Age, affect, and cognitive ability influence the magnitude of the memory trade-off effect

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ABSTRACT

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Most adults demonstrate a memory trade-off when they look at an emotionally salient image. This means that their memory for the central, emotional object is fairly good, while memory for the background details is "traded-off" in favor of the emotional piece, and is relatively poor. The goal of this project was to examine possible correlations between age, affect, and cognitive ability and the memory trade-off effect. It was predicted that participants with high-affective control and higher scores in working memory tests (linked to cognition) would have a less pronounced memory trade-off. Sixty-four younger adults and sixty-seven older adults studied composite scenes that included positive, neutral, and negative items placed on neutral backgrounds and their memory was later tested for these items and backgrounds separately. In addition to the memory trade-off task, participants also completed measures designed to examine affective traits and working memory. Older and younger adults had the same pattern of performance in the memory trade-off (positive trade-off scores being higher than negative), as well as the same magnitude of memory trade-off scores. Some measures of affect were correlated with the memory trade-off in older adults, though a few of them were unexpectedly negatively correlated, meaning better performance on the affective tasks were associated with a more pronounced memory trade-off. No affective or cognitive testing scores were significantly correlated with the memory trade-off for younger adults. These results further emphasize the complexities of individual characteristics in the memory trade-off effect, and suggest that these traits may have more or less influence on memory depending on an individual's age.

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Introduction

What personal characteristics are the most important for preserving memories of the things we see day-to-day? Why do we vividly remember some components of images while forgetting the rest? It is likely that a combination of abilities is necessary and intertwined for this type of memory process. Some factors that could be involved are how a person attends to visual scenes, their ability to flexibly engage and disengage with components of an image, their level of state and trait anxiety, as well as their overall availability of cognitive and emotional resources. These aspects of cognitive ability and emotional control could both be vital for recall of specific scenes. In addition, the way these components contribute to memory for scenes could change as we age.

All of these personal characteristics could contribute to the memory trade-off effect, in which there is enhanced memory of an emotional stimulus at the expense of forgetting peripheral details (E. A. Kensinger, Garoff-Eaton, & Schacter, 2007; Waring & Kensinger, 2011; Waring, Payne, Schacter, & Kensinger, 2010). In complex visual scenes, emotional information attracts attention more quickly and allows for heightened memory of that image, while memory for the neutral background information is diminished. Memory for the background details is "traded-off" in favor of providing enhanced recall for the emotional content (Waring & Kensinger, 2011). This phenomenon has been fairly well characterized using negative emotional images.

An example of this memory trade-off effect can be described using the weapons focus effect. As can be inferred from the name, this paradigm evaluates an onlooker's ability to recall specific details of a scene when a negatively charged item, such as a weapon, is present in the scene. In one classic study, participants viewed a series of slides in which customers walk through a cafeteria line at a fast-food restaurant. The control group watches a scene in which a customer selects an item to purchase, presents the cashier with a check, and then receives some change from the cashier. The slides presented in the weapons condition is matched in all regards except for that instead of presenting a check, the customer points a gun at the cashier (Loftus, Loftus, & Messo, 1987).

Participants in this weapons focus study were then tested on their memory of the slides. Part of this memory component involved presenting participants with 12 photographs of people's faces, and one of these photographs was of the subject who interacted with the cashier. Participants were instructed to identify which person of the 12 was this target individual. Only about 39% of participants in the control condition were able to correctly identify the target customer, but the participants in the weapons groups were significantly impaired, in comparison, in identifying their target (Loftus et al., 1987). This demonstrates a memory trade-off effect because in the weapons scene, participants were much less likely to remember the peripheral details of the image, including the face of the customer.

The study also measured each participant's eye movements during the slide presentation. Overall, participants in the weapons group made more fixations on the weapon than participants in the control group did when looking at the check. In addition to more fixations, the participants in the weapons group also spent more time in general looking at the weapon than the control group did for the check (Loftus et al., 1987). These pieces of evidence support the memory trade-off effect in negative, emotionally salient scenes. Because participants had their attention focused more often and for longer amounts of time on the gun in the scene, their memory for the peripheral information (the distinguishing characteristics of the customer holding the gun) was traded-off in favor of remembering the emotionally salient item itself. We show enhanced memory for the emotional component at the detriment of the surrounding information.

Other studies show that a boundary effect can occur when participants are exposed to negative emotional stimuli (Mathews & Mackintosh, 2004; Safer, Ê, Christianson, Autry, & Sterlund, 1998). When viewing scenes that contain negative items, people tend to recall a restricted boundary of negative scenes and an expanded boundary for neutral scenes. In a study conducted by Safer *et al.* (1998), participants examined a progression of scenes in which traumatic and neutral story events were depicted, such as a woman being attacked in a park or a woman picking flowers in a park. After encoding, some images of the scenes were revisited, with both a close-up version of the emotional component as well as a wide-angled image of the scene. In traumatic scenes, participants tended to select narrower views of the emotional component, demonstrating "tunnel memory" for these scenes compared with neutral scenes. When the neutral scenes were reexamined, the boundaries for these images were remembered more clearly than the emotionally charged scenes (Safer et al., 1998). This boundary effect was also found in a similar study which revealed that people with higher levels of trait anxiety were more likely to remember emotional scenes being "zoomed in" than participants with low levels of anxiety (Mathews & Mackintosh, 2004). This enhanced trade-off effect has been found to persist even in people presenting with sub-clinical levels of anxiety, since the bias toward focusing on negative components of a scene is demonstrated in both people with higher and lower levels of anxiety (Calvo & Avero, 2005). Other studies, however, suggest that the threat related bias of attention does not exist in non-anxious individuals (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007).

Affective factors have consistently been a target of study in the memory trade-off. People with higher levels of trait anxiety show increased attentional bias toward perceived threatening material, as well as showing increased attention to even mildly negative stimuli (Calvo & Avero, 2005). Negative material tends to be remembered especially well compared to neutral material (E. A. Kensinger, Garoff-Eaton, & Schacter, 2006; Kim, Vossel, & Gamer, 2013), possibly in part because negative information draws attention more quickly than other types of cues (Waring & Kensinger, 2011). For these reasons, higher levels of trait anxiety are implicated in a more pronounced trade-off effect (Waring et al., 2010).

Although levels of anxiety may contribute to the memory trade-off effect, it is uncertain whether anxiety would also influence memory trade-off effects for positive stimuli. Previous work has shown that given certain levels of arousal, negative trade-offs and positive trade-offs can occur at approximately the same magnitude (Waring & Kensinger, 2011). Such findings converge with other literature revealing positivity biases in information processing, especially for older adults. Some research suggests that older adults show greater attention to positive stimuli than they do to negative stimuli (Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Mather, 2008) and this increased attention can lead to enhanced memory for positive stimuli (Carstensen & Mikels, 2005). Leal and Yassa (2014) provided evidence that a positivity bias exists in a task where previously studied items are presented along with low-similarity and high-similarity lures. Both younger and older adults had higher false recognition rates for low-similarity lures to emotional items compared to neutral items, suggesting that both age groups consolidated the information in a similar way. Older adults, however, were more likely to falsely recognize high-similarity negative emotional items as well, compared with younger adults who were better able to discriminate. This finding supports the existence of a positivity bias. Because older adults were unable to discriminate between old and new high-similarity negative items but successfully discriminated between old and new high-similarity positive items, they exhibited a bias to encode positive items more fully which led to better accuracy in recognition (Leal & Yassa, 2014).

There is also research that suggests there is no positivity bias for older adults. In one study, a word task revealed that neither younger nor older adults were more capable of detecting positive arousing words (Mickley Steinmetz, Muscatell, & Kensinger, 2010). Other findings argue that there is no difference in memory enhancement between older and younger adult groups for remembering high-arousal positive items (Waring & Kensinger, 2009).

Other factors, such as overall cognitive function, are also likely to play a role in what parts of a scene are remembered. In particular, executive functioning skills such as working memory, selective attention, and inhibitory control could be of crucial importance in the magnitude of the memory trade-off effect. In studying visuospatial working memory as it relates to the memory trade-off, one study found that a negative correlation exists between the two. Performance in the Spatial Span backwards working memory task was negatively correlated with overall specific memory trade-off, but not with enhancement of memory for emotional items or neutral backgrounds when those pieces were seen separately (Waring et al., 2010). In the same study, participants also performed a word fluency task to assess their executive functioning skills. The number and percentage of perseverative errors made were specifically highlighted. This analysis showed a positive correlation between the number and percentage of perseverative errors made and the magnitude of the memory trade-off. Participants with more errors in the verbal fluency task showed greater recall of emotionally salient items and less detail for background information (Waring et al., 2010). These components of cognitive ability may be especially important in processing visual scenes. Having greater visuospatial working memory skills could allow a person to keep components of a scene fresh in their memory and allow them to update the information as necessary. Executive functioning skills in general would also be important. Greater ability in this domain could allow a person to pay selective attention to certain parts of the scene, flexibly engage and disengage with these components, and inhibit the urge to allocate too many resources on encoding select parts of the scene. With greater overall cognitive ability, there can be effective processing of visual stimuli that will allow a viewer to disengage from a central, emotional image and attend to background details.

Some research provides evidence that both affect and cognition are contributing components to the memory trade-off effect (Waring et al., 2010). In one such study, testing for memory trade-offs was conducted using composite scenes that utilized both neutral and negative-arousing central objects on neutral backgrounds. The images consisted of an object, like a snake, placed on a plausible background, like a scene of a river. Participants were asked to indicate on a scale from 1 through 7 whether they would like to approach or retreat from the composite scene, which would indicate the emotional intensity that they felt from the scene. After this encoding process, participants were shown pieces of the scenes independently, and they were asked to indicate if the objects and backgrounds were the same objects and backgrounds, similar images, or completely new images from the composite scenes they studied earlier (Waring et al., 2010). As expected, participants did show a trade-off in which negative items were remembered better than neutral items, and memory for neutral backgrounds was diminished in scenes that were originally paired with negative stimuli (Waring et al., 2010). Higher levels of state and trait anxiety correlated with a greater magnitude of specific recognition memory trade-off. Specific recognition trade-off was also correlated with poorer performance on cognitive measures. This study looked primarily at visuospatial working memory and executive control. Participants who were better able to use executive control functions demonstrated a less pronounced memory trade-off, likely because they were able to disengage from emotional components of scenes and could better attend to background information (Waring et al., 2010).

Apart from affect and cognition, other personal characteristics are also likely to influence performance in this type of memory trade-off, specifically age. Most previous research has focused primarily on younger adult groups in the context of this research question. Conflicting literature exists in how healthy aging will influence the memory trade-off effect. Some evidence suggests that young, middle age, and older adults have no significant difference in memory for emotional stimuli, with all groups showing an enhancement of memory for emotional pieces (Denburg, Buchanan, Tranel, & Adolphs, 2003). Another study that specifically tested the memory trade-off in older and younger adults also found that there was similar performance between the two groups in a short study-test delay design (Waring & Kensinger, 2009). Other work suggests that older adults can differ from younger adults in their memory trade-off, including having a smaller trade-off score than younger adults (see 24-hour delay in Waring & Kensinger, 2009) or a larger score, even when they are given specific strategies in which to help them encode visual scenes (E. A. Kensinger et al., 2007).

In this study, we investigated how personal characteristics such as cognitive ability and emotional control contributed to the memory trade-off effect. To test cognition, we used a standard Stroop task, as well as a Letter-Number sequencing task and a Controlled Oral Word Association task. Measures of affective traits included an affective Stroop task, a Dot Probe task, a Visual Search task, as well as the Positive and Negative Affect Schedule and Spielberger State Trait Anxiety Inventories. We then examined if cognition or affect contributed differently to the memory trade-off effect during healthy aging. This study extended the work of previous researchers by adding several components to testing measures that have been used to study memory trade-off in the past. The memory trade-off has been more thoroughly investigated using negative emotional stimuli, so we included positive emotional stimuli as well as negative. We included measures designed to examine affect as well as cognitive ability to determine if emotional control or cognition plays a larger role in the memory trade-off. Then we examined how this relationship changed across the lifespan, comparing younger and older adults. To our knowledge, this was the first study of its kind to specifically investigate the effects of age, affect, and cognition on the memory trade-off effect.

Methods

Participants

Younger adults and older adults were recruited to form the two cohorts of the study. Younger adults were enrolled primarily using Brandeis University's psychology department recruitment website, Sona Systems. All younger adults were between the ages of 18 and 35. Older adults between the ages of 59 and 99 were enrolled primarily through the lab's database, recruited through advertisements in local newspapers. All older adults were screened for eligibility prior to study participation using a questionnaire designed to identify psychiatric illness, education level, and English language fluency, among other factors. Health and demographic information was collected from participants prior to involvement in the research. Each participant provided written informed consent in a method approved by the Institutional Review Board of Brandeis University. At the conclusion of the study, each participant received either course credit or monetary compensation for their time.

Procedure

A series of computer-based and written tasks were used in this study, presented in the order described. A research assistant was present throughout the duration of testing.

Questionnaires to Measure Affect

We administered the Positive and Negative Affect Schedule (PANAS) and the Spielberger State-Trait Anxiety Inventory (STAI) to all participants before the encoding task began (Kvaal, Ulstein, Nordhus, & Engedal, 2005; Watson, Clark, & Tellegen, 1988). These measures indicated trait affect per individual, and the STAI has been found to be sensitive to both anxiety and depressive disorders (Kvaal et al., 2005), and so would be helpful in identifying individuals with possible affective disorders. Directly after encoding, the PANAS and STAI were administered a second time to measure state affect. In a different study that examined the memory trade-off, researchers collected similar measures of trait and state anxiety scores in their participants (Waring et al., 2010).

Hypothesis: Individuals who present with higher levels of anxiety likely have less emotional control. These participants will show a more pronounced trade-off than individuals with lower levels of anxiety, which would support the findings of Waring et al. (2010). It is unlikely that younger adults will differ from older adults on these scores.

Encoding

Participants studied a series of scenes that were displayed on a computer screen. All scenes were of comparable size and consisted of central and peripheral images (Figure 1). Central objects, such as a chipmunk, were placed on a neutral background, such as a meadow (Waring et al., 2010). The images used included emotionally valenced negative, neutral, and positive images. Ninety composite scenes, 30 of which were positive, 30 neutral, and 30 negative, were displayed on the screen for 5 seconds each. Within those 5 seconds, participants recorded the emotional intensity that each scene made them feel by pressing the keys 1-9 on a keyboard. Lower ratings on the scale indicated negative feelings, and higher ratings indicated positive feelings. Scenes progressed automatically every 5 seconds and were displayed in sequential order. The order was counterbalanced across two conditions of the task.

Standard Stroop

In the standard Stroop task, participants were instructed to indicate the text color of words that were displayed on the screen as quickly as they could. Four colors (red, yellow, green, and blue) were tested in congruent (word “red” is written in red text), incongruent (word “red” is written in blue text), and neutral conditions (nonsensical “XXX” written in red text). Participants were instructed to ignore the meaning of the word and respond strictly to the color of the text that they viewed by pressing a key. There were two blocks of 52 trials each, for a total of 104 trials, which were presented in random order. In each block there were 18 congruent trials, 18 incongruent trials, and 16 neutral trials. Items remained on the screen until a button was pressed. A blank screen replaced the previous item for 1000 ms, and then the next trial began.

Hypothesis: Consistent with other studies, it is expected that both older and younger adults will demonstrate a Stroop effect, with reaction time slower for incongruent trials than the other conditions (Zurron, Lindin, Galdo-Alvarez, & Diaz, 2014). Older adults will have a slower response time in all conditions than do younger adults. Participants presenting with less ability to inhibit the prepotent response will show an enhanced Stroop effect. Participants who have a less pronounced Stroop effect show greater cognitive ability, as they are able to inhibit their urge to name the written word in the incongruent conditions (Zurron et al., 2014). For this reason, participants with a less pronounced Stroop effect will also have a less pronounced trade-off effect.

Recognition

Recognition of objects and backgrounds from the encoding task was assessed. One block of 360 images was presented in random order on a computer screen. These trials included all 90 objects and all 90 backgrounds that had been viewed previously, as well as 90 new objects and 90 new backgrounds that were not presented earlier (Figure 2). Participants were tasked with determining which objects and backgrounds were new images and which ones had been viewed previously. Participants rated their familiarity with the objects and backgrounds by pressing the numbers 1-6 on a keyboard. Low numbers indicated that the presented image was not remembered and was a new image, and higher numbers indicated that the image was remembered and was old.

Hypotheses: A trade-off effect will be present in both older and younger adults. There will be better recall of emotionally valenced items, but lessened recall of the neutral backgrounds that were originally associated with the emotional central components (Waring & Kensinger, 2009, 2011; Waring et al., 2010). Younger and older adults will have a similar magnitude of memory trade-off in both positive and negative conditions (Denburg et al., 2003; Waring & Kensinger, 2009). In terms of relationships with other measures, participants who have better executive control abilities will have a smaller memory trade-off than those with poorer executive control (Waring & Kensinger, 2009). People with higher levels of state and trait anxiety, indicators of less emotional control, will have a larger trade-off effect (Waring & Kensinger, 2009). Conflicting literature exists in how aging will influence the memory trade-off effect, with some evidence suggesting that there will be no difference across age (Denburg et al., 2003), and other work suggesting that there can be a difference, depending on task instructions or time of testing (E. A. Kensinger et al., 2007). Because we aren't implementing strategies designed to reduce the memory trade-off and because we are using a short test delay, we expect that older and younger adults will have similar trade-off scores.

Letter Number Sequencing/ Controlled Oral Word Association Test (FAS Version)

The Letter-Number Sequencing task from the WAIS-III was administered (Wechsler, 1997). Participants also completed the FAS version of the Controlled Oral Word Association (COWA) Test (Benton, 1968).

Hypothesis: Individuals who receive higher scores on these cognitive tests show greater cognitive ability in working memory. These individuals will demonstrate a lessened memory trade-off than those who score lower on cognitive testing (Waring et al., 2010). There will be no difference in performance between age groups.

Visual Search Task

In the Visual Search task, participants viewed a series of faces on a computer screen and were instructed to identify the facial expressions they perceived as quickly as they could (Figure 3). The task contained one block of 156 trials, with items presented in random order. There were 52 trials of fearful faces, 52 neutral, and 52 happy faces. Each trial began with a fixation cross, and then two images of the same person's face were displayed in rapid succession on the screen. The first picture shown depicted either a fearful face, neutral face, or happy face. The second picture in the sequence always showed the same face with a neutral expression, which served as a backward mask of the first image. This task was based off of a similar study, where the first picture was displayed for 67 ms, and the neutral mask that followed was shown for 83 ms, resulting in a 150 ms sequence (Japee, Crocker, Carver, Pessoa, & Ungerleider, 2009). Participants pressed keys labelled "F", "N", or "H" to indicate which expression they perceived, and these keys corresponded with fearful, neutral, and happy face detection. Participants were then instructed to rate the confidence in their response by pressing the keys 1-3. A rating of 1 indicated low confidence in their choice, and a rating of 3 indicated high confidence. The total trial duration lasted for 3.5 seconds (Japee et al., 2009).

Hypothesis: Both younger and older adults who present with higher levels of anxiety will be able to perceive fearful facial expressions more reliably than neutral facial expressions (Japee et al., 2009). Due to the positivity effect, older adults will detect happy expressions more reliably than younger adults. These affective measures will also predict which participants will have a greater memory trade-off. Being able to accurately identify negative and positive faces in this task will correlate with a greater trade-off effect.

Affective Stroop

The affective Stroop task tested how quickly participants were able to name the color of the text of emotionally salient words that were displayed on the screen. The same four color options were presented as during the standard Stroop task. In this task, the words were positively valenced, negatively valenced, or neutral. Unlike in the standard Stroop task, lexical control is important, so to control for lexical features, emotionally neutral words matched the word-frequency, length, and neighborhood density of emotionally charged words. All words were selected from the Affective Norms for English Words (ANEW) database (Bradley & Lang, 1999; Fackrell, Edmondson-Jones, & Hall, 2013). This task contained four blocks of 48 samples each, for a total of 192 trials. There were two blocks of neutral words, one block of positive words, and one block of negative words. Six counterbalancing conditions were tested. The words remained on the screen until the participant pressed keys which corresponded to the colors. The response time was measured from the time of stimulus onset to the time when the participant pressed a key.

Hypothesis: All participants will present with an affective Stroop effect, in which participants will take a longer time to respond to emotional words than to neutral words (Fackrell et al., 2013). Participants with a less pronounced Stroop effect will have greater emotional control, as their attention will be less focused on the emotional word, or they will be better able to disengage from the emotional word (Fackrell et al., 2013). The ability to allocate attention and disengage from emotional stimuli are also skills that could be important in the memory trade-off paradigm, so it is thought that participants with a less pronounced affective Stroop effect will also have a smaller memory trade-off score. While both groups will show an affective Stroop effect, older adults will present with a greater impairment (Ashley & Swick, 2009; Wurm, Labouvie-Vief, Aycock, Rebucal, & Koch, 2004).

Dot Probe

During the Dot Probe task, participants were instructed to identify the location of an asterisk that appeared on the screen (Figure 4). A fixation cross appeared on the screen, followed by a pair of words selected from a preexisting database (Warriner, Kuperman, & Brysbaert, 2013). The presented words consisted of emotionally negative, emotionally positive, and neutral words. Word pair combinations consisted of negative-neutral, positive-neutral, and neutral-neutral pairs (Salemink, van den Hout, & Kindt, 2007).

Trials consisted of a fixation cross for 500 ms, followed by randomized word pairs for 500 ms. Words were presented on the screen with one word above the other, separated by 3 cm. After 500 ms, the word pairs disappeared and an asterisk replaced the location of one of the previously presented words. The probe appeared in either congruent (probe replaces emotional-word) or incongruent (probe replaces neutral-word) fashion. Participants responded to the location of this probe as quickly as they could by pressing keys which indicated if the asterisk appeared in the top or bottom location of the screen. After some word pairs, no probe appeared, and participants were instructed to simply wait for 1 s until the next trial began (Salemink et al., 2007). There was one block of 128 trials, presented in random order. Thirty-two pairs were negative-neutral pairs, 32 were positive-neutral pairs, 32 were neutral-neutral pairs, and 32 pairs were from the filler condition where no probe appeared afterward,

Hypothesis: Participants with higher levels of trait anxiety will have trouble disengaging from negative words and will thus respond slower to probes that appear in an incongruent manner (Salemink et al., 2007). Older adults will also have difficulty disengaging attention from positive words. Participants who show greater inability to disengage from valenced words will also have a more pronounced trade-off.

MMSE

The Mini-Mental State Exam was administered to older adults only. Testing and scoring was completed according to protocol (Folstein, Folstein, & McHugh, 1975). It has been found that level of education can impact the initial MMSE score. Increased level of education correlates positively with MMSE score, with each additional year of formal education resulting in 02.-0.4 increase in score (Piccinin et al., 2013). Because the younger adult group generally completed between 12-16 years of formal education, older adults who participated were previously screened to ensure they received at least 10 years of formal education, but could have up to about 22 years. The MMSE administration is not to determine cognitive ability of the older adults, but rather to screen for participants who could be experiencing disorientation, including early signs of mild cognitive impairment.

Results

The data from one younger adult was excluded entirely due to inattentiveness, and data from two older adults were excluded due to inability to perform tasks and for severe vision impairments. In each task, participants who completed ≥50% of each trial type were included in the analyses. Demographic information and scores from neuropsychological tasks are summarized in Table 1.

Prior research suggested that scores for trait PANAS evaluations will be higher than state PANAS evaluations (Watson et al., 1988), and in comparing our Pre- (trait) and Post- (state) PANAS scores, younger adults seem to follow this trend, but older adults seem consistent over time in their scores. It also seems that our participants had elevated STAI-S scores compared to the general population. In one study of healthy older adults, the mean value on the STAI-S was 39.2 (Kvaal et al., 2005), while ours were between 44 and 45 for pre- and post-tests. In the general adult population, the average STAI-S score was found to be about 33.2 (Forsberg & Björvell, 1993), and our younger adult group seemed to be higher than that as well, with scores for pre- and post-tests between 41 and 42.

The mean Letter-Number Sequencing score for younger adults between the ages of 20-24 has been found to be 11 (Ardila, 2007), and our younger adult group scored an average of 12.52. The mean score for older adults aged 70-79 drops to an average score of 8 (Ardila, 2007), and our older adults scored 9.58 on this subtest.

Mean values for the F-A-S version of the Controlled Oral Word Association task were calculated. After subtracting perseverations and other errors, younger adults scored an average of

43.67 words and older adults scored 44.81. A previous study found that younger adults score on average 45.2 words and older adults score 40 words (Lanting, Haugrud, & Crossley, 2009).

The Mini-Mental State Examination (MMSE) is a reliable measure of cognitive impairment in the older adult population (Cockrell & Folstein, 2002). Scores range from 0-30, with lower scores showing decreased cognitive functioning. The mean score of adults over age 65 is 27, which categorizes them into normal functioning range. The average MMSE score of our older adult group was 28.43.

Recognition

Recognition values were calculated for the six scene components: negative items, neutral items, positive items, and backgrounds that were originally paired with the negative, neutral, and positive items. The trade-off examined the expected enhanced memory for emotional central stimuli at the expense of memory for backgrounds that were paired with those emotional items (Waring et al., 2010). Recognition scores consisted of hits minus false alarms. Baseline recognition rates were determined for neutral items and backgrounds (Waring & Kensinger, 2009). We then subtracted the baseline recognition rates for neutral items from the recognition rates for each of the emotional items, and then did the same for the backgrounds by subtracting the recognition rates of neutral backgrounds from the backgrounds of emotional scenes (Waring & Kensinger, 2009). This resulted in two trade-off scores, one for positive and one for negative stimuli. The largest memory trade-off values would be present when memory for emotional items was much better than memory for neutral items, and memory for emotional-paired backgrounds was much worse than neutral-paired backgrounds (Waring et al., 2010).

Next we ran a 2 x 2 repeated measures ANOVA with age as the between-participants variable and trade-off score (positive or negative) as the within-participants variable. This revealed a significant main effect of trade-off score, F (1,118) = 8.36, $p < 0.01$, $\eta_p^2 = 0.07$, but there was no main effect of age ($p = 0.77$) and no interaction between the variables ($p = 0.43$). Follow up t-tests confirmed that positive trade-off scores were greater than negative trade-off scores, t (119) = 2.88, $p < 0.01$. Trade-off values for each age group can be seen in Figure 5.

Standard Stroop

Incorrect trials were discarded and RTs faster than 200 ms or slower than 2000 ms were excluded from further analyses. Mean reaction times can be seen in Figure 6. First, we conducted a 2 x 3 repeated measures ANOVA with age as the between-participants factor and congruency of color-words (congruent, neutral, and incongruent) as the within-participants factor. Notably, this revealed an age x congruency interaction, F (2,228) = 6.27, $p = 0.002$, $\eta_p^2 = 0.05$, as well a main effect of age, F (1,114) = 201.28, $p < 0.001$, $\eta_p^2 = 0.64$, and a main effect of congruency, F (2,228) = 207.07, $p < 0.001$, $\eta_p^2 = 0.65$. Follow up t-tests revealed that mean RTs to congruent trials were faster than incongruent trials, t (115) = 15.95, $p < 0.001$, and neutral trials were faster than incongruent trials, t (115) = 14.84, $p < 0.001$, while there was only a marginal difference between neutral and congruent trials t (115) = 1.72, $p = 0.09$. As the figure indicated that performance on incongruent trials could be disproportionately slower with age, we followed up with a 2 x 2 repeated measures ANOVA using mean RTs in incongruent and congruent trials as the within-participants factor and age as the between-participants factor. This revealed a main effect of age, F (1,114) = 274.02, $p < 0.001$, $\eta_p^2 = 0.71$, as well as an age x congruency interaction, F (1,114) = 7.12, $p = 0.01$, $\eta_p^2 = 0.06$. Additional paired samples t-tests revealed that

RTs to congruent trials were significantly faster than incongruent trials in both younger adults, t (63) = 10.52, $p < 0.001$, and older adults, t (51) = 12.72, $p < 0.001$, with a tendency for a larger effect in older adults.

Visual Search

We calculated the unbiased hit rate for each participant, as this is able to account for multiple categories (in this instance, fearful-face detection, neutral-face detection, and happy-face detection) (Suzuki & Suga, 2010; Wagner, 1993). To calculate the unbiased hit rate, we first determined each participant's hit rate ($\frac{\#\ correctly\ IDed\ in\ the\ condition}{total\ \#\ trials\ in\ the\ condition}$), as well as their response bias ($\frac{\#\ correctly\ IDed\ in\ the\ condition}{total\ \#\ IDed\ as\ the\ condition}$). Then, we multiplied the hit rate and response bias to find the unbiased hit rate, which ranges in value from 0 to 1 (Figure 7).

Next we conducted a 2 x 3 repeated measures ANOVA using age as a between-participants variable and emotion of the face stimuli (happy, neutral, and fearful) as a within-participant variable. Notably, we found an age x emotion interaction, F (2,234) = 4.09, $p = 0.02$, $\eta_p^2 = 0.03$, as well as a main effect of emotion, F (2,234) = 86.11, $p < 0.001$, $\eta_p^2 = 0.42$, and a main effect of age, F (1,117) = 153.45, $p < 0.001$, $\eta_p^2 = 0.57$. To better understand the age x emotion interaction, we ran one-way ANOVAs on emotion separately for both younger and older adults. These analyses revealed a main effect of emotion in both younger adults, F (2,126) = 54.3, $p < 0.001$, $\eta_p^2 = 0.46$, and older adults, F (2,108) = 38.13, $p < 0.001$, $\eta_p^2 = 0.41$. Next we conducted a 2 x 2 repeated measures ANOVA using age as a between-participants variable and emotion (happy vs. neutral) as a within-participants variable. This revealed main effects of emotion, F (1,117) = 20.01, $p < 0.001$, $\eta_p^2 = 0.15$, and age, F (1,117) = 122.62, $p < 0.001$, $\eta_p^2 = 0.51$, but there was no age x emotion interaction ($p = 0.77$). We then ran similar analyses using fear and neutral trials as within-participants variables, and this demonstrated an age x emotion interaction, F (1,117) = 6.60, $p = 0.01$, $\eta_p^2 = 0.05$, as well as a main effect of emotion, F (1,117) = 208.13, $p < 0.001$, $\eta_p^2 = 0.64$, and a main effect of age, F (1,117) = 168.11, $p < 0.001$, $\eta_p^2 = 0.59$. A final 2 x 2 repeated measures ANOVA used happy and fearful trials as within-participants variables, and this also revealed an age x emotion interaction F (1,117) = 6.19, $p = 0.01$, $\eta_p^2 = 0.05$, as well as a main effect of emotion, F (1,117) = 62.12, $p < 0.001$, $\eta_p^2 = 0.35$, and a main effect of age, F (1,117) = 147.95, $p < 0.001$, $\eta_p^2 = 0.56$. In comparing the unbiased hit rates graphically, it seemed that the unbiased hit rate in fearful-face trials for older adults were disproportionately lower than the unbiased hit rate in younger adults. Follow up t-tests revealed that the unbiased hit rate for each trial type differed from one another. The unbiased hit rate for fearful-face trials was lower than neutral, t (118) = 13.95, $p < 0.001$, unbiased hit rate for happy-face trials was lower than neutral, t (118) = 4.53, $p <0.001$, and the unbiased hit rate for fearful-face trials was lower than happy-face trials, t (118) = 7.55, $p < 0.001$.

Affective Stroop

Analyses for the affective Stroop task were conducted in a manner similar to the standard Stroop task. Mean RTs are shown in Figure 8. A 2 x 3 repeated measures ANOVA using age as a between-participants variable and valence of the words (positive, neutral, and negative) as a within-participants variable revealed a significant age x valence interaction, F (212) = 4.68, $p = 0.012$, $\eta_p^2 = 0.04$, as well as a main effect of age, F (1,106) = 147.86, $p < 0.001$, $\eta_p^2 = 0.58$, and a main effect of valence, F (2,212) = 63.44, $p < 0.001$, $\eta_p^2 = 0.37$. Follow up t-tests found that mean RTs to positive words were faster than to neutral words, t (107) = 11.49, $p <0.001$, and responses to neutral words were faster than negative words, t (107) = 8.36, $p < 0.001$. There was no difference in RTs between positive and negative words, t (107) = 1.81, $p = 0.07$. To further investigate the interaction, we conducted a 2 x 2 repeated measures ANOVA using age as a between-participants factor and valence of the words (positive and neutral) as a within-participants factor. This analysis revealed a main effect of valence, F (1,106) = 149.21, $p <$ 0.001, $\eta_p^2 = 0.59$, as well as an age x valence interaction, F (106) = 12.34, $p = 0.001$, $\eta_p^2 = 0.001$. Additional paired-samples t-tests confirmed that mean RTs to positive words were faster than neutral words in younger adults, t (56) = 6.46, $p < 0.001$, as well as older adults, t (50) = 10.6, $p < 0.001$, with a tendency for a larger effect in older adults.

Dot Probe

Response times less than 200 ms or greater than 2000 ms were excluded from analyses, and to reduce the influence of outliers, RTs that were 2.5 standard deviations above or below individual means were also excluded. Seven additional older adults were omitted for having MMSE scores ≤ 26. Then, attentional bias indices were calculated. To calculate the orienting indices, the mean RT of emotional stimuli was subtracted from the mean RT of neutral stimuli, and to calculate the disengaging indices, the mean RT of neutral-neutral stimuli were subtracted from the mean RT of neutral-emotional stimuli (Salemink et al., 2007). Separate orienting and disengaging indices were calculated for positive and negative stimuli (Figure 9).

Next we conducted a 2 x 2 x 2 ANOVA to examine the effects of age (young and old), as a between-participants variable, and valence (positive and negative) and detection (orienting vs. disengaging) as within-participant variables on reaction times. Critically, results revealed a significant three-way interaction between age x valence x detection, F (1,104) = 4.05, $p = 0.05$, $\eta_p^2 = 0.04$. There was also a valence x detection interaction, F (1, 104) = 7.78, $p = 0.01$, $\eta_p^2 =$

0.07. We found a marginal main effect of valence, F (1, 104) = 3.67, p = .06, $\eta_p^2 = 0.03$, but no other main effects or interactions approached significance ($\eta_p^2 \leq 0.02$). To further understand the nature of the three-way interaction, additional 2 (valence) x 2 (detection) ANOVAs were conducted separately for each age group. The interaction of valence x detection was significant in older adults, F (1, 47) = 6.08, p = 0.02, $\eta_p^2 = 0.11$, but did not approach significance in the younger adults, F (1, 57) = 0.85, p = 0.37, $\eta_p^2 = 0.02$. Older adults took considerably longer to disengage from negative words than positive words, t (47) = 2.98, $p < 0.01$, but negative and positive words did not differ for orienting (p = 0.43). In contrast, there were no significant differences for younger adults, *p*s > 0.26.

Trade-Off Correlations to Affective and Cognitive Tasks and Measures

We ran Pearson correlations to help determine which of the various affective and cognitive measures in this study were related to the magnitude of the memory trade-off effect. These were run for all tasks and questionnaires used. Unsurprisingly, positive trade-off scores were positively correlated with negative trade-off scores in both younger adults, r (61) = 0.35, $p < 0.01$, and older adults, r (59) = 0.37, $p < 0.01$ (Tables 2 and 3). Three components of the Dot Probe task also had significant correlations to the negative trade-off effect, but only for older adults. These included positive orienting scores being negatively correlated to the negative trade-off, r (50) = -0.39, $p < 0.01$, negative orienting scores being negatively correlated to the negative trade-off, r (50) = -0.38, $p < 0.01$, and positive disengaging being positively correlated with the negative trade-off, r (50) = 0.29, p = 0.04 (Table 2). For older adults, the Post PANAS negative affect score was also negatively correlated with the negative trade-off, r (59) = -.27, p = 0.04, but there were no significant correlations for younger adults (Table 2).

There were, however, some correlations with marginal significance in both age groups. Pre-PANAS negative affect scores had a marginal negative correlation with the positive trade-off, but for older adults only, r (58) = -0.24, p = 0.07 (Table 2). Younger adults also had a marginal positive correlation between Post STAI-S scores and the negative trade-off, r (61) = 0.24, p = 0.07 (Table 2). There was also a marginal positive correlation for older adults only between Letter-Number Sequencing scores and the negative trade-off effect, r (58) = 0.24, p = 0.07 (Table 3).

Discussion

The goal of this study was to examine the affective and cognitive correlates of the memory trade-off effect, and to see if these correlates change in healthy aging. Most importantly, we were able to elicit the predicted trade-off effect, in which memory for central, emotionally-valenced items were remembered better than backgrounds associated with those items. The memory trade-off effect has been replicated under several conditions in multiple studies (E. A. Kensinger et al., 2007; Waring & Kensinger, 2009, 2011; Waring et al., 2010).

There was a more robust positive memory trade-off than negative memory trade-off, which suggests that positive images are remembered better than negative images. A previous study has shown that positive trade-offs can occur in both younger and older adults when they are presented with high-arousal images. In that study, however, there was a greater enhancement of negative-item memory than of positive-item memory for both age groups (Waring & Kensinger, 2009). Our findings coincide more with a related line of work, in which a forced recognition task found that young, middle-aged, and older adults tend to remember positive images better than negative images (Denburg et al., 2003). Their younger adult group, however, ranged in age from 26-51 years old (Denburg et al., 2003), so it is possible that their younger adult group performed behaviorally more like our older adult group.

In addition to positive trade-off scores being more robust than negative trade-off scores, there was also no change in this trend across our two age groups. Younger and older adults have been observed to have similar accuracy in memory for emotional scenes (Denburg et al., 2003), including similarly large memory enhancements for positive images in a trade-off task (see short test delay in Waring & Kensinger, 2009). Other work has demonstrated that memory trade-offs can be greater for older adults than for young (E.A. Kensinger et al., 2007) and alternatively, greater for younger adults than for old (see 24 hour test delay in Waring & Kensinger, 2009).

Some work has suggested that a positivity bias could exist in older adult groups, meaning that older adults will remember more positive information than younger adults (Mather, 2008). This has been demonstrated in a visual recognition task, where older adults were found to be better at discriminating between high- and low-similarity positive images than younger adults (Leal & Yassa, 2014). Our trade-off task does not support a positivity bias, however, because our younger and older adults had the same magnitude of positive trade-off scores. This suggests that both younger and older adults preferentially attend to positive stimuli in composite scenes, or perhaps show slow disengagement with these positive central images, which could help them encode that information more fully.

Many questions still remain on whether cognitive or affective mechanisms are more responsible for influencing the magnitude of the memory trade-off effect. To better understand the relationship between these traits and memory trade-off scores, we ran correlational analyses to see which tasks were related. Positive trade-off scores were positively correlated with negative trade-off scores in both the younger and older adults. Of the eight measures of affect used in this study, however, only two were found to have significant correlations with memory trade-off scores. Two others were of marginal significance. No measure of cognitive performance had significant correlations with the trade-off, but one task did show a trend toward significance.

The two affective measures that had significant associations with the memory trade-off were both for older adults, and included three components of the Dot Probe task and one measure in the state PANAS questionnaire. One measure in the Dot Probe task, positive disengaging scores, supported our prediction that being slower to disengage from positive words in the Dot Probe would be related to higher scores in negative memory trade-off. This finding suggests that disengaging from emotional words would be similarly difficult to disengaging from emotional images, which would lead to a greater trade-off score. Interestingly, this correlation was found only between positive disengaging scores and the negative trade-off, and correlations between positive trade-off scores and negative disengaging scores did not approach significance.

Two other measures of the Dot Probe task, positive orienting scores and negative orienting scores, had unexpected relationships with the memory trade-off. For older adults, being able to more quickly orient to emotional words in the Dot Probe task was associated with a less pronounced memory trade-off effect. These results are in opposition to the original hypothesis that having your attention quickly oriented to emotional words would be similar to having your attention drawn to the emotional central image in the trade-off paradigm, which would lead to a greater trade-off score.

Also contradictory to our predictions was the relationship between the older adult group's state PANAS score and the negative trade-off. For older adults, higher levels of negative affect in the state PANAS test was related to a smaller negative trade-off score. Previous work has shown a positive relationship between state anxiety levels and memory trade-off scores (Waring et al., 2010), so it is interesting that we have found a negative association between these two measures. We did, however, uncover a marginal relationship between the younger adult group's STAI-S scores and negative trade-off scores. This relationship supports findings from Waring et al. (2010), though our effect was marginal, and should be interpreted with caution.

We also failed to find a relationship between our trait anxiety measures (STAI-T and Pre-PANAS) and trade-off scores, which is also in opposition of our hypothesis that higher trait anxiety scores would yield larger trade-off scores. We did notice a trend between the older adult group's Pre-PANAS negative affect score and the positive trade-off effect, and other work has shown significant associations between trait anxiety measures and memory trade-off scores (Waring et al., 2010). It should be noted that this relationship is also marginal, and should also be treated with some skepticism.

There are a few possible explanations for the unanticipated relationships and the lack of relationships between some of our state and trait affect measures and memory trade-off scores. Our original hypothesis was partly built off of the work by Waring et al. (2010), which suggested that higher levels of both state and trait anxiety are related to larger trade-off effects. The participants in their study, however, were assessed using the Beck Anxiety Inventory (Beck, Epstein, Brown, & Steer, 1988). Because we used the STAI and PANAS measures, we should be careful about making direct comparisons between our groups and the Waring et al. (2010) group, as these questionnaires may be assessing slightly different components of anxiety and affect.

Another possible explanation for the unexpected associations between state and trait anxiety scores and memory trade-off scores is that we sampled from a different part of the population distribution than Waring et al. (2010) did. It seemed that both the younger and older adult participants at Brandeis had elevated levels of anxiety compared to average scores for adults in their age group. It is unclear, however, where in the distribution the participants in the Waring et al. (2010) study fell. Perhaps the higher anxiety participants in their group had anxiety scores closer to the population average, and their memory trade-off scores, while higher, fell in the optimal range. Our participants, who seemed to lie further along the distribution than the national average, had lower trade-off scores, which could be disadvantageous.

Although there were no strong relationships between tasks in the cognitive battery and memory trade-off scores, one measure did show marginal significance. In older adults only, there was a marginal positive relationship between the Letter-Number Sequencing task and negative trade-off scores. This is an interesting association, as it also opposes our original prediction that there would be a negative association between the two. Instead, our findings suggest that higher scores on Letter-Number Sequencing, which indicate better working memory capacity, are associated with a more pronounced negative trade-off score. It is possible that our Letter-Number Sequencing task was an inappropriate measure for our study, and contributes to our unexpected result. Letter-Number Sequencing is an auditory working memory task (Wechsler, 1997), though working memory is considered to have several components (Baddeley, 2003), and auditory processing would be placed in one branch. Other researchers have used a visuospatial working memory task, the Spatial Span backwards task, and have found that it is significantly correlated with the memory trade-off effect, such that better performance on the Spatial Span backward task is associated with a less-pronounced trade-off (Waring et al., 2010). Perhaps this suggests that the type of working memory task matters in relation to the memory trade-off effect.

It remains unclear whether affect or cognition more strongly influences the magnitude of the memory trade-off effect. There were some significant correlations between our affective task measures and the trade-off for older adults, but some of these correlations were counterintuitive, where less affective control was associated with a less pronounced memory trade-off. Because there were separate correlations with the trade-off for younger and older adults, it is possible that the traits that influence the magnitude of the effect change over time. This may be due in part with altered patterns of neural activation or changes in volume of neuroanatomical structures.

An fMRI study has shown that picture encoding involves both bilateral activation in frontal lobe regions as well as increased activation in the hippocampus and surrounding regions (Kelley et al., 1998). Subsequent work has demonstrated that the levels of activation in these regions change with age (Gutchess et al., 2005). In a complex picture encoding task, younger adults have greater parahippocampal engagement for remembered images and older adults show greater bilateral frontal engagement. The study also supported that the increased frontal lobe activation in the older adults served as a compensatory measure to the decreased activation in hippocampal regions (Gutchess et al., 2005). A factor that can help explain the decreased hippocampal activation for older adults is that there is often volumetric declines in medial-temporal structures with age. One report found that in older adults, the volume of the hippocampus declined more rapidly than other brain regions over a 30-month period (Raz, Ghisletta, Rodrigue, Kennedy, & Lindenberger, 2010). Anatomical changes and differences in activation patterns could play a role in how complex images are encoded, and so they could be related to how the images are recognized later. This may help to explain why there were different correlations between our affective and cognitive measures in our older and younger adult groups.

As a next step, we will use structural equation modeling methods to characterize our data. This will allow us to combine our tasks into factors, helping us better understand whether cognitive or affective traits influence the memory trade-off effect more. If we were to conduct a similar project in the future, a more condensed protocol could also be beneficial. Fatigue may have affected the older adult group's performance, with several participants commenting on the length of the protocol or refusing to complete the final task. To remedy this, we could shorten the protocol by eliminating some tasks that do not seem to be associated with the trade-off effect (Visual Search, Affective Stroop, and Standard Stroop). Alternatively, we could adopt a two-day protocol (Waring & Kensinger, 2009), though that may eliminate the observed trade-off effect in the older adult group.

In conclusion, older and younger adults do present with a memory trade-off effect, with memory for emotionally valenced central objects being better remembered better at the expense of the neutral backgrounds associated with them. The magnitude of the trade-off was the same in both age groups, and positive trade-off scores were higher than negative trade-off scores. Further work must be done to determine whether affect or cognition more strongly influences the magnitude of the trade-off.

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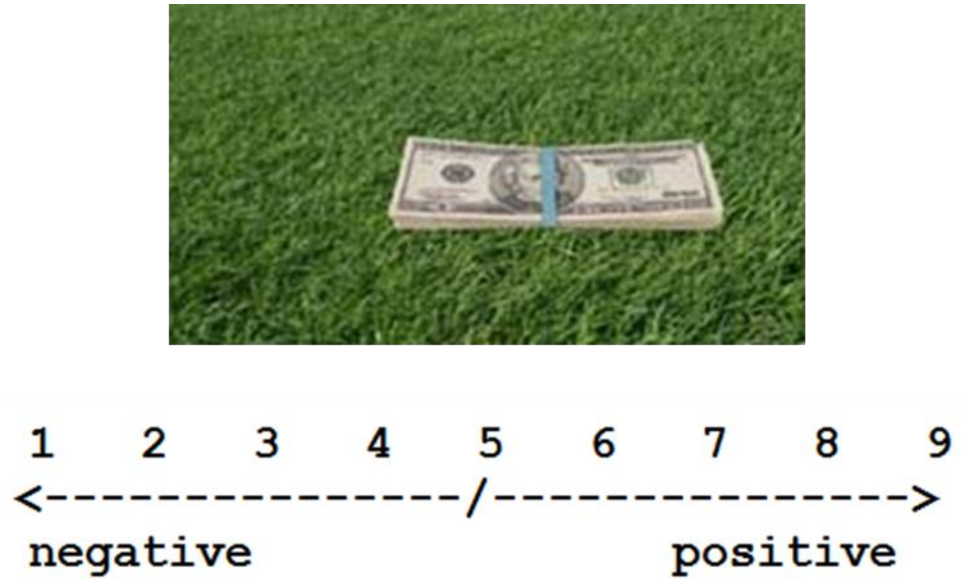

Figure 1. Image used for memory trade-off task during encoding. Images consisted of emotionally valenced central items placed on neutral backgrounds. The above image is an example of one of the positively valenced stimuli.

Figure 2. Images used in recognition task. Composite scenes from the encoding task were broken apart and presented separately. Additional unstudied images were also included.

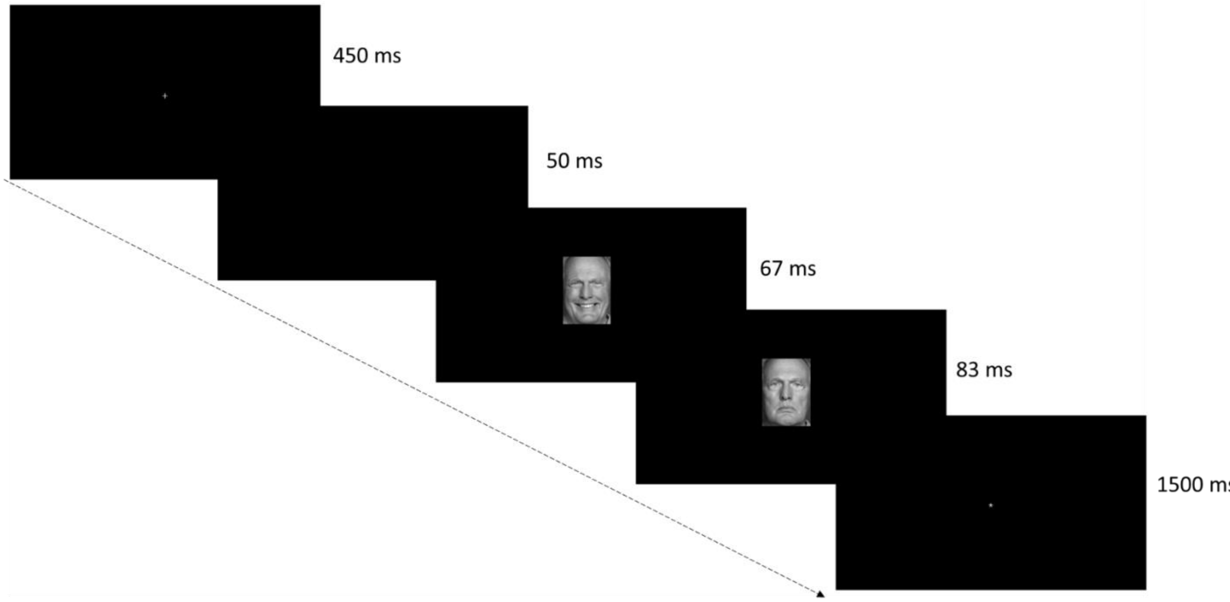

Figure 3. Visual Search task sequence. Participants were instructed to identify the emotion of a target face as quickly as they could.

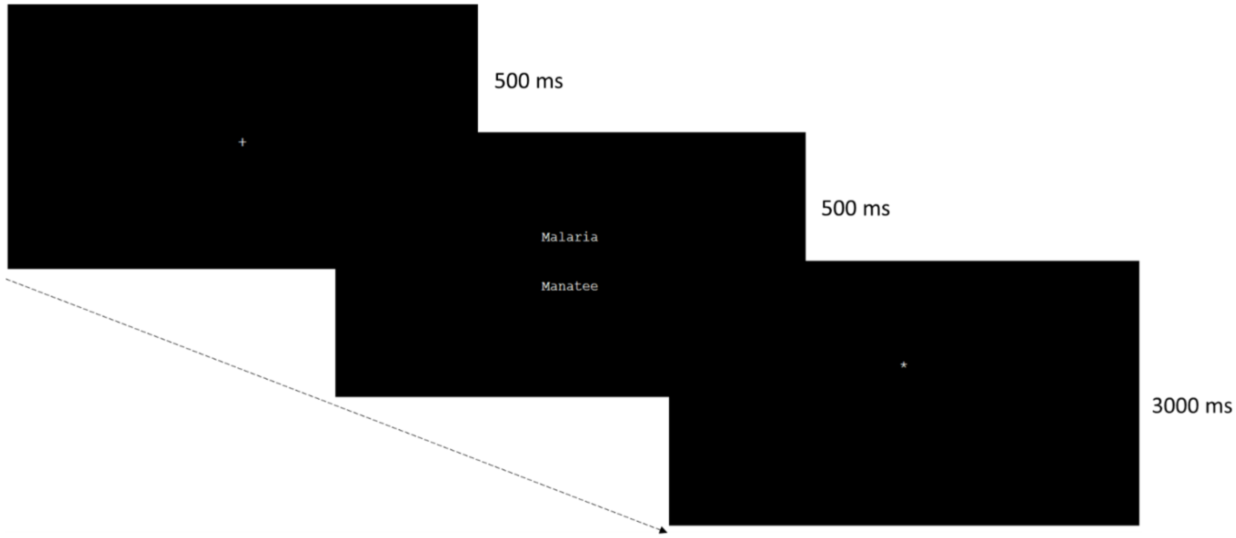

Figure 4. Dot Probe task sequence. Participants were instructed to identify the location of an asterisk that appeared on the screen where a word had been present earlier.

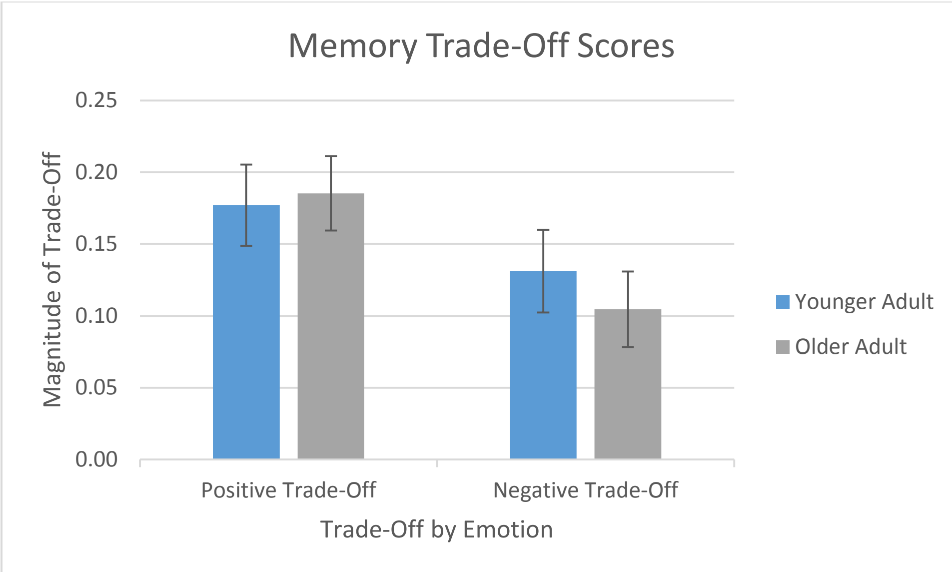

Figure 5. Memory trade-off scores by age group. Positive trade-off scores were significantly larger than negative trade-off scores, and this pattern was the same for younger and older adults.

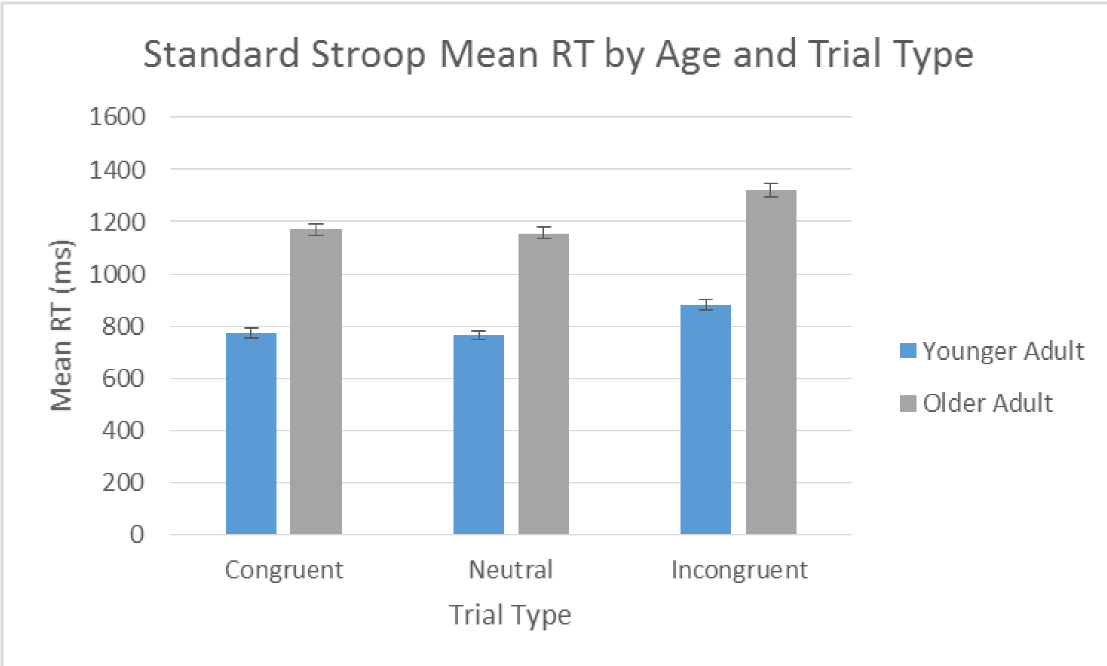

Figure 6. Mean RTs for the standard Stroop task. Although younger adults were quicker to respond in all trial types compared to older adults, older adults were disproportionately slower in the incongruent condition of the standard Stroop.

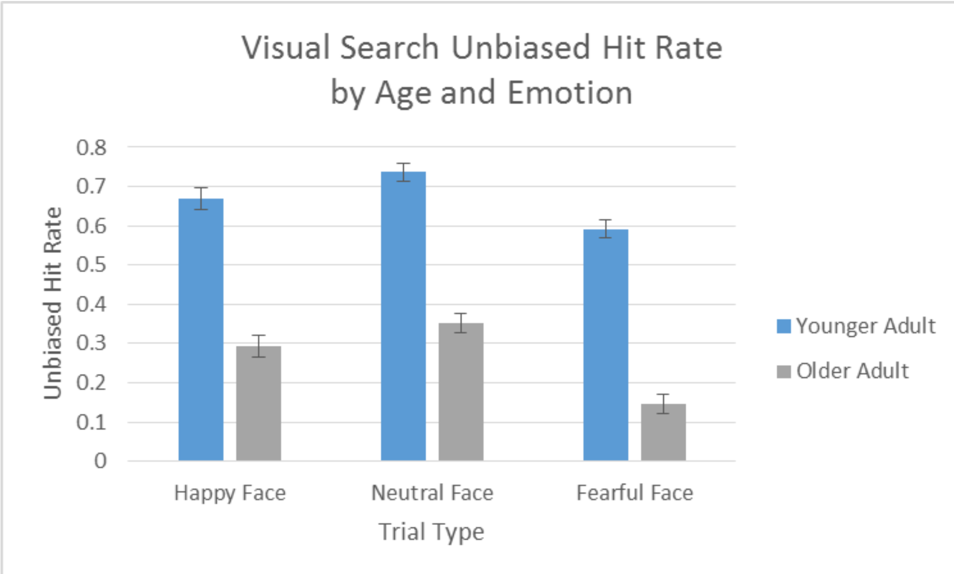

Figure 7. Unbiased hit rates in Visual Search task. Although older adults performed poorer than younger adults, the unbiased hit rate for fearful-face trials was disproportionately lower in older adults than it was in younger adults.

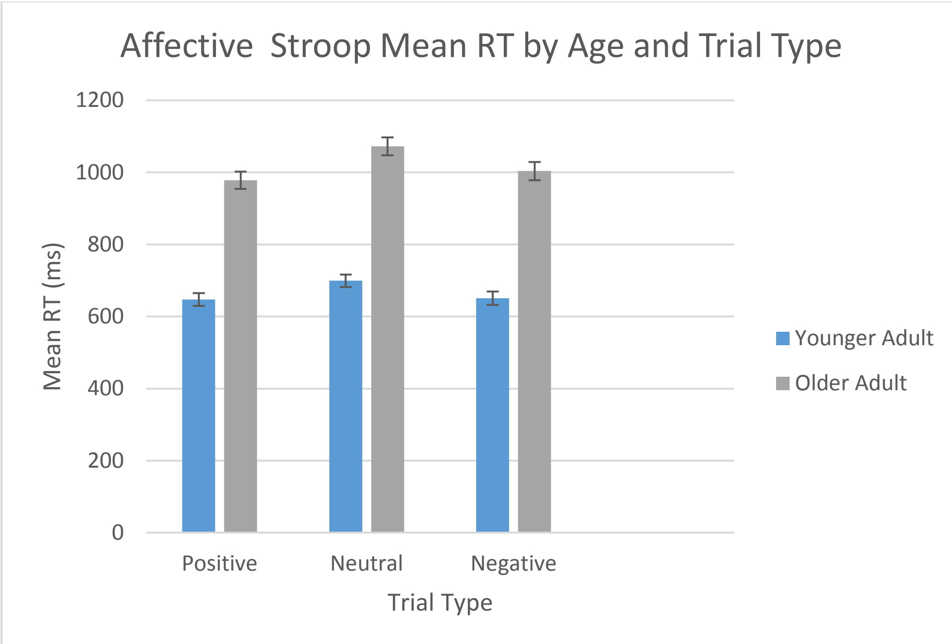

Figure 8. Mean RTs in affective Stroop task. Younger adults were faster to respond to all trial types compared to older adults, but older adults responded disproportionately faster to positive words than neutral words, compared to younger adults.

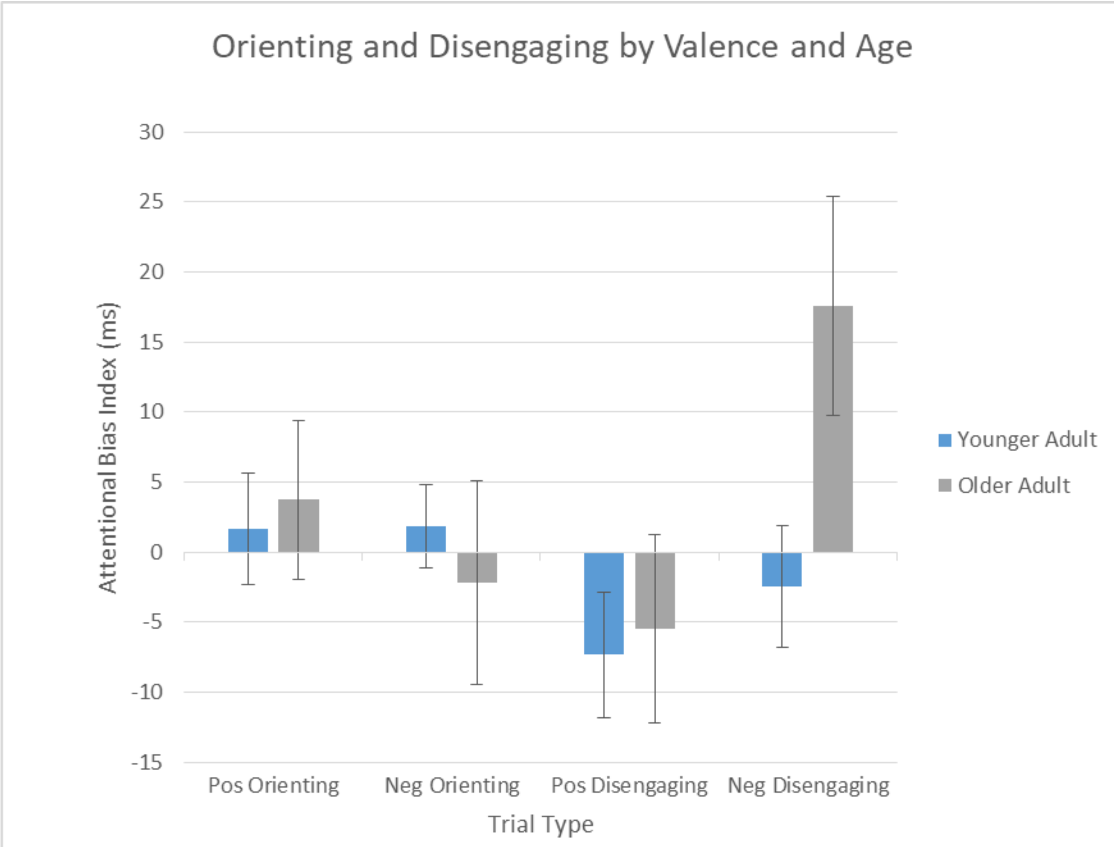

Figure 9. Attentional bias indices in Dot Probe. Attentional bias indices were calculated, for which a mean score of zero indicates no attentional bias. Older adults demonstrated the greatest impairment in disengaging from negative words compared with positive words, while negative and positive words did not differ for orienting. No significant differences in performance were found in younger adults.

Table 1. *Demographic information and neuropsychological test results in younger and older adult participants (standard deviation)*

Characterization of Participants			
	Younger Adults	**Older Adults**	**Age Difference**
Female/Male	49 / 14 (1 unknown)	43 / 23 (1 unknown)	N/A
Age (years)	19.06 (1.42)	75.84 (7.42)	$p < 0.001$
Education (years)	12.81 (1.71)	16.34 (2.48)	$p < 0.001$
Pre-PANAS	36.77 (8.36)	45.95 (7.06)	$p < 0.001$
Pre-STAI-S	42.64 (5.56)	44.52 (6.1)	n.s. ($p = 0.07$)
Pre-STAI-T	47.45 (5.22)	43.91 (4.45)	$p < 0.001$
Post-PANAS	33.53 (8.21)	45.75 (7.78)	$p < 0.001$
Post-STAI-S	41.27 (6.4)	45.13 (5.33)	$p < 0.001$
L-N Sequencing	12.52 (2.65)	9.58 (2.06)	$p < 0.001$
COWA (FAS Version)	43.67 (10.19)	44.81 (14.87)	n.s. ($p = 0.61$)
MMSE	N/A	28.43 (1.82)	N/A

Table 2. *Trade-Off Correlations to Affective Tasks and Measures*

				Positive Trade-Off	Negative Trade-Off
Trade-Off	Positive Trade-Off	Younger	Corr.	1	.351**
			Sig.	--	0.006
		Older	Corr.	1	.368**
			Sig.	--	0.004
	Negative Trade-Off	Younger	Corr.	.351**	1
			Sig.	0.006	--
		Older	Corr.	.368**	1
			Sig.	0.004	--
Visual Search	Unbiased Hit Rate- Happy	Younger	Corr.	-0.054	0.101
			Sig.	0.680	0.439
		Older	Corr.	0.114	0.119
			Sig.	0.430	0.412
	Unbiased Hit Rate- Neutral	Younger	Corr.	0.002	0.060
			Sig.	0.986	0.645
		Older	Corr.	0.075	0.102
			Sig.	0.607	0.479
	Unbiased Hit Rate- Fear	Younger	Corr.	-0.016	0.156
			Sig.	0.901	0.229
		Older	Corr.	0.104	0.185
			Sig.	0.472	0.199
Dot Probe	Positive Orienting	Younger	Corr.	0.151	0.060
			Sig.	0.268	0.662
		Older	Corr.	-0.186	-.388**
			Sig.	0.197	0.005
	Negative Orienting	Younger	Corr.	0.067	0.156
			Sig.	0.623	0.251
		Older	Corr.	-0.045	-.378**
			Sig.	0.754	0.007
	Positive Disengaging	Younger	Corr.	-0.010	-0.180
			Sig.	0.940	0.185
		Older	Corr.	0.051	.292*
			Sig.	0.725	0.039
	Negative Disengaging	Younger	Corr.	-0.037	-0.107
			Sig.	0.787	0.431
		Older	Corr.	0.066	0.089
			Sig.	0.648	0.540
Pre STAI-S	Total Score	Younger	Corr.	-0.045	-0.013
			Sig.	0.732	0.921
		Older	Corr.	-0.079	0.088
			Sig.	0.555	0.513

Pre STAI-T	Total Score	Younger	Corr.	0.209	-0.007
			Sig.	0.105	0.960
		Older	Corr.	-0.216	-0.097
			Sig.	0.103	0.470
Affective Stroop	RT Positive	Younger	Corr.	0.193	0.154
			Sig.	0.161	0.265
		Older	Corr.	-0.017	-0.147
			Sig.	0.908	0.326
	RT Neutral	Younger	Corr.	0.178	0.130
			Sig.	0.198	0.348
		Older	Corr.	0.027	-0.060
			Sig.	0.858	0.687
	RT Negative	Younger	Corr.	0.058	0.104
			Sig.	0.675	0.455
		Older	Corr.	0.007	-0.134
			Sig.	0.963	0.369
Pre PANAS	Total Score	Younger	Corr.	0.081	0.112
			Sig.	0.536	0.388
		Older	Corr.	-0.057	-0.049
			Sig.	0.672	0.716
	Positive Affect	Younger	Corr.	0.103	0.181
			Sig.	0.430	0.163
		Older	Corr.	0.074	0.054
			Sig.	0.582	0.688
	Negative Affect	Younger	Corr.	0.006	-0.098
			Sig.	0.965	0.450
		Older	Corr.	-0.238	-0.175
			Sig.	0.072	0.189
Post STAI-S	Total Score	Younger	Corr.	0.016	0.236
			Sig.	0.903	0.067
		Older	Corr.	0.101	-0.008
			Sig.	0.446	0.950
Post PANAS	Total Score	Younger	Corr.	0.056	0.122
			Sig.	0.667	0.348
		Older	Corr.	0.090	0.042
			Sig.	0.497	0.754
	Positive Affect	Younger	Corr.	0.020	0.179
			Sig.	0.880	0.169
		Older	Corr.	0.071	-0.010
			Sig.	0.595	0.938
	Negative Affect	Younger	Corr.	0.101	-0.120
			Sig.	0.441	0.358
		Older	Corr.	-0.114	-.267*
			Sig.	0.388	0.041

Table 3. *Trade-Off Correlations to Cognitive Tasks and Measures*

				Positive Trade-Off	Negative Trade-Off
Trade-Off	Positive Trade-Off	Younger	Corr.	1	.351**
			Sig.	--	0.006
		Older	Corr.	1	.368**
			Sig.	--	0.004
	Negative Trade-Off	Younger	Corr.	.351**	1
			Sig.	0.006	--
		Older	Corr.	.368**	1
			Sig.	0.004	--
Standard Stroop	RT Congruent	Younger	Corr.	0.051	0.006
			Sig.	0.696	0.965
		Older	Corr.	0.212	-0.028
			Sig.	0.157	0.855
	RT XXX	Younger	Corr.	0.057	0.027
			Sig.	0.662	0.834
		Older	Corr.	0.160	-0.032
			Sig.	0.289	0.833
	RT Incongruent	Younger	Corr.	-0.010	0.072
			Sig.	0.939	0.582
		Older	Corr.	0.157	0.021
			Sig.	0.292	0.888
Controlled Oral Word Association Test (FAS)	Total Score	Younger	Corr.	0.028	-0.020
			Sig.	0.828	0.879
		Older	Corr.	-0.009	0.082
			Sig.	0.949	0.539
Letter-Number Sequencing	Total Score	Younger	Corr.	-0.110	-0.192
			Sig.	0.398	0.139
		Older	Corr.	0.153	0.244
			Sig.	0.253	0.065