Published in final edited form as:
Psychol Aging. 2008 December ; 23(4): 873–885. doi:10.1037/a0013761.

The Emotional Blink: Adult Age Differences in Visual Attention to Emotional Information

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Abstract

To assess age differences in attention-emotion interactions, younger adults (ages 18–33 yrs) and older adults (ages 60–80 yrs) identified target words in a rapid serial visual presentation (RSVP) task. The second of two target words was neutral or emotional in content (positive in Experiment 1, negative in Experiment 2). In general, the ability to identify targets from a word stream declined with age. Age differences specific to the attentional blink were greatly reduced when baseline detection accuracy was equated between groups. With regard to emotion effects, older adults showed enhanced identification of both positive and negative words relative to neutral words, whereas younger adults showed enhanced identification of positive words and reduced identification of negative words. Together these findings suggest that the nature of attention-emotion interactions changes with age, but there was little support for a motivational shift consistent with emotional regulation goals at an early stage of cognitive processing.

Keywords

aging; attention; attentional blink; emotion; positivity effect

Aging, Emotion, and Cognition

Recent evidence indicates that there is a change in how emotions are experienced and regulated in later adulthood (see reviews by Carstensen & Charles, 1998; Lawton, 2001; Magai, 2001. For example, older adults report similar or higher levels of positive affect and lower levels of negative affect as compared to younger or middle-aged adults (Gross et al., 1997; Mroczek & Kolarz, 1998) as well as enhanced control of emotion and greater stability of mood (Gross et al., 1997; Lawton, Kleban, Rajagopal, & Dean, 1992). In response to specific emotional stimuli (e.g., slides of positive or negative images), older adults report similar subjective experiences of emotion in comparison to younger adults (Kunzmann, Kupperbusch, & Levenson, 2005; Reminger, Kaszniak, & Dalby, 2000), and they are similarly able to decode emotional information from verbal material (Phillips, MacLean, & Allen, 2002). Thus, it appears that emotional functioning is preserved if not enhanced with age.

What accounts for adult developmental patterns of emotional functioning? According to the socioemotional selectivity (SES) theory (Carstensen & Charles, 1998), it is the perception of available time. Early in adulthood, individuals prioritize information seeking goals to best prepare themselves for the future, but as people age they become increasingly aware of limited

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remaining time and are motivated to pursue emotionally meaningful goals. This motivational shift is reflected in information that is attended and later retrieved, with a greater emphasis on cognitive processing of emotional information, particularly positive information.

The proposition that emotional functioning and cognitive functioning are closely interconnected in later life has been supported by memory findings. Older adults recall emotional information better than neutral information (Denburg, Buchanan, Granel, & Adolphs, 2003; Kensinger, Piguet, Krendl, & Corkin, 2005), and in some cases this emotion effect is greater for older adults than for younger adults (Carstensen & Charles, 1994) or even qualitatively different such that older adults demonstrate an emotional bias to recall positive information over negative information (Charles, Mather, & Carstensen, 2003; Kennedy, Mather, & Carstensen, 2004; Thomas & Hasher, 2006). This latter effect has been termed the *positivity effect*. Similar age-enhanced emotion effects have been found for problem solving tasks (Blanchard-Fields, Jahnke, & Camp, 1995; Hess & Pullen, 1994).

Mather and Carstensen (Kennedy et al., 2004; Mather & Carstensen, 2005; Mather & Knight, 2005) have proposed that the positivity effect is the result of a motivated, strategic process that functions to enhance well-being and emotional goals. Consistent with the idea that strategic processes require cognitive control, older adults who perform better on cognitive control tasks (e.g., sentence span, flanker interference) are more likely to show a positivity effect in memory recall, whereas older adults who are distracted during encoding (thus reducing controlled resources) no longer recall positive images better than negative images (Mather & Knight, 2005).

Attention involves both automatic and controlled processes. If the age-emotion interactions observed in memory extend to the attention domain, then an attentional bias toward positive information should be more probable on tasks that provide opportunities for strategic processing. A review of attention studies to date is largely consistent with such a pattern. When participants were given ample time to view stimuli (e.g., 1–8 seconds) on dot-probe and eye tracking tasks, older adults biased their attention toward happy faces and away from angry or sad faces (when paired with neutral faces), whereas younger adults' attention did not vary by emotional expression (Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Knight et al., 2007; Mather & Carstensen, 2003).. Arguing that these tasks m not have captured early attentional orienting but instead measured post-orienting looking preferences (guided by strategic processing), Knight et al. (2007) found no emotional preference associated with initial orienting (the first visual fixation), but did find age differences in preferential looking beyond the first fixation that was consistent with a positivity effect for older adults.

Although positivity effects have been observed on viewing tasks, they have not been observed on attention tasks that involve early detection and orienting processes. During visual search, both younger adults and older adults oriented rapidly toward threatening or angry target faces but not toward happy target faces (Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006). This negativity effect was likely due to automatic shifts to highly arousing stimuli, and this effect appeared to be relatively insensitive to age. When positive and negative stimuli were less arousing, older adults demonstrated a broader and deeper emotion effect than younger adults, but with no evidence of an age-specific positivity effect (Leclerc & Kensinger, 2008; Wurm, Labouvie-Vief, Aycock, Rebucal, & Koch, 2004).

Attention-Emotion Interactions in the RSVP Task

We assessed age differences in attention-emotion interactions using the rapid serial visual presentation (RSVP) task (Raymond, Shapiro, & Arnell, 1992; Shapiro, Arnell, & Raymond, 1997). This task assesses detection of target items from a rapid temporal stream of distractors. With its fast pace and heavy resource demands, there is little opportunity for strategic deployment of emotion regulation strategies. Thus, based on the Mather and Carstensen (2005) model, we expected that an age-enhanced emotion effect might be observed on this task but not specific to positive information.

A particular attentional phenomenon that has been identified on the RSVP task is the *attentional blink*. When participants identify two target items (e.g., a red letter and a green letter from a stream of black letters), and these two items are presented close together in time, participants have difficulty identifying the second target item. Allocating attention to the first target presumably results in fewer attentional resources available to process the second target, leaving the second target vulnerable to decay or substitution by non-target items in working memory (Shapiro et al., 1997).

Aging affects the attentional blink. Both the magnitude (Lahar, Isaak, & McArthur, 2001; Maciokas & Crognale, 2003) and the duration (Maciokas & Crognale, 2003) of the blink are increased with age. When participants are told to ignore the first target, detection of the second target is less affected by age, suggesting that age differences in the attentional blink are not due simply to differences in detection ability. Maciokas and Crognale (2003) argued that age-related changes in the blink are due to diminished attentional resources; as a result, older adults have fewer resources remaining to process the second target when presented shortly after the first target. Lahar et al. (2001) proposed that, instead of reduced attentional resources, older adults are less able to inhibit extraneous stream items from competing for available attentional resources.

Anderson and Phelps (2001) assessed attention-emotion interactions with the RSVP task. When the emotionality of the second target was manipulated, participants detected arousing aversive words better than neutral words, leading to a reduced attentional blink for emotional words. The blink was not eliminated for emotional words, suggesting that emotional stimuli were not processed automatically but perhaps less effortfully than non-emotional information, leading to enhanced processing in a limited capacity system.

The Present Study

Age differences in attention-emotion interactions have been assessed primarily on tasks involving spatial attention to faces or images (Isaacowitz et al., 2006; Knight et al., 2007; Leclerc & Kensinger, 2008; Mather & Carstensen, 2003, but cf. Wurm et al., 2004). Age differences have not been assessed on a task assessing temporal attention to words. If the critical element for determining the nature of the age-emotion pattern (e.g., presence of a positivity effect) is the potential afforded by the task to strategically alter processing of emotional information (Mather & Carstensen, 2005; Mather & Knight, 2005), then the positivity effect should be anticipated based on strategic opportunities regardless of the task characteristics. Because the RSVP task is a resource-demanding task that assesses early and rapid detection of information, we predicted that older adults would *not* show a positivity effect. Instead, we predicted enhanced detection of emotional words that would not be valence-specific (Leclerc & Kensinger, 2008; Wurm et al., 2004).

To assess for potential positivity effects on the RSVP task, we used less arousing words than those used by Anderson and Phelps (2001). Both younger and older adults orient relatively automatically to highly arousing stimuli (Hahn et al., 2006; Mather & Knight, 2006), and positivity effects have been found with emotional stimuli that are less arousing (Isaacowitz et al., 2006; Knight et al., 2007). Thus, we used moderately-arousing positive and negative words that similarly deviated from a neutral midpoint. Although it was possible that the magnitude of emotion effects would be less pronounced with less arousing words, the advantage to this approach was that the contributions of valence to age differences in detection performance could be more closely specified.

Experiments 1a and 1b compared detection of neutral words with positive words, and Experiments 2a and 2b compared detection of neutral words with negative words. In accordance with previous findings (Lahar et al., 2001; Maciokas & Crognale, 2003), we predicted that target detection would decrease and the attentional blink would increase with age. With regard to emotion effects, we predicted that when the emotionality of the second target was manipulated, both younger and older adults would detect emotional words better than neutral words (Anderson & Phelps, 2001), but that this emotion effect would be greater for older adults (Leclerc & Kensinger, 2008; Wurm et al., 2004). In two follow-up experiments (1b and 2b), we manipulated task difficulty so that age differences in the attentional blink and in emotion effects could be assessed against a baseline that equated detection performance of younger and older adults.

Experiment 1a

In Experiment 1a, the first target word (T1) of the RSVP task was always neutral, and the second target word (T2) was either positive or neutral. The target words were presented in red and green, and the stream words were presented in black, at a rate of 116 ms per item. In the dual task, participants identified both colored words. In the single task, participants ignored the first colored word and identified the second colored word. The target-to-target lag was manipulated (using lags of 1 to 8 items) to assess the attentional blink. Accuracy in identifying T2 was the primary dependent variable; the blink would be evidenced by a greater reduction in T2 accuracy in the dual task as compared to the single task, and this reduction would be specific to short target-to-target lags. We predicted that the attentional blink would be greater for older adults as compared to younger adults and that both groups would show a reduced attentional blink for positive targets as compared to neutral targets.

Method

Participants—Thirty younger adults (12 men, 18 women), ages 18 to 24 yrs, were recruited from psychology courses and received extra credit for participation. Thirty older adults (10 men, 20 women), ages 60 to 77 yrs, were recruited from the community and received $20 for participating. All participants were fluent in English and had obtained at least a high school education. Self-reports from a health questionnaire (Christensen, Moye, Armson, & Kern, 1992) indicated that participants were free from medical conditions that could influence cognitive functioning such as heart disease, stroke, head injury, or drug abuse. All participants scored 9 points or less on the Geriatric Depression Scale (GDS; Yesavage et al., 1982), indicating minimal self-reported depression, and participants were not currently taking medications for depression or anxiety. Participants scored 26 points or higher on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), consistent with no observable signs of cognitive disturbance. Near visual acuity was 20/40 or better, and all participants had normal color vision. To assess age differences in positive and negative affect, participants completed the Philadelphia Geriatric Center (PGC) Positive and Negative Affect Scale (Lawton, Kleban, Dean, Rajagopal, & Parmelee, 1992). There were no age differences in self-reported levels of positive or negative affect. Demographic, screening, and psychometric data are provided in Table 1.

Materials and stimuli—The experimental task, programmed using E-Prime version 1.1 (Psychology Software Tools, Pittsburgh, PA), was presented on a PC computer with a 17 inch monitor. On each trial the stimulus stream consisted of two target words (T1 and T2) in red and green and 15 non-target stream words in black. The assignment of red and green to T1 and T2 was counterbalanced across participants but remained constant for a participant. All words appeared in lowercase Arial font at a height of 1° visual angle and an average width of 4.7° (range = 2.9°– 8.6°). On each trial, the T1 word was randomly selected from a set of three neutral words (once, math, and difference), and the T2 word was randomly selected from a set of six words - three positive (love, joy, and excited) and three neutral (side, time, and vertical). The fifteen stream items were randomly selected from a set of thirty neutral words (e.g., adjective, brief, carry, deal, fill) with the constraint that the same word never appeared twice within a stream, so that on average a particular stream item was presented on every other trial.

Positive and neutral words were chosen from the Toglia and Battig (1978) handbook of word norms (**see** Table 2). As closely as possible, we matched the neutral and positive words on number of letters, familiarity, and concreteness. On a scale from 1 to 7 (1 = very unpleasant, 7 = very pleasant), the chosen positive items had pleasantness ratings above 5.5, and the neutral items had ratings from 3.5 to 4.5. To assess potential age differences in perceived pleasantness and arousal of items, participants rated the task words after completing the RSVP task. Participants rated the words for level of likability (same scale as above) and level of stimulation (1 = not at all arousing, 7 = very arousing). Mean ratings for each age group are presented in Table 2. There were no significant age differences in the pleasantness or arousal ratings of the T2 items, but older adults rated the neutral T1 items as more pleasant and more arousing than did younger adults (primarily because younger adults rated the word "math" as less pleasant than did older adults). On average, both groups rated the neutral items within the neutral range.

Procedure—Participants completed all test procedures during a two-hour session. The order of task completion on the RSVP task (dual task or single task first) was counterbalanced across participants. For each task, participants completed 20 practice trials and 192 test trials divided into three blocks of 64 trials. The presentation rate during the first 8 practice trials of each task was slowed to 300 ms per word to familiarize participants with the task. The sequence of stimuli (depicted in Figure 1) was identical across single and dual tasks. Each trial began with a fixation cross in the middle of the screen for 500 ms, replaced by a stream of 17 words presented at a rate of 116 ms per item. The first target (T1) appeared randomly in the fifth or eighth position, and the second target (T2) appeared one to eight items after T1. The eight possible lags were presented an equal number of times across trials, as were the three T1 targets and the six T2 targets.

Following the stream of words, participants identified target words using the keyboard keys S, D, and F (left hand) and J, K, and L (right hand). In the dual task, a response screen was presented 1000 ms after the last stream item with the question, "What was the first colored word?". The three potential target words were listed side by side in the lower left corner, and participants pressed the key that corresponded with the presented T1 target word. To identify T2, a second response screen was presented immediately after the T1 response with the question, "What was the second colored word?". The six potential target words were listed at the bottom (three words on the left, three words on the right), and participants pressed the corresponding key. For both the T1 and T2 response screens, the positioning of the words at the bottom of the screen was randomly determined but remained constant for a participant throughout the task. Under single task conditions, participants were instructed to ignore the first colored word (T1) and identify the second colored word (T2), and only the T2 response screen was presented. Participants were told that accuracy was more important than speed, but that they should guess if they were unsure of the correct response. Participants took short breaks between blocks.

Results

To reduce the influence of floor effects, data from two older participants who did not attain a minimum of .40 accuracy on the single task (chance = .17) were excluded from the analysis and replaced with data from two new participants. (The participant data reported in Table 2 reflects the final participant group.)

T2 accuracy data is presented in Table 3. Accuracy rates (proportion correct) were submitted to a 2 × 2 × 8 × 2 mixed analysis of variance (ANOVA) with age group (younger adults and older adults) as the between-subjects factor and task (single and dual), lag (1–8), and valence (emotional and neutral) as the within-subjects factors. Only dual task trials in which T1 was correctly identified were included in the analysis (which excluded 6% of trials for younger adults and 16% of trials for older adults). All main effects were significant: age group, $F(1, 58) = 36.70$; task, $F(1, 58) = 124.94$; lag, $F(7, 406) = 40.43$; and valence, $F(1, 58) = 25.43$, all *p*s < .0001. Younger adults identified T2 more accurately than did older adults (.91 vs. .72, respectively), single task accuracy was higher than dual task accuracy (.90 vs. .74, respectively), T2 accuracy was lowest at a lag of 2 and increased gradually after that (.79, .72, .77, .81, .83, .85, .87, and .88 for lags 1–8, respectively), and positive targets were identified more accurately than neutral targets (.84 vs. .79, respectively).

Attentional blink—Two-way interactions of age × task, $F(1, 58) = 40.28$, $p < .0001$, age × lag, $F(7, 406) = 4.17$, $p < .001$, and task × lag, $F(7, 406) = 26.27$, $p < .0001$, were modified by a three-way interaction of age × task × lag, $F(7, 406) = 4.13$, $p < .001$, consistent with age differences in the attentional blink. To explore the three-way interaction, we calculated each participant's task effects by subtracting single task accuracy from dual task accuracy. This approach, which indicated the additional cost to performance under dual task conditions relative to single task conditions, served to adjust for age differences in single task accuracy (.94 for younger adults, .85 for older adults). As depicted in Figure 2, the attentional blink was reflected in the performance of both younger adults, $F(7, 203) = 13.37$, $p < .0001$, and older adults, $F(7, 203) = 13.37$, $p < .0001$, with dual task decrements being greatest at a lag of 2 and diminishing with increasing lag. Older adults showed greater task discrepancies in accuracy than younger adults at each lag, all $Fs(1, 58) > 7.0$, all *p*s < .01, but this age difference was most marked at lags 3–5, for which older adults continued to show a marked dual task deficit, but for which younger adults showed a diminishing deficit.

Emotion effects—In addition to the main effect of valence, there was an age × valence interaction, $F(1, 58) = 4.55$, $p < .05$. Emotion effects, reported in Table 3, were calculated by subtracting neutral T2 accuracy from positive T2 accuracy. Both age groups identified positive words more accurately than neutral words, $ts(30) > 3.90$, *p*s < .001. However, emotion effects were significantly greater for older adults (.07) than for younger adults (.03), $F(1, 58) = 4.70$, $p < .05$. Note that the absence of other interactions involving valence suggests that the age difference in emotion effects generalized across tasks and lags and was not specific to the attentional blink.

Discussion

Two questions were addressed in this study: Were there age differences in the attentional blink, and if so, did emotional content modify that age pattern? Attention impairments were greater for older adults than for younger adults. Detection performance was poorer overall, and impairments were greater when identifying two targets. Although both age groups found it difficult to identify a target word when it followed shortly after an initially-identified target word, the attentional blink at its maximum effect (at a lag of 2 items) was greater in magnitude for older adults (−.38) as compared to younger adults (−.19), and the blink for older adults persisted longer before beginning to diminish. This age-related increase in the attentional blink is consistent with a deficit in attentional resources and/or distractor inhibition (Lahar et al., 2001; Maciokas & Crognale, 2003).

Older adults were more likely than younger adults to be influenced by the emotional content of target words. Both groups identified positive words more accurately than neutral words, but this effect was greater for older adults. Interestingly, the age-emotion interaction was not specific to the dual task or to the attentional blink, but instead reflected older adults' overall enhanced identification of emotional information. The pattern overall suggests that age differences in rapid visual attention may be minimized according to the emotional nature of the attended information. The pattern, unexpectedly, was also consistent with an enhanced positivity effect on the part of older adults.

Experiment 1b

In Experiment 1a, older adults were generally less accurate in identifying target words than younger adults, even under single task conditions. Perhaps more importantly, younger adults' accuracy was near ceiling (over .90) on the single task, which may have restricted the magnitude of task effects and emotion effects to be observed in this group. In an attempt to increase the task difficulty for younger adults, additional participants were tested on the RSVP task at a faster presentation rate (84 ms/item). If similar baseline accuracy rates could be attained for younger and older adults, age differences specific to the attentional blink and to the effect of emotional content could then be examined.

Method

Participants—A new sample of 30 young adults (10 men, 20 women), ages 18 to 33 yrs, were recruited and screened in the same manner as described in Experiment 1a. Demographic and screening data are reported in Table 1. There were no age differences in positive or negative affect as measured by the PGC Affect Scale.

Stimuli and procedure—The stimuli and task remained unchanged from Experiment 1a except that the presentation rate of items was increased from 116 ms/item to 84 ms/item. This rate was identified through pilot testing to produce single task accuracy rates for younger adults that were similar to older adults' rates in Experiment 1a. The participants again rated the target items on both pleasantness and arousal after completing the experiment (see Table 2). The only age differences in ratings were for the neutral items; older adults rated the T1 neutral items as more pleasant than did younger adults (again, primarily due to younger adults' lower ratings for the word "math"), and older adults rated the T1 and T2 neutral items as more arousing than did younger adults.

Results

We replaced the data from two younger participants with low single-task accuracy scores (below .40) with data from two new participants.

Younger adults' T2 accuracy data collected at the 84 ms rate were combined with older adults' data collected at the 116 ms rate and submitted to the same 2 × 2 × 8 × 2 mixed ANOVA used in Experiment 1a. There were significant main effects of task, $F(1, 58) = 174.22$, $p < .0001$, lag, $F(7, 406) = 44.82$, $p < .0001$, and valence, $F(1, 58) = 50.69$, $p < .0001$, but not of age group, $F < 1$. Similar to Experiment 1a, the target was more accurately identified in the single task than in the dual task (.84 vs. .63, respectively), T2 accuracy was lowest at a lag of 2 and increased thereafter (.74, .63, .67, .73, .75, .77, .80, and .80 for lags 1 through 8, respectively), and positive targets were identified more accurately than neutral targets (.78 vs. .69, respectively). In contrast to Experiment 1a, there was no age difference in overall accuracy (.75 for younger adults, .72 for older adults).

Attentional blink—There were two-way interactions of age × task, $F(1, 58) = 6.55$, $p < .05$, and task × lag, $F(7, 406) = 24.67$, $p < .0001$, reflecting attention effects. With similar accuracy on the single task (.84 for younger adults, .85 for older adults), the age × task interaction was explained by greater task effects for older adults (a .25 decline in accuracy from the single task to the dual task) than for younger adults (a .17 decline). Consistent with the attentional blink, the task × lag interaction was explained by task effects (dual task accuracy minus single task accuracy) that were greatest at a lag of 2 and then diminished at longer lags (depicted in Figure 2). Although the three-way interaction of age × task × lag reflecting age differences in the attentional blink was not significant, $F(7, 406) = 1.66$, $p > .10$, an analysis of group differences in task effects at each lag revealed greater dual task deficits for older adults than for younger adults at lags 1 through 4, all Fs(1, 58) > 4.0, all ps < .05, but not at lags 5 through 8, all Fs(1, 58) < 3.0, all ps > .05.

Emotion effects—In addition to the valence main effect, there was a task × valence interaction, $F(1, 58) = 4.52$, $p < .05$, due to greater emotion effects in the dual task than in the single task (.11 vs .07, respectively). As indicated in Table 3, emotion effects did not differ by age (.10 for younger adults, .08 for older adults), $F < 1$, with both younger adults and older adults identifying positive words more accurately than neutral words.

Discussion

The results of Experiment 1b suggest that younger adults' high accuracy in Experiment 1a may have obscured attentional blink effects and emotion effects, thus inflating observed age differences. By increasing the task presentation rate, single task accuracy rates were equated between younger and older adults. Even with similar overall accuracy, older adults continued to have more difficulty than younger adults attending to two target words, particularly when the words occurred close together in time. However, age differences specific to the attention blink were much less evident than in Experiment 1a.

A key finding of this experiment was that increasing the difficulty of the task revealed greater emotion effects for younger adults. In contrast to Experiment 1a, now both age groups showed enhanced identification of positive words by approximately .10 (as compared to .03 for younger adults in Experiment 1a). This emotion effect was larger on the dual task as compared to the single task, suggesting that the emotional meaning of words enhanced identification particularly under conditions with greater attentional demands. Thus, we must be cautious in interpreting the pattern of Experiment 1a as revealing true age differences in attention to emotion. Enhanced emotion effects for older adults, instead of being due to an enhanced positivity bias for older adults, may have been a byproduct of their overall poorer (or at least non-ceiling) performance on the attention task.

Experiment 2a

We were interested in whether the age patterns obtained for positive words would be similarly observed for negative words. Older adults in previous studes have directed attention *away* from negative information, consistent with a positivity effect (Isaacowitz et al., 2006; Knight et al., 2007; Mather & Carstensen, 2003). However, given that the present RSVP task afforded little opportunity for goal-directed strategic processing, we predicted that both younger and older adults would show better detection of negative than neutral targets, reflecting a general emotion enhancement effect (Leclerc & Kensinger, 2008).

Method

Participants—Thirty younger adults (10 men, 20 women), ages 18 to 33 yrs, and 30 older adults (10 men, 20 women), ages 63 to 80 yrs, were recruited and screened in the same manner as described in Experiment 1a. Demographic and screening data are reported in Table 1. Older adults reported higher positive affect than younger adults on the PGC Affect Scale.

Stimuli and procedure—The task was identical to that of Experiment 1a except that three negative words (fear, hurt, and misery) replaced the positive words used for T2. The neutral words for T1 (once, math, and difference), T2 (side, time, and vertical), and the stream items remained unchanged. Negative items all had Toglia and Battig (1978) pleasantness ratings below 3.0 on a scale from 1 to 7. Negative items were approximately matched to neutral items on word length, familiarity, and concreteness. Considering both the Toglia and Battig ratings and the participants' ratings, the average pleasantness ratings of the negative items were a similar distance from the neutral midpoint as were the positive items from Experiment 1. Participants' pleasantness and arousal ratings for Experiment 2 items are presented in Table 2. There were no significant age differences in pleasantness or arousal ratings.

Results

We replaced the data of five older adults with low single-task accuracy scores (below .40) with data from five new participants. Accuracy data are presented in Table 4. Submitted to a 2 × 2 × 8 × 2 mixed ANOVA, the T2 accuracy data revealed main effects of age group, $F(1, 58) = 75.90$, task, $F(1, 58) = 139.57$, and lag, $F(7, 406) = 46.39$, all *p*s < .0001. Younger adults were more accurate than older adults (.90 vs. .65, respectively), single task accuracy was higher than dual task accuracy (.86 vs. .69, respectively), and T2 accuracy was lowest at a lag of 2 and increased thereafter (.77, .66, .71, .77, .80, .82, .83, and .84 for lags 1 through 8, respectively).

Attentional blink—Two-way interactions of age × task, $F(1, 58) = 26.24$, $p < .0001$, age × lag, $F(7, 406) = 3.61$, $p < .001$, and task × lag, $F(7, 406) = 21.00$, $p < .0001$, were modified by a three-way interaction of age × task × lag, $F(7, 406) = 2.85$, $p < .01$, consistent with age differences in the attentional blink. As depicted in Figure 3, older adults showed greater dual task discrepancies in accuracy than did younger adults at each lag, all *F*s > 4.50, all *p*s < .05, except at lag 2, $F(1, 58) = 3.57$, $p > .05$, and this age discrepancy was most marked at lags 3–5.

Emotion effects—Although there was no main effect of valence, there was an age × valence interaction, $F(1, 58) = 7.69$, $p < .01$. As shown in Table 4, difference scores reflecting emotion effects (negative T2 accuracy minus neutral T2 accuracy) were significantly greater for older adults (.03) than for younger adults (−.01), $F(1, 58) = 7.56$, $p < .01$. Older adults identified negative targets more accurately than neutral targets, $t(30) = 2.38$, $p < .05$, but younger adults did not, $p > .10$.

Discussion

Consistent with the findings of Experiment 1a, older adults generally had more difficulty identifying target items from a rapid visual stream than did younger adults, and this was particularly true when attending to two items. Although the attentional blink was evident for both groups, age differences in blink effects were greatest at target-to-target lags of three to five items, consistent with an extended blink for older adults.

With reference to emotion effects, older adults were more influenced than younger adults by the emotional content of words. Older adults identified negative words more accurately than neutral words, but younger adults did not. Looking across experiments, older adults were able to identify both positive and negative words more accurately than neutral words, although older adults' emotion effects were larger for positive words (.07) than they were for negative words (.03). As found in Experiment 1a, the age-emotion interaction was not specific to the dual task or to the attentional blink temporal region, but instead, influenced rapid visual attention more generally.

Experiment 2b

In Experiment 1a, near-ceiling accuracy rates for younger adults limited the observation of blink effects and emotion effects. To address the possibility of such a pattern influencing the results of Experiment 2a (single task T2 accuracy was .95 for younger adults, .77 for older adults), we tested a new group of younger adults on the RSVP task at an accelerated rate of 84 ms per item. As observed in Experiment 1b, we predicted that the faster presentation rate would increase blink effects and emotion effects for younger adults, thus reducing age differences in these effects.

Method

Participants—Thirty younger adults (10 men, 20 women), ages 18 to 29 yrs, participated in the experiment. There were no significant age differences in positive or negative affect as measured by the PGC Affect Scale. Demographic and screening data are reported in Table 1.

Stimuli and procedure—The stimuli and task remained unchanged from Experiment 2a except that items were presented at a rate of 84 ms per item. Participants again rated the target words for pleasantness and arousal following the computer task (mean ratings are reported in Table 2). Younger adults rated the negative T2 items as less arousing that did older adults and the neutral T1 items as less pleasant (again primarily due to the word "math").

Results

We replaced the data of two younger adults with low single-task accuracy scores with the data of two new participants. Younger adults' T2 data were combined with older adults' T2 data collected at the 116 ms rate. From the 2 × 2 × 8 × 2 mixed ANOVA, there were main effects of task, $F(1, 58) = 163.26$, $p < .0001$, and lag, $F(7, 406) = 48.28$, $p < .0001$, but not of age group or valence, both $Fs < 1$. Single task accuracy was higher than dual task accuracy (.76 vs. .53, respectively), and accuracy was lowest at a lag of 2 and generally increased after that (.65, .52, .57, .64, .66, .69, .73, and .72 for lags 1 through 8, respectively). In contrast to Experiment 2a, there were no age differences in overall accuracy (.65 for younger adults, .65 for older adults).

Attentional blink—There was a two-way interaction of task × lag, $F(7, 406) = 19.92$, $p < .0001$, consistent with the attentional blink, but this effect did not interact with age, $F(7, 406) = 1.16$, $p > .30$. Single task accuracy was similar between younger adults and older adults (.75 vs. .77, respectively). Discrepancies between dual task and single task performance were greatest at target-to-target lags of 2 to 4 items and then generally diminished at longer lags. Comparing task difference scores between groups (as depicted in Figure 3), the only lag at which dual task deficits were greater for older adults as compared to younger adults was lag 1, $F(1, 58) = 7.74$, $p < .01$. Thus, there was little evidence that the attentional blink differed with age.

Emotion effects—Although there was no main effect of valence, there was an age × valence interaction, $F(1, 58) = 10.57$, $p < .01$. Older adults demonstrated emotion effects (.03) in the opposite direction of younger adults (−.03), $F(1, 58) = 10.00$, $p < .01$. Older adults identified negative information *more* accurately than neutral information, $t(30) = 2.81$, $p < .01$, whereas younger adults identified negative information *less* accurately than neutral information, $t(30) = -2.12$, $p < .05$. Emotion effects (reported in Table 4) were specific to the dual task for younger adults and were evident on both tasks for older adults.

Discussion

As anticipated, the results of Experiment 2b demonstrated that younger adults' blink effects and emotion effects in Experiment 2a may have been dampened by ceiling effects. Once single task performance was comparable between groups, age differences specific to the attentional blink were no longer evident. Both younger and older adults demonstrated dual task deficits that were greatest at lags of 2 to 4 items and then diminished with increasing lag. However, age differences in emotion effects were actually accentuated with the increased presentation rate. Whereas older adults showed *enhanced* processing of emotional information, younger adults showed *reduced* processing of emotional information. Potential explanations for this age pattern are described in the General Discussion.

General Discussion

Age Differences in Rapid Visual Attention

Consistent with age-related changes in selective attention (see reviews by McDowd & Shaw, 2000; Rogers & Fisk, 2001), older adults in the present study had difficulty identifying target items from a rapidly-presented stream of distractors. Age differences were accentuated when participants attended to two targets rather than one, particularly when the words were presented close together in time. This age-related change in attention may have been due to attentional resources that were not sufficient for storing and maintaining two target items simultaneously until target identification (Maciokas & Crognale, 2003) or to a reduced ability to inhibit processing of distractor items from the word stream, thus making it more likely that the second target was vulnerable to replacement in working memory (Lahar et al., 2001).

Another interpretation of the present age pattern emerges from a recent alternative account of the attentional blink. Olivers and colleagues (Olivers, 2007; Olivers, van der Stigchel, & Hulleman, 2007) have proposed that attention is actually enhanced rather than depleted following processing of the first target, but this temporary enhancement must be suppressed when a distracting item is subsequently presented. Distractor suppression does not have time to resolve when the second target is presented shortly thereafter, and as a result, identification of the second target is compromised. If the attentional blink does reflect reactive suppression, then an age-related increase in the attentional blink may reflect overzealous suppression of distraction or a reduced ability to lift suppression when it is no longer needed. Thus, this explanation of blink effects suggests that older adults have overactive or inflexible inhibition rather than insufficient inhibition.

Evidence that age differences in attention were not specific to the attentional blink came when baseline accuracy performance was equated for the two age groups (Experiments 1b and 2b). When younger adults were tested at an increased presentation rate, their single target accuracy scores dropped (to a level comparable to those of older adults), and at the same time, their blink effects increased. At the adjusted rates, age differences in blink effects were reduced in Experiment 1 and eliminated in Experiment 2. (Note that age differences in emotion effects likely contributed to the elimination of age differences in blink effect in Experiment 2. See the next section for further explanation.) Thus, ceiling effects in younger adults' performance may have contributed to observed age differences in blink effects. When younger adults were presented with increased time constraints, they showed a drop in the ability to efficiently process two successively presented target items. This effect of time manipulation suggests that diminished processing speed for older adults may have contributed to age-related deficits in the attentional blink (Madden, 2001; Salthouse, 1996).

Increasing the presentation rate for younger adults was successful in equalizing single-target identification rates between groups, but it compromised the ability to fully interpret the attentional blink. It is unclear whether it is the length of time or the number of items presented between target items, or some combination of the two, that is critical for inducing the attentional blink, but if time is a critical variable, then direct comparison of the attentional blink between age groups is clouded with different presentation rates (the blink duration can be compared in terms of item lag but not temporal lag). Future studies should find a means of manipulating task difficulty independent of target-to-target presentation rates.

Although accuracy rather than response latency was measured in the present study, it is likely that older adults were slower than younger adults to identify target words. With the working memory requirements of the task, older adults' slower responses may have led to more decay from memory of the target words before they were identified. It could be argued that the compounding of decay when two responses were required may have accounted for differences between dual task and single task performances. However, a memory decay explanation does not account for blink-related differences in accuracy at different dual task lags (which would have the same memory requirements). Furthermore, when single-task accuracy was matched by increasing younger adults' presentation rate (i.e., younger and older adults were equally able to hold one item in memory), target identification accuracy did not differ between younger and older adults at the longest lags of the dual task (i.e., holding two items in memory was not more burdensome for older adults than for younger adults). Therefore, greater memory decay for older adults does not appear to account for the present age patterns.

Age Differences in Attention to Emotional Information

We have provided evidence that emotional processing may buffer against age-related declines in rapid selective attention. As predicted, older adults could detect emotional targets more accurately than neutral targets. This pattern was true for both positive (Experiment 1a) and negative (Experiment 2a) items. When task difficulty was not considered, this emotion effect was more robust for older adults than for younger adults, consistent with findings of other aging studies (Leclerc & Kensinger, 2008; Mather & Carstensen, 2003; Wurm et al., 2004). To specify, in Experiment 1a, both younger adults and older adults demonstrated more accurate identification of positive items as compared to neutral items, but this effect was larger for older adults. In Experiment 2a, younger adults did not show differential identification accuracy for negative and neutral items, whereas older adults identified negative items more accurately than neutral items.

When task difficulty was increased, emotion effects grew in strength for younger adults (increased identification of positive items in Experiment 1 and decreased identification of negative items in Experiment 2). As a result, age differences in emotion effects were eliminated for positive items (Experiment 1b), but age differences were accentuated for negative items (Experiment 2b), with enhanced detection of negative words for older adults and reduced detection of negative words for younger adults. Emotion effects were not specific to the attentional blink temporal region, but there was a tendency for emotion effects to be greater under dual task conditions, suggesting that emotional meaning enhanced word identification particularly under greater attentional demands or higher working memory load.

The present set of findings contributes to a growing literature delineating the conditions under which particular age patterns of emotion effects are found. When there is opportunity to adapt attention processing to be consistent with emotional goals, older adults will demonstrate a positivity effect, but in the absence of such strategic conditions (such as on the present RSVP task), more global emotion enhancement may be observed (Mather & Carstensen, 2005). Consistent with this framework, there was scant evidence for a positivity effect unique to older adults' performance on a rapid visual detection task. Instead, older adults oriented to negative as well as to positive information, suggesting that this group may have been sensitive to emotional information more generally. Early emotional monitoring is likely important for determining at later processing stages which information is consistent with emotional goals and should thus receive preferential processing, and which information is inconsistent with goals and should thus be suppressed (Knight et al., 2007).

The RSVP task was unique from other attention tasks used to investigate age-emotion interactions in that it involved detection of words (rather than faces or pictures) from a temporal (rather than a spatial) arrangement of distractors (Hahn et al., 2006; Isaacowitz et al., 2006; Knight et al., 2007; Leclerc & Kensinger, 2008; Mather & Carstensen, 2003). Despite these differences, the emotion pattern observed in the present study closely mirrors that found by Leclerc and Kensinger (2008) on a task involving visual search for emotional images (younger adults showed enhanced detection of positive stimuli, whereas older adults showed enhanced detection of both positive and negative stimuli). Together, these findings argue against particular stimulus or spatial characteristics as responsible for driving the observed patterns of age-emotion interactions. Instead, on tasks that require early, relatively automatic detection of information, older adults' performance appears to reflect generally enhanced emotional processing rather than processing in response to emotional goals.

The pattern of younger adults' emotion effects (reduced processing of negative information) is contrary to reports of greater vigilance for and orientation toward negative information (Dijksterhuis & Aarts, 2003; Hansen & Hansen, 1988). The discrepancy may be the result of study differences in stimulus intensity levels (moderately arousing in the present study, highly arousing/threatening in other studies). Mogg and Bradley (1998) made the case that younger adults direct the focus of attention away from mildly aversive but non-threatening information (such as the words used in the present study) and toward highly aversive or threatening information that they may need to act upon. The arousal explanation may account for Anderson and Phelps (2001) finding of enhanced detection of arousing taboo words relative to neutral words on an RSVP task. It is possible that younger adults in the present study were able to direct less attention to the negative words because they found them non-threatening, but that they would have demonstrated enhanced processing of the words if they were more arousing.

If younger adults did not find negative words attention-grabbing, how do we interpret older adults' performance of enhanced detection of negative words? Do automatic responses to emotional information change with age? One explanation is that older adults rated the negative items as more arousing than did younger adults, and this enhanced arousal may have increased the saliency (and attention-grabbing nature) of negative words for this group. (Arousal ratings were more uniformly high for positive words and may have accounted for younger and older adults' similar emotion enhancement effects for positive targets.) Other studies have found age differences in valence and arousal ratings of emotional stimuli, with a tendency for older adults to make more extreme ratings (Gruhn & Scheibe, 2008; Smith, Hillman, & Duley, 2005). These changes in stimulus perceptions (enhanced valence or arousal) may impact early automatic processing of emotional stimuli. Or it is possible that independent of perceived valence and arousal levels, older adults are more sensitive to both positive and negative emotional information, even at early processing stages (Leclerc & Kensinger, 2008). Future studies will need to distinguish between these possibilities.

Because there is evidence that current mood affects target detection accuracy (Jefferies, Smilek, Eich, & Enns, 2008; Rokke, Arnell, Koch, & Andrews, 2002), we assessed participants' affect levels immediately prior to testing. There were no systematic differences in younger and older adults' self-reports of positive and negative affect, although older adults reported higher positive affect than younger adults in Experiment 2a. With higher positive affect, older adults showed enhanced detection of negative stimuli, whereas younger adults did not. Age differences in affect were not significant in Experiment 2b, but age differences in the processing of emotional information were actually accentuated. Although we did not find strong evidence for age-mood interactions, it is worth noting that we did not assess affect levels in the middle or at the end of the task, so we do not know if the emotional target words had a different impact on the moods of younger and older adults.

Conclusions

To summarize, age-related deficits in attention were evident in terms of older adults' greater difficulty in identifying target items from a rapidly presented stream of items. Older adults also demonstrated a greater attentional blink than did younger adults, consistent with age-related changes in attentional resources, distractor inhibition, or processing speed. Age differences specific to the blink were reduced once baseline accuracy performance was age-matched, highlighting the caution that ceiling effects in younger adults' performance can lead to premature conclusions regarding age deficits specific to a particular attentional process.

The emotional nature of attended information modified observed age patterns of attention. Older adults showed enhanced identification of both positive and negative items relative to neutral items, whereas younger adults showed enhanced identification of positive information and reduced identification of negative information. As a result, age-related changes in attention were reduced when individuals attended to negative information. Although older adults showed general emotion enhancement effects, there was no evidence of a positivity effect unique to older adults' performance, arguing against motivational emotion regulation influences at this early stage of attention processing. Instead, it appears that older adults are generally more sensitive to emotional information during target detection and identification, and it is possible that perceived stimulus arousal influences these age differences.

Acknowledgements

This work was supported by Grant P20 RR020151 from the National Center for Research Resources (NCRR) of the National Institutes of Health (NIH) and by Grant 01322899 from the National Science Foundation. We are grateful to Sara Kveno, Scot Dewitz, Brandon Dosch, David Hughes, Jessica Ihry, Nichole Keller, Laura Klubben, Savannah Kraft, Shelly Manger, Marie Schaaf, and Melissa Tarasenko for their assistance with data collection and to Wren Pasieka for programming the experiments.

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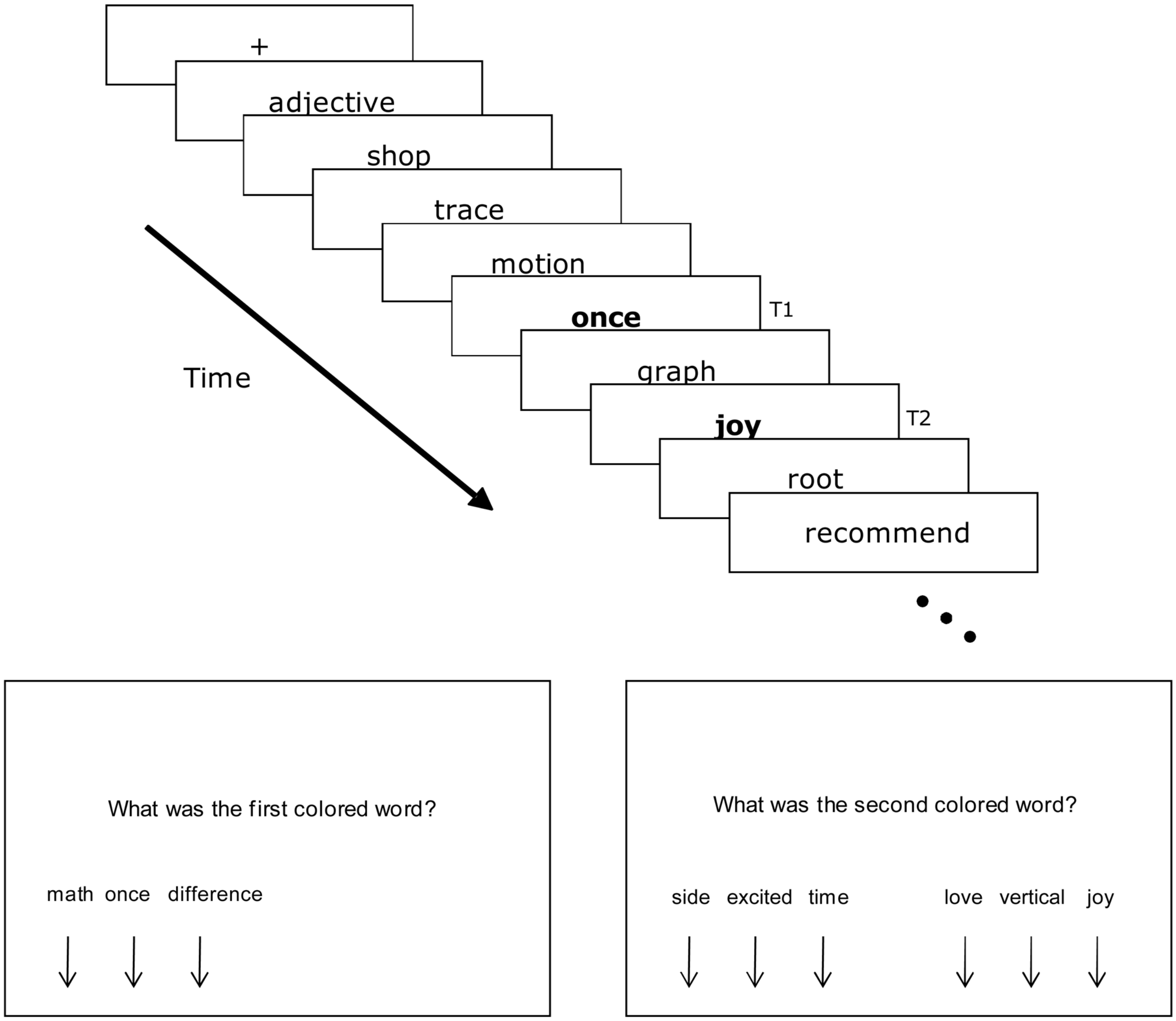

Figure 1.
Sequence of events for a sample trial in Experiments 1 and 2. Black words were presented against a grey background; the target words (T1 and T2) were presented in red and green (shown in bold in this figure). Seventeen items (15 black stream items and 2 colored target items) were presented on each trial. The first target item (T1) was presented in the 5th or 8th position in the sequence; the second target item (T2) was presented 1 to 8 items after T1. T1 was always neutral in valence; T2 varied between emotional words (positive in Experiment 1, negative in Experiment 2) and neutral words. On dual task trials, participants identified T1 and T2 upon presentation of separate response screens following the stimulus stream. On single task trials, participants ignored T1 and identified T2; on these trials, only the second response screen was presented. In Experiments 1a and 2a (younger adults and older adults), stimulus items were presented at a rate of 116 ms/word; in Experiments 1b and 2b (younger adults only), stimulus items were presented at a rate of 84 ms/word.

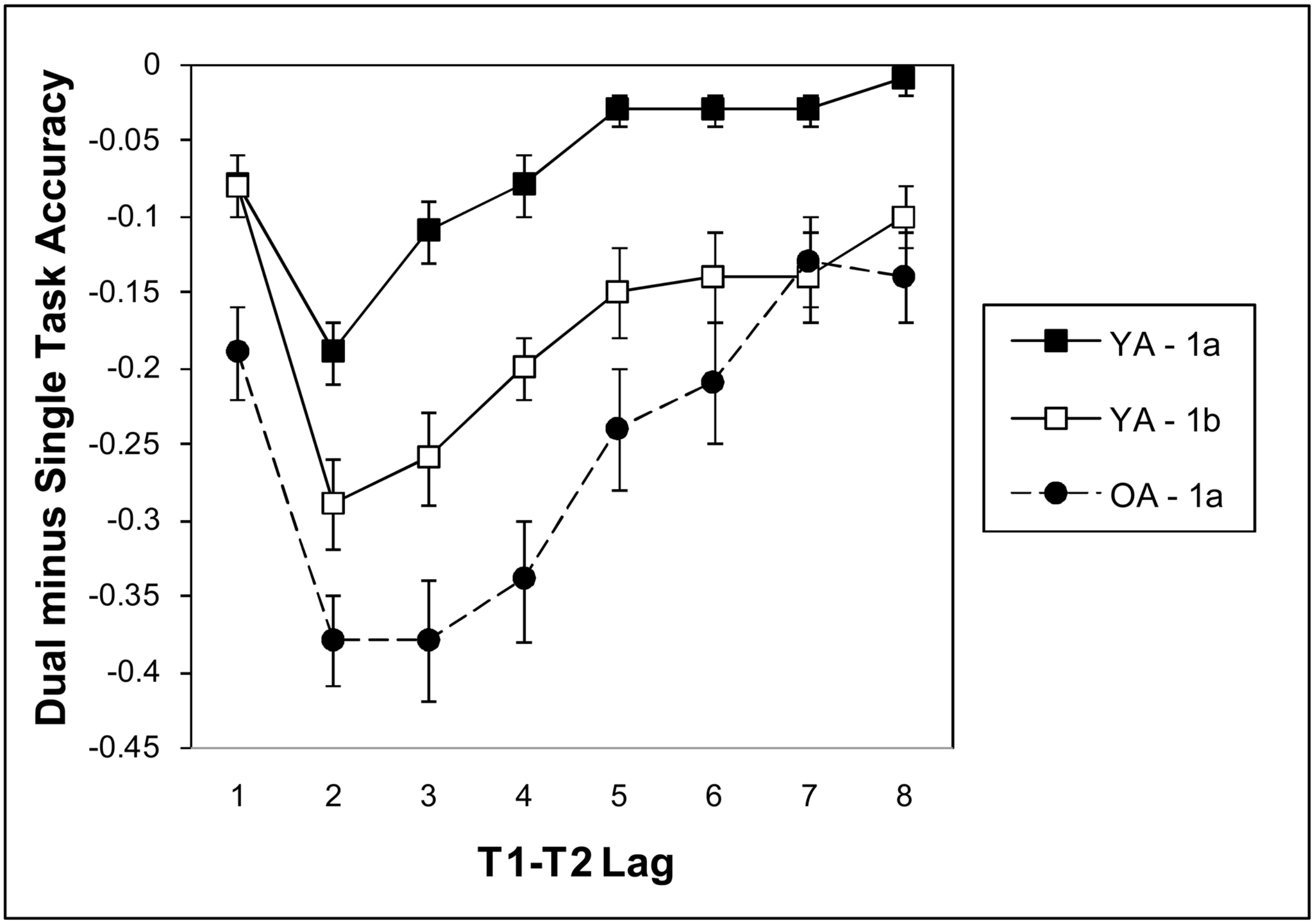

Figure 2.
Accuracy in identifying T2 as a function of age group and target-to-target lag in Experiment 1. Scores represent the discrepancy between dual and single task accuracy (dual task accuracy minus single task accuracy) in proportion correct. YA = younger adults; OA = older adults; 1a = Experiment 1a (116 ms rate); 1b = Experiment 1b (84 ms rate).

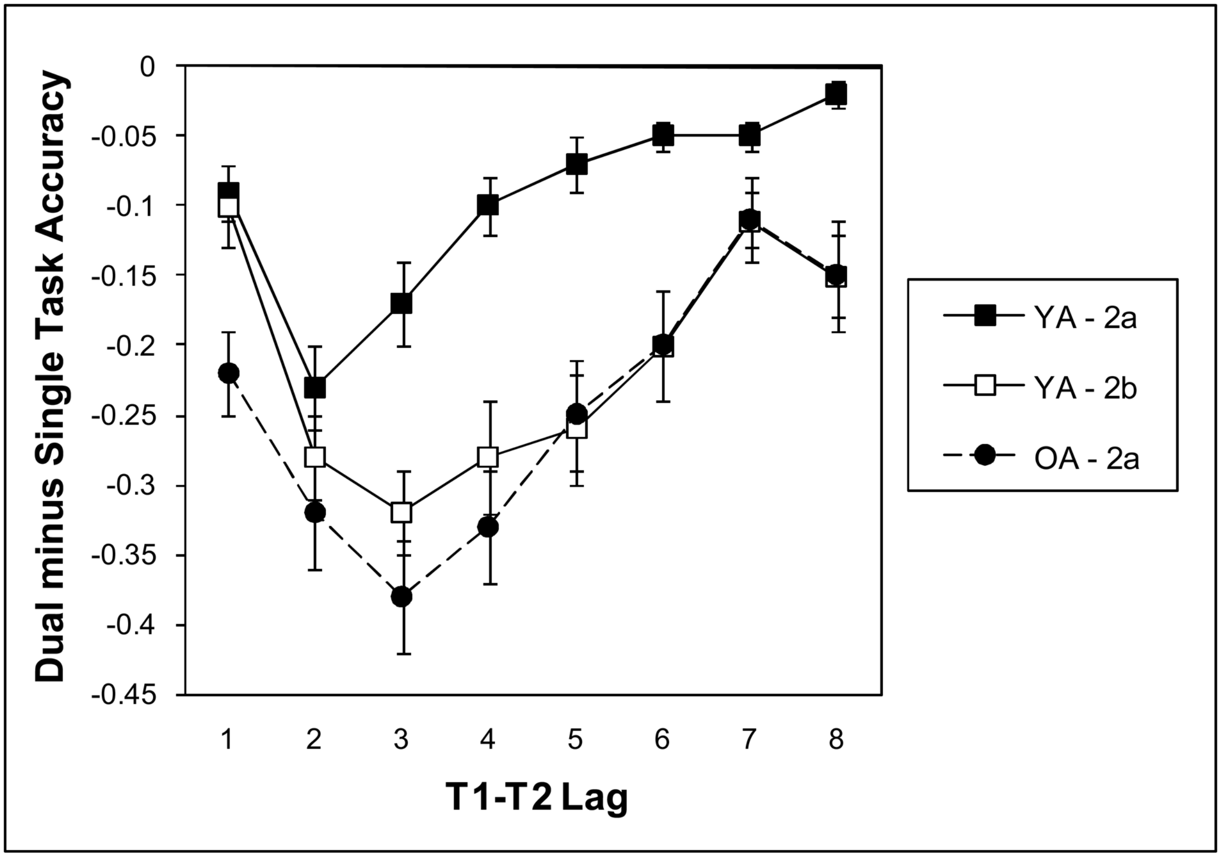

Figure 3.
Accuracy in identifying T2 as a function of age group and target-to-target lag in Experiment 2. Scores represent the discrepancy between dual and single task accuracy (dual task accuracy minus single task accuracy) in proportion correct. YA = younger adults; OA = older adults; 2a = Experiment 2a (116 ms rate); 2b = Experiment 2b (84 ms rate).

Table 1

Participant Characteristics

	Experiment 1						Experiment 2					
	Mean			SD			Mean			SD		
	YA-a	OA-a	YA-b	YA-a	OA-a	YA-b	YA-a	OA-a	YA-b	YA-a	OA-a	YA-b
Age (yrs)	19.4 *	68.6	20.3 *	1.5	5.6	2.9	21.2 *	68.9	20.2 *	3.2	4.6	2.4
Education (yrs)	13.2 *	15.0;	13.6 *	0.8	2.7	1.1	14.4	15.2	14.0	1.3	3.3	1.1
GDS (30 max)	1.7	1.7	1.3	2.8	2.3	1.8	2.2	1.4	1.9	2.3	2.2	2.6
WASI Vocab. (80 max)	59.5 *	70.7	61.6 *	6.6	5.8	5.2	62.1 *	69.7	61.5 *	7.0	7.1	5.7
Snellen acuity (20/___)	14.9 *	22.3	15.8 *	3.8	5.7	3.9	16.2 *	22.1	15.4 *	2.6	5.8	3.1
MMSE (30 max)	29.3	29.5	29.4	0.9	0.8	0.9	29.6 *	29.2	29.6 *	0.6	1.0	0.6
PGC Affect Scale												
Positive Scale	20.7	20.7	20.1	2.5	2.4	2.1	20.1 *	21.4	20.6	2.5	2.3	1.8
Negative Scale	11.2	10.1	11.4	2.5	3.4	2.2	12.0	10.7	11.7	3.2	2.3	2.4

Note. SD = standard deviation. YA-a = younger adults in Experiment 1a or Experiment 2a; OA-a = older adults in Experiment 1a or Experiment 2a. YA-b = younger adults in Experiment 1b or Experiment 2b; GDS = Geriatric Depression Scale. Maximum score is 30, with a higher score indicating greater depression. WASI = Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999). Maximum score on the vocabulary subscale is 80 points, with a higher score indicating better vocabulary performance. Snellen acuity = denominator of the Snellen fraction for corrected near vision. A smaller number indicates better vision. MMSE = Mini Mental State Examination. Maximum score is 30 points, with a higher score indicating better performance. PGC Affect Scale = Philadelphia Geriatric Center Positive and Negative Affect Scale. Maximum score per scale is 25 points, with a higher score indicates stronger affect according to self-report. An asterisk (*) indicates that mean scores differed significantly from the older adult comparison group according to independent *t* test, $p < .05$.

Table 2

Pleasantness and Arousal Ratings for Word Stimuli in Experiments 1 and 2

	Stimulus Characteristics			Experiment 1						Experiment 2					
	Letters	Syllables	TB Pleas.	Pleasantness			Arousal			Pleasantness			Arousal		
				YA-a	OA-a	YA-b	YA-a	OA-a	YA-b	YA-a	OA-a	YA-b	YA-a	OA-a	YA-b
N				29	24	23	29	24	23	26	18	25	26	18	25
<u>T2: Positive</u>															
excited	7	3	#	6.3	5.9	6.5	6.0	5.7	6.2						
joy	3	1	6.0	6.5	6.6	6.0	5.5	6.0	5.0						
love	4	1	6.1	6.6	6.3	6.6	6.3	6.6	6.0						
Mean	4.7	1.7	6.1	6.5	6.3	6.4	5.9	6.1	5.7						
<u>T2: Negative</u>															
fear	4	1	2.8							2.2	1.6	1.6	4.7	5.3	3.2
hurt	4	1	2.4							2.2	2.3	2.0	3.9	5.2	2.9
misery	6	3	2.0							1.9	2.0	1.5	3.7	4.6	2.4
Mean	4.7	1.7	2.4							2.1	2.0	1.7	4.1	5.0	2.8 *
<u>T2: Neutral</u>															
side	4	1	3.7	3.9	4.0	3.7	2.1	3.0	1.9	4.0	4.0	3.9	1.9	2.9	2.2
time	4	1	4.2	4.3	4.5	4.2	2.6	3.7	2.7	4.5	4.3	4.2	2.9	3.5	2.7
vertical	8	3	4.0	4.2	4.0	3.8	2.7	2.9	2.5	4.2	4.3	3.9	2.3	2.9	2.5
Mean	5.3	1.7	4.0	4.1	4.2	3.9	2.5	3.2	2.4 *	4.2	4.2	4.0	2.4	3.1	2.5
<u>T1: Neutral</u>															
difference	10	3	4.0	4.0	4.1	4.0	2.9	4.0	2.3	4.2	4.1	4.0	2.8	3.2	2.6
math	4	1	3.9	3.0	4.1	3.0	1.9	3.4	2.0	4.0	3.9	3.1	2.9	3.1	2.5
once	4	1	3.8	3.8	4.0	3.6	2.0	3.1	1.8	3.9	4.0	3.8	1.9	2.9	2.0
Mean	6.0	1.7	3.9	3.6 *	4.1	3.5 *	2.3 *	3.5	2.0 *	4.0	4.0	3.6 *	2.5	3.1	2.4

Note. TB pleas. = Toglia and Battig (1978) pleasantness ratings. YA-a = younger adults in Experiment 1a or Experiment 2a; OA-a = older adults in Experiment 1a or Experiment 2a. YA-b = younger adults in Experiment 1b or Experiment 2b. N = number of participants providing ratings. The total number of participants contributing to each mean rating is less than the total sample size (30 per group) because some participants completed the ratings incorrectly (e.g., only using the 1 and 7 ratings), incompletely (not rating all items), or not at all. Pleasantness and arousal ratings were gathered on a 1–7 scale (arousal: 1 = not at all arousing, 7 = very arousing; pleasantness: 1 = very unpleasant, 7 = very pleasant). Participants provided pleasantness and arousal ratings for stimulus items after completing the RSVP task. # = This item was not selected from the Toglia and Battig (1978) handbook. An asterisk (*) indicates that younger adults' pleasantness or arousal ratings differed significantly from the older adult comparison group (calculated for mean ratings only), $p < .05$.

Table 3

Mean Accuracy (Proportion Correct) for Identifying the Second Target (T2) in Experiment 1 (Positive and Neutral Items).

	Dual task									Single task								
Lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Ave**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Ave**
Means																		
Younger adults - 116 ms/item (Exp. 1a)																		
Emot T2	.84	.76	.85	.89	.92	.95	.95	.98	.89	.93	.95	.96	.95	.96	.97	.98	.98	.96
Neut T2	.81	.73	.81	.86	.90	.91	.91	.95	.86	.89	.91	.93	.96	.92	.94	.94	.96	.93
E-N Diff	*.03*	*.03*	*.04*	*.03*	*.02*	*.04*	*.04*	*.03*	***.03***	*.04*	*.04*	*.03*	*−.01*	*.04*	*.03*	*.04*	*.02*	***.03***
Older adults - 116 ms/item (Exp. 1a)																		
Emot T2	.68	.46	.49	.61	.66	.69	.80	.77	.65	.85	.83	.86	.91	.89	.88	.89	.88	.87
Neut T2	.57	.37	.44	.48	.58	.61	.66	.66	.55	.79	.75	.82	.86	.82	.83	.83	.85	.82
E-N Diff	*.11*	*.09*	*.05*	*.13*	*.08*	*.08*	*.14*	*.11*	***.10***	*.06*	*.08*	*.04*	*.05*	*.07*	*.05*	*.06*	*.03*	***.05***
Younger adults - 84 ms/item (Exp. 1b)																		
Emot T2	.81	.55	.62	.68	.77	.78	.78	.80	.72	.85	.86	.86	.89	.87	.90	.90	.89	.88
Neut T2	.63	.48	.52	.58	.61	.66	.69	.71	.61	.74	.75	.79	.78	.80	.83	.85	.83	.80
E-N Diff	*.18*	*.07*	*.10*	*.10*	*.16*	*.12*	*.09*	*.09*	***.11***	*.11*	*.11*	*.07*	*.11*	*.07*	*.07*	*.05*	*.06*	***.08***
Standard Deviations																		
Younger adults - 116 ms/item (Exp. 1a)																		
Emot T2	.14	.18	.14	.13	.12	.08	.07	.08	.12	.13	.07	.08	.09	.07	.05	.05	.05	.07
Neut T2	.16	.20	.18	.13	.10	.12	.11	.10	.14	.14	.10	.10	.07	.12	.08	.09	.06	.10
E-N Diff	*.16*	*.22*	*.16*	*.12*	*.13*	*.10*	*.10*	*.10*	***.14***	*.10*	*.09*	*.09*	*.09*	*.09*	*.06*	*.07*	*.08*	***.08***
Older adults -116 ms/item (Exp. 1a)																		
Emot T2	.26	.19	.27	.21	.22	.23	.19	.22	.22	.17	.19	.20	.13	.17	.17	.13	.17	.17
Neut T2	.31	.20	.27	.26	.28	.29	.26	.28	.27	.23	.22	.21	.19	.20	.22	.22	.18	.21
E-N Diff	*.27*	*.24*	*.22*	*.23*	*.23*	*.21*	*.26*	*.27*	***.24***	*.14*	*.16*	*.14*	*.12*	*.17*	*.13*	*.15*	*.11*	***.14***
Younger adults - 84 ms/item (Exp. 1b)																		
Emot T2	.18	.22	.25	.22	.17	.25	.18	.17	.21	.15	.17	.16	.14	.14	.12	.13	.14	.14
Neut T2	.18	.22	.21	.20	.24	.24	.25	.23	.22	.21	.22	.20	.22	.22	.20	.19	.15	.20
E-N Diff	*.16*	*.20*	*.23*	*.21*	*.22*	*.24*	*.18*	*.16*	***.20***	*.16*	*.18*	*.13*	*.17*	*.17*	*.15*	*.15*	*.09*	***.15***

Note. Exp. = Experiment; Emot T2 = T2 accuracy for emotional items; Neut T2 = T2 accuracy for neutral items; E-N Diff = Emot T2 minus Neut T2 difference scores.

Table 4

Mean Accuracy (Proportion Correct) for Identifying the Second Target (T2) in Experiment 2 (Negative and Neutral Items).

	Dual task									Single task								
Lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Ave.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Ave.**
Means																		
Younger adults - 116 ms/item (Exp. 2a)																		
Emot T2	.83	.67	.76	.84	.89	.92	.93	.94	.85	.92	.91	.94	.95	.97	.98	.96	.96	.95
Neut T2	.84	.71	.82	.86	.90	.92	.91	.93	.86	.94	.93	.97	.95	.96	.96	.98	.96	.96
E-N Diff	*−.01*	*−.04*	*-.06*	*−.02*	*−.01*	*.00*	*.02*	*.01*	***−.01***	*−.02*	*−.02*	*−.03*	*.00*	*.01*	*.02*	*−.02*	*.00*	***−.01***
Older adults - 116 ms/item (Exp. 2a)																		
Emot T2	.58	.34	.38	.48	.53	.61	.71	.67	.54	.78	.70	.77	.83	.83	.82	.79	.81	.79
Neut T2	.52	.35	.35	.48	.54	.59	.62	.64	.51	.74	.64	.73	.78	.75	.79	.77	.80	.75
E-N Diff	*.06*	*−.01*	*.03*	*.00*	*−.01*	*.02*	*.09*	*.03*	***.03***	*.04*	*.06*	*.04*	*.05*	*.08*	*.03*	*.02*	*.01*	***.04***
Younger adults - 84 ms/item (Exp. 2b)																		
Emot T2	.54	.40	.36	.46	.56	.52	.65	.63	.52	.68	.68	.74	.77	.82	.78	.78	.78	.75
Neut T2	.67	.41	.48	.51	.51	.65	.70	.64	.57	.73	.68	.73	.78	.77	.80	.78	.79	.76
E-N Diff	*−.13*	*−.01*	*−.12*	*−.05*	*.05*	*−.13*	*−.05*	*−.01*	***−.05***	*−.05*	*.00*	*.01*	*−.01*	*.05*	*−.02*	*.00*	*−.01*	***−.01***
Standard Deviations																		
Younger adults - 116 ms/item (Exp. 2a)																		
Emot T2	.14	.18	.18	.14	.12	.09	.09	.08	.13	.11	.12	.13	.10	.06	.05	.08	.07	.09
Neut T2	.14	.18	.18	.14	.11	.09	.09	.10	.13	.08	.09	.07	.06	.06	.06	.04	.07	.07
E-N Diff	*.13*	*.19*	*.16*	*.15*	*.14*	*.10*	*.11*	*.09*	***.13***	*.13*	*.14*	*.09*	*.10*	*.06*	*.06*	*.07*	*.06*	***.09***
Older adults - 116 ms/item (Exp. 2a)																		
Emot T2	.29	.22	.25	.24	.28	.26	.22	.20	.25	.19	.21	.19	.16	.17	.18	.21	.19	.19
Neut T2	.25	.21	.24	.29	.24	.26	.25	.22	.25	.23	.22	.22	.24	.20	.18	.19	.20	.21
E-N Diff	*.26*	*.26*	*.28*	*.25*	*.22*	*.23*	*.19*	*.18*	***.23***	*.20*	*.17*	*.16*	*.14*	*.13*	*.16*	*.14*	*.11*	***.15***
Younger adults - 84 ms/item (Exp. 2b)																		
Emot T2	.26	.21	.22	.20	.23	.26	.19	.21	.22	.23	.21	.18	.20	.21	.18	.21	.20	.20
Neut T2	.24	.17	.22	.21	.25	.22	.23	.22	.22	.23	.20	.22	.23	.17	.20	.20	.20	.21
E-N Diff	*.27*	*.23*	*.21*	*.22*	*.22*	*.23*	*.24*	*.21*	***.23***	*.15*	*.17*	*.18*	*.16*	*.17*	*.17*	*.19*	*.16*	***.17***

Note. Exp. = Experiment; Emot T2 = T2 accuracy for emotional items; Neut T2 = T2 accuracy for neutral items; E-N Diff = Emot T2 minus Neut T2 difference scores.