more hits ($M= 26.61$, $SD= 6.98$) than older adults ($M= 22.60$, $SD= 9.14$), $t(79) = 2.22$, $p < .05$. However, the number of false alarms did not significantly differ between the two age groups (younger adults: $M= 9.10$, $SD= 5.70$; older adults: $M= 10.10$, $SD= 6.36$), $t(79) = -.75$, $p > .05$.

Hits by Valence

A 2 (age group: young and old) x 3 (valence category accuracy: positive, neutral, negative) mixed ANOVA was conducted for hits (correct item recognition). Results indicated a nonsignificant main effect of age, $F(1,78) = 1.44$, $p > .05$, and a significant main effect of valence, $F(2,156) = 5.75$ $p < .05$. Furthermore, there was a marginally significant interaction between age group and valence, $F(2,156) = 2.20$, $p = .103$.

As seen in Figure 2, a one-way ANOVA revealed that older adults ($M= 7.73$, $SD= 3.66$) had significantly fewer negative hits than younger adults ($M= 9.90$, $SD= 2.39$), $F(1,78) = 4.84$, $p < .05$. younger adults and older adults did not differ on hits for the positive and neutral words, both p's $> .05$. The interaction between age and valence of hits was likely driven by a bias towards negative words exhibited by younger adults, coupled with an apparent lack of valence bias in older adults.

False Alarms by Valence

A 2 (age group: young and old) x 3 (valence category: positive, neutral, negative) mixed ANOVA was conducted for false alarms (FA; incorrect positive recognitions) with total FAs covaried out. Results indicated nonsignificant main effects of age $F(1,78) = 1.35$, $p > .05$, and valence, $F(1,156) = .65$, $p > .05$. The interaction effect was nonsignificant.

Hits + Correct Rejections (Total Memory) by Valence

A 2 (age group: young and old) x 3 (valence category: positive, neutral, negative) mixed ANOVA for total memory, calculated by summing Hits+Correct Rejections within each valence category, was conducted with total accuracy across the 3 valence categories covaried out. Results indicated nonsignificant main effects of age, $F(1,78) = .23$ $p > .05$, and of valence, $F(2,156) = .31$ $p > .05$. The interaction effect was nonsignificant.

Gaze Patterns & Memory

Exploratory analyses revealed a significant correlation between the proportion of dwell time spent on negative words and total negative hits (r= .291), $p < .05$, but a nonsignificant correlation between the proportion of dwell time spent on positive words and total positive hits (r= .06), $p > .05$. Analyses within age groups indicated that the correlation between proportional dwell time on the negative words and number of negative hits was significant for older adults (r= .33), $p < .05$, but not younger adult. Thus, in older adults, greater dwell time on negative words was associated with greater recognition ability for negative words This shows that a direct relationship between gaze patterns and memory was apparent in older adults but not younger adults, and only for negative words.

Mediation Model

The effect of age group on memory, as measured by total hits, was significant (r= -.24), $p < .05$, and in the expected direction. Specifically, age group was significantly negatively correlated with negative hits (r= -.34), $p < .01$, but nonsignificantly correlated with neutral (r= -.20), and positive hits (r= -.16), both p's $> .05$. Taken together, the lower magnitudes of correlations between age and memory as the valence category becomes more positive suggests an age-related positivity effect of memory.

Figure 3 presents the conceptual model of the relationships between age, memory, emotion regulation, mood, and gaze time. Structural equation modeling was used to assess the fit of this model to the data. Results indicate a good fit of data to model, χ^2=45.54, $p > .10$; PCLOSE= .339; RMSEA= .061; CFI=.948. Furthermore, the direct effect of age on memory (r= -.24) became nonsignificant (r= .14), when the mediators where included in the model. This result provides support for a full mediation effect.

Discussion

The hypotheses regarding memory performance were partially supported and the hypotheses for gaze patterns were not confirmed.

For gaze patterns, I hypothesized that older adults would exhibit a positivity bias, but found they actually exhibited a negativity bias. Specifically, younger adults tended not to show a valence preference in gaze patterns. Younger adults spent equal amounts of time viewing positive, neutral, and negative words, whereas older adults spent much longer viewing negative words than both neutral and positive. When controlling for total view time, older adults spent significantly longer time on negative words than younger adults, while the two age groups did not significantly differ on the other two valence categories.

The lack of a positivity effect in older adult gaze patterns appears to contradict much of the previous literature in the field (Isaacowitz et al., 2006a; b). Yet, there is also some previous evidence suggesting that positivity effects in gaze patterns may be driven by mood regulation motivations, such that age differences are only evident when participants are induced into negative moods, whereas those in positive and neutral moods do not exhibit a positivity effect (Isaacowitz et al., 2009). In this study, we found that older adults rated themselves as quite high on positive affect immediately prior to the viewing phase and therefore were perhaps less motivated to regulate their mood through preferential attention to positive stimuli, which may explain the lack of a positivity effect in gaze patterns.

For memory performance, age differences appeared for the negative words only, with younger adults producing a greater number of negative hits than older adults. This supports previous research on age differences in positivity effects on memory tasks (Kensinger, 2008), especially trends of larger age differences in memory for negative stimuli than positive stimuli (Charles, Mather, & Carstensen, 2003).

Taken together, the analyses of age differences on mean gaze patterns and analyses of age differences on memory performance yielded opposite age trends: Older adults looked longer at negative stimuli and younger adults remembered more negative stimuli.

To understand whether gaze patterns were related to memory performance, correlations between proportional gaze allocation and hits within each valence category were calculated and analyzed separately within each age group. These analyses showed that proportion spent viewing positive words did not predict hits on positive words for either age group, however the proportion spent viewing negative words did significantly correlate with negative hits, but only for older adults. Relative dwell time allocation on negative words appeared to facilitate greater memory for those words, but only for older adults, whereas greater allocation on positive words did not impact recognition ability for either age group.

The fact that older adults who allocated proportionally more view time on the negative words also remembered more negative words, coupled with 1) more time viewing negative words by older adults, 2) lack of a large memory deficit with age (only about 4 hits less for older adults than younger adults), and 3) lack of a deficit in memory for negative words compared to neutral or positive by older adults (as would be expected in the positivity effect), suggests that an age-related positivity bias and neglect of negative stimuli in memory was counteracted by the atypical negativity bias in older adults' gaze patterns. Older adults did not require relatively equal dwell time allocation across the three valence categories in order to equally *remember* those valence categories. Rather, prioritizing the negative during encoding appeared to ameliorate age-related deficits in memory for negative stimuli.

Though not all older adults reported anticipating the incidental memory task (around 46%), perhaps their greater allocation of attention to the negative words was partly intentional. If

the age-related positivity bias is a true phenomenon and is prevalent in the everyday lives of older adults, over time older adults may learn to counterbalance their positive bias by allocating more attention to the negative, especially when they are aware they will be tested (Reed et al., 2014) or are experiencing stereotype threat (Barber et al., 2018), in order to regulate information processing demands and to remember negative as well as positive information. Because differences between older adults who did and did not anticipate the memory test were nonsignificant on the average dwell time on negative words, proportional dwell time on the negative words, and the number of negative hits they made, the obtained age-related negativity bias effect in gaze patterns appears not to be driven solely by a motivation to ameliorate the positivity effect at test. However, it is important to note that the anticipation of the memory test was a self-report, one-item question immediately following the test phase, which could have led many older adults, especially those feeling unconfident about their memory performance and experiencing a self-imposed stereotype threat, to falsely report the lack of anticipation of a memory test or any efforts to study the stimuli during encoding.

In sum, the most salient findings in this study pertain to the negative stimuli, as these form the one category that appeared to drive age differences in attention, memory, and the relationship between these two cognitive processes. Though we found seemingly contradictory age by valence interactions for gaze patterns and memory, there was a strong link for older adults between proportional dwell time and hits, but again only for the negative words, suggesting there is something unique about older adults' interactions with negative stimuli, at least in this study. These findings are important when considering how to frame, study, and measure the positivity effect in future studies.

The full mediation model presented in this study brings us one step closer to understanding how age impacts memory and why gaze patterns alone cannot function as the sole predictor of memory patterns. Mediator variables including affective state during the experiment and emotion regulation strategy usage also contribute to the relationship between age, gaze patterns, and memory, as seen by the reduction of the direct effect of age group on memory to a nonsignificant level after these mediators were taken into account. These findings are promising because, while age is not a variable that is easily manipulated through interventions, mood and emotion regulation strategies are more flexible and have the potential to be altered through interventions.

Future research should continue to focus specifically on the positivity effect for word stimuli and, importantly, what aspects of words, in addition to valence, drive age differences in encoding and retrieval patterns. Not all positive words are created equal. Some, like "family" or "poetry" may carry more meaning than others, such as "cake" or "flower." Furthermore, item-level analyses of individual differences in the perceptions of words may illuminate age differences and the positivity effect more clearly, such that an older adult who loves poetry but hates flowers will remember seeing "poetry" but not "flower." Personal ratings of word valence (which were collected in this study) and word salience may add to an understanding of the memory trends found in this study (and other studies of the positivity effect) that aggregate valence alone cannot fully explain.

Another important limitation that provides opportunities for future research was the inclusion of 6 different triplet types in this study that all had different valence compositions. For our analyses, the positive words were all treated equally, regardless of which triplet type they had presented in, as were all neutral and all negative words. This is problematic, however,

because the triplet types were created with the intention of eliciting different gaze patterns (e.g. the positive word in type 1 triplets would draw the most attention of older adults, but in triplet type 2 attention would be equally divided across the 2 positive words). For the current study, averaging dwell times across all words of a valence regardless of the triplet type in which they were presented allowed us to better understand general gaze patterns trends that would not be highly powered had we analyzed each triplet type separately. Future studies that attempt to use word triplets may want to just use one type, due to the limited use of word triplets in studies of the positivity effect thus far and the ease and simplicity of doing so.

The current study chose to investigate the positivity effect with word stimuli, and word triplets in particular, using eye-tracking methodology because much of the information that is important to us- such as medicine dosage, safety instructions, directions, and even the news- is presented in the form of words, not just images. The field of psychology already knows that older adults may look away from angry faces or gruesome photos, but we do not yet know if they are also avoiding negative language. This study found that they actually are not avoiding looking at the negative, or at least when they do spend more time attending to the negative, older adults also tend to better remember the negative. Interestingly, greater memory for positive and neutral information did not require greater visual attention, suggesting that perhaps the positivity effect can be conceptualized as valence differences in ease of encoding or putting stimuli into one's memory. Furthermore, our mediation model suggests that gaze patterns are not the only predictor of memory and that as we age, many other factors can play a role in what we learn and remember. This model is an attempt to add one more piece to the puzzle of cognitive aging, hopefully shedding some encouraging light onto negative portrayals of aging and memory.

Tables & Figures

Table 1

Triplet valence and frequency, per stimuli list.

Triplet Type	Frequency
Positive-Neutral-Negative	6
Positive-Neutral-Neutral	4
Negative-Neutral-Neutral	4
Positive-Negative-Negative	6
Negative-Positive-Positive	6
Neutral-Neutral-Neutral	5

Table 2

Demographic Information

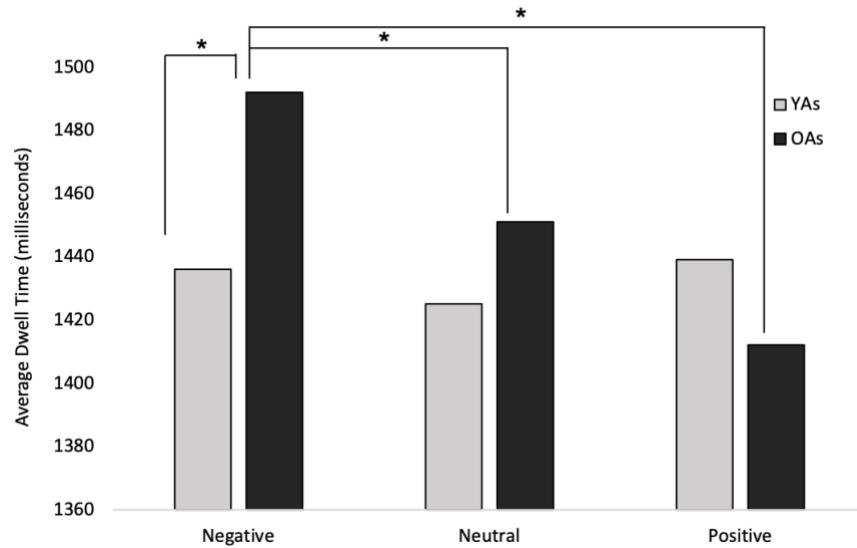| Measure	Younger Mean (SD)	Older Mean (SD)	Significance
Years of Education	13.27 (1.19)	17.34 (2.95)	$p < .001$
DSST	69.00 (16.90)	46.85 (14.16)	$p < .001$
Ekstrom Vocabulary Task	24.64 (3.52)	29.28 (3.07)	$p < .001$
WMS-R	18.88 (6.34)	18.78 (4.91)	*ns*
Self-Rated Health	8.12 (1.68)	8.49 (1.14)	*ns*
Self-Rated Vision	7.81 (1.81)	8.10 (1.58)	*ns*
Self-Rated Hearing	8.64 (1.59)	8.05 (1.70)	*ns*

Figure 1. Average view time by valence with total view time as a covariate. Total view time was calculated as the time spent on the interest areas of all stimuli, which was treated as a covariate due to individual differences and age-related trends in looking off the stimuli. Older adults (OAs) spent significantly more time viewing negative words compared to younger adults (YAs) and compared to neutral and positive words. Younger adults did not exhibit any valence-related bias. * denotes $p < .05$
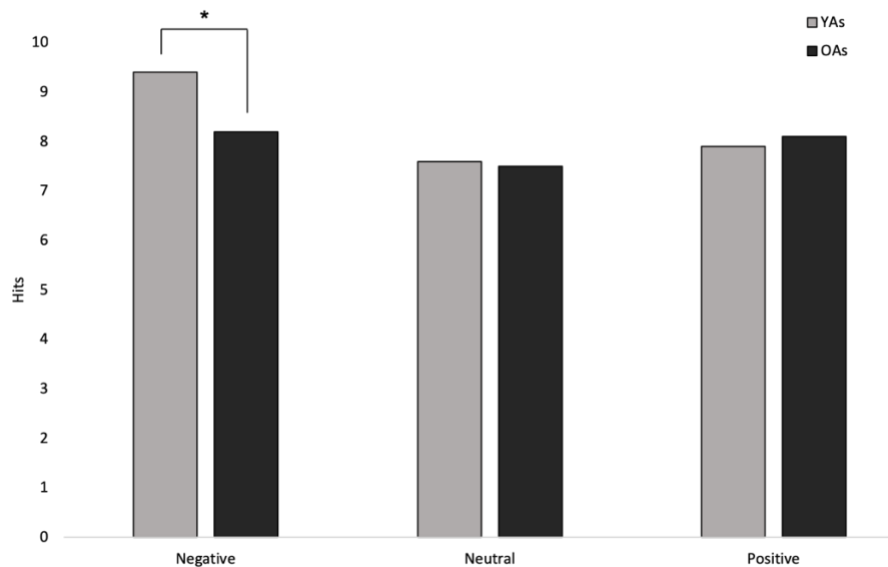

Figure 2. Hits by valence with total hits as a covariate. Hits only include correct identifications on the recognition task (not current rejections of novel words). Younger adults (YAs) made significantly more hits on negative words than older adults (OAs). * denotes $p < .05$
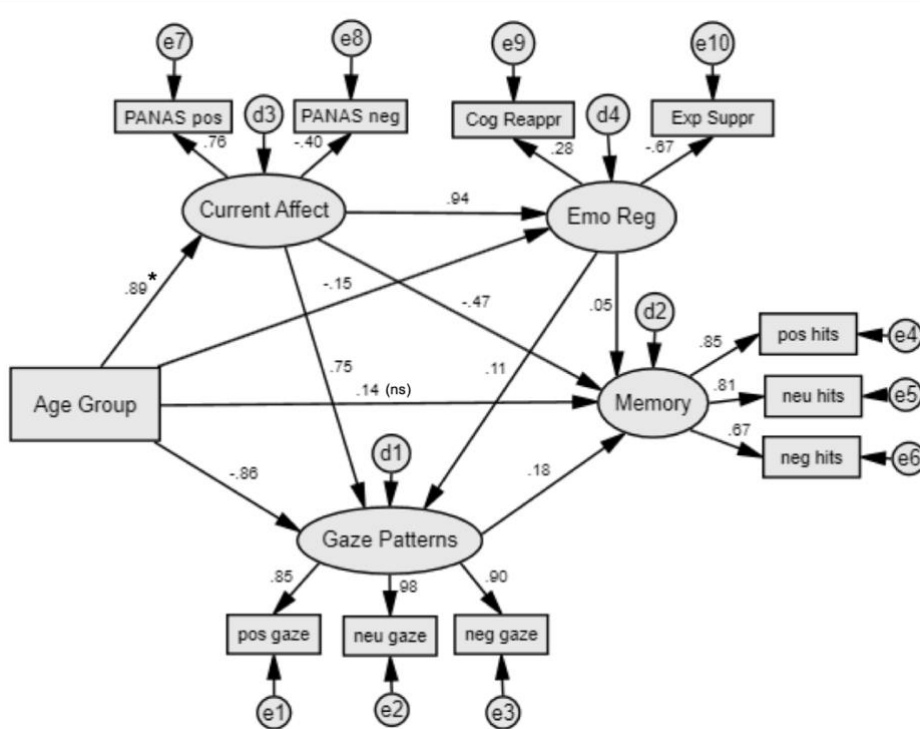
Figure 3. Mediation of the relationship between age and memory (hits). Standardized regression coefficients are presented next to their respective paths (arrows). Gaze patterns represent the average dwell time per valence, current affect is measured by PANAS, Emo Reg represents the two strategies of the ERQ subscales (cognitive reappraisal and expressive suppression). The model was a good fit for the data $\chi^2=45.54$, $p > .10$; PCLOSE= .339; RMSEA= .061; CFI=.948. * denotes $p < .05$, (ns) denotes the reduction of significance of the direct effect of age group on memory after all other mediator variables were taken into account.
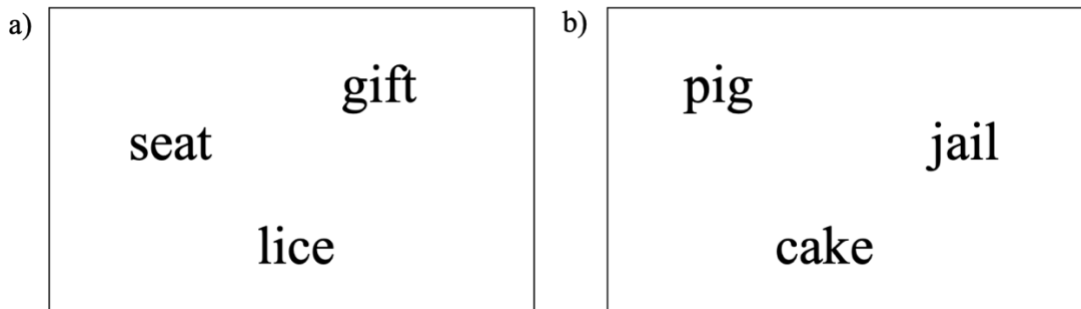

Figure 4. The two configurations of word stimuli presentation.

Stimuli

List 1

Positive	Neutral	Negative
friend	patent	wound
beauty	moment	abuse
refreshment	hairdryer	blackmail
cuddle	elevator	paralysis
cake	pig	jail
kindness	engine	crisis

Positive	Neutral	Neutral
freedom	locker	custom
trophy	elbow	manner
millionaire	curtain	utensil
hug	sentiment	quart

Negative	Neutral	Neutral
stench	lamp	detail
cockroach	iron	bowl
disaster	theory	poster
pain	trunk	cork

Positive	Negative	Negative
laughter	penalty	rotten
rainbow	pus	hostage
warmth	poison	lie
vacation	criminal	danger
peace	mistake	loneliness
song	headache	failure

Negative	Positive	Positive
stress	nature	wish
mosquito	justice	sunrise
grief	kiss	beach
massacre	passion	delight
hatred	cheer	diamond
burn	champion	joke

Neutral	Neutral	Neutral
pencil	inhabitant	cannon
chin	passage	statue
clock	stomach	hammer
lightbulb	runner	kerchief
taxi	context	barrel

List 2

Positive	Neutral	Negative
gift	seat	lice
victory	method	abduction
treasure	taxi	prison
respect	hairpin	fraud
reward	hydrant	agony
sunlight	context	neglect

Positive	Neutral	Neutral
liberty	manner	fabric
grin	cow	vest
affection	hammer	corridor
perfection	industry	bathroom

Negative	Neutral	Neutral
crash	phase	barrel
victim	metal	statue
vandal	arm	lantern
trauma	rock	gender

Positive	Negative	Negative
ambition	injury	fever
holiday	gloom	maggot
heaven	discomfort	coward
success	trouble	death
gold	waste	fear
comedy	insult	accident

Negative	Positive	Positive
ache	music	fun
corpse	knowledge	treat
illness	enjoyment	angel
nightmare	acceptance	blossom
obesity	honor	sweetheart
divorce	cash	puppy

Neutral	Neutral	Neutral
clock	alien	runner
stomach	umbrella	passage
cord	pencil	kerchief
scissors	appliance	cabinet
theory	trunk	quart

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