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The Effect of Emotional Faces on the Attentional Blink in Younger and Older Adults

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THE IMPACT OF EMOTIONAL FACES ON THE ATTENTIONAL BLINK IN
YOUNGER AND OLDER ADULTS

A Thesis
Presented to
The Faculty of the Department of Psychological Sciences
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Allison Sklenar

August 2016

THE IMPACT OF EMOTIONAL FACES ON THE ATTENTIONAL BLINK IN
YOUNGER AND OLDER ADULTS

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The attentional blink occurs when detection of a second target (T2) is impaired when it occurs between 180 to 450 ms after the first target (T1) in a rapid serial visual presentation (RSVP). The attentional blink can be affected by relevant emotional stimuli, like emotional faces, such that an emotional T1 enhances the attentional blink, and an emotional T2 attenuates it. However, not all studies use the same type of face stimuli, and there is debate over whether schematic and photo-realistic faces are processed in the same way. Furthermore, the effect of emotion on the attentional blink should differ with age, given the tendency for younger adults to display a negativity bias and for older adults to display a positivity effect. Very little research has been conducted on the attentional blink with emotional stimuli in older adults. In fact, the effect of emotional faces, which are arguably more salient stimuli than other stimuli such as emotional words, on the attentional blink has not been investigated in older adults. Therefore, this study sought to examine the impact of emotional faces on the attentional blink in younger and older adults using photo-realistic faces with angry, happy, and neutral expressions as targets in a RSVP. Although older adults did perform worse overall, there were no age differences in the effect of emotion on the attentional blink. Angry faces, as well as happy faces to a limited extent, increased the attentional blink when they served as T1. Neither the angry or happy faces as T2 were able to attenuate the blink. Given that emotional faces affected the attentional blink at T1 but not at T2, it may be the case that

the emotional expressions served to maintain attention, rather than to capture it. Future studies are necessary to test this idea, as well as to more directly test the differential effect of emotional photorealistic and schematic faces on the attentional blink.

Chapter 1: Introduction

The attentional blink is a phenomenon in which detection of a second target is impaired when it appears shortly after a first target within a rapid serial visual presentation (RSVP), where each item is presented for approximately 100 ms. Participants who view a RSVP stream are asked to identify two target stimuli, target 1 (T1) and target 2 (T2), among a number of distractor stimuli (see Figure 1). When the second target follows the first within a few lags, usually within 180 to 450 ms after T1, detection of T2 is impaired (Ogawa & Suzuki, 2004). This phenomenon has been demonstrated with a wide variety of stimuli, including letters, numbers, symbols, words, and pictures (Shapiro, Arnell, & Raymond, 1997). Researchers have used the attentional blink to investigate the visual system, information processing, attentional allocation, and consciousness. Emotion, particularly emotional faces, can have a strong impact on the attentional blink (Bach, Schmidt-Daffy, & Dolan, 2014; Mack, Pappas, Silverman, & Gray, 2002). However, the literature on the contribution of emotion to the attentional blink is conflicting. There are a number of theories that account for the phenomenon of the attentional blink.

Theories for the Attentional Blink

The precise reason for the attentional blink and the time course of the impairment of the second target is unclear. However, researchers have proposed some possible explanations for the phenomenon. Neurophysiological studies on the standard attentional blink using event-related potentials (ERP) and functional magnetic resonance imaging (fMRI) have shown that even when the attentional blink occurs and T2 is not detected,

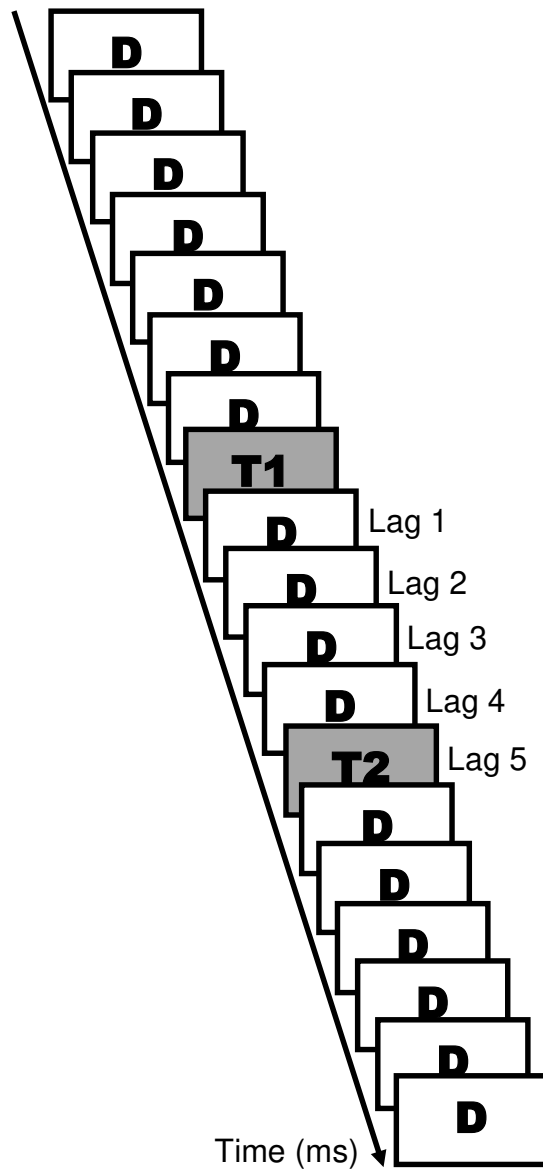


Figure 1. Diagram of the typical RSVP stream used in attentional blink studies, comprised of distractors (D) and targets one (T1) and two (T2). Each stimulus is presented for around 100 ms. The position of T1 and T2 varies within the stream by trial, with a preset number of distractors always appearing at the beginning and end of the stream.

T2 processing still occurs to a certain extent (Kranzloch, Debener, Schwarzbach, Goebel, & Engel, 2004; Vogel, Luck, & Shapiro, 1998). More specifically, T2 is still visually perceived and is processed up to the point of meaning extraction, but it is not consciously attended (Luck, Vogel, & Shapiro, 1996; Vogel et al., 1998). Therefore, interference involved in the attentional blink most likely occurs post-perceptually, at a later stage of processing. Arnell, Stokes, MacLean, and Gicante (2008) suggested that working memory may be involved in the attentional blink, with the two being negatively correlated. It seems that the attentional blink occurs because of an impairment either just before or during the encoding of T2 into working memory (Vogel et al., 1998).

Interference Theory. Although there are many possible explanations for the attentional blink, most popular theories posit that there is a limited capacity for information processing. According to the interference theory, when T2 follows shortly after T1, the processing of T1 monopolizes the limited capacity, thus interfering with the ability of T2 to be processed and therefore detected (Maciokas & Crognale, 2003; Ogawa & Suzuki, 2004). Both T1 and T2 enter into working memory so that they can be processed to the extent that targets are distinguished from distractors and later reported. However, the processing of T1 in working memory interferes with the representation of T2 in working memory, sometimes causing it to be lost. Therefore, the processing of T2 depends on the amount of processing that T1 receives. However, this theory seems a bit too simplistic to fully describe the mechanisms for the attentional blink. For instance, there are different types and levels of processing, and it may be the case that both T1 and T2 can be processed perceptually simultaneously and without interference, but that more

complex processing to the point of planning a response consumes more of the limited capacity, and therefore is susceptible to interference.

Two-Stage Model. Another limited capacity theory is the two-stage model, which theorizes that information processing occurs in two stages (Chun & Potter, 1995). Current research suggests that the first stage, which deals with the visual-perceptual processing of basic features, occurs outside of an individual's awareness (Harris, McMahon, & Woldorff, 2013; Simione et al., 2014) and additionally has an unlimited capacity (Chun & Potter, 1995). Therefore, all information is visually processed and analyzed categorically in the first stage, likely in order to discriminate targets from distractors, but the resulting representation is susceptible to interference (Chun & Potter, 1995; Olivers & Nieuwenhuis, 2006). The second stage of processing is thought to require attention to select the items that receive further processing, occurs more consciously (Harris et al., 2013; Simione et al., 2014), and has a limited capacity, which is reached due to the rate at which items are presented in the RSVP (Chun & Potter, 1995). Given that relevant information is encoded into a durable form capable of being reported during the second stage (Anderson, 2005; Chun & Potter, 1995; Olivers & Nieuwenhuis, 2006), interference occurs before T2 is encoded into working memory, rather than during this encoding, like the interference theory suggests.

Support for a two-stage interference explanation comes from the finding that the attentional blink does not occur when T2 follows immediately after T1 at a lag of one, with no distractor stimuli in between the two targets (Hommel & Akyürek, 2005). This phenomenon, known as lag-1 sparing, suggests that during RSVP trials with a lag of one, T1 is presented and enters into the first stage of processing, but that T2 is presented

before T1 can enter into the second stage of processing. Therefore, resources are allocated to T2 before T1 can monopolize the limited capacity of the processing system, and both targets can enter into the same window of processing and be detected. However, when T2 is presented around lag 2, with a distractor between T1 and T2, T1 is more likely to enter into the second stage of processing just before T2 is presented. T2 will subsequently enter into the first stage of processing, but entrance into the second stage is delayed until the end of T1 processing, if not lost, thus interfering with the ability of T2 to be processed and detected (Chun & Potter, 1995).

Some researchers have speculated that a combination of the two-stage and interference models may be a more accurate explanation of the mechanisms for the attentional blink (Kranzioch et al., 2004; Vogel et al., 1998). Before information moves from the first to the second stage of processing, it is first temporarily stored in a conceptual short-term memory buffer where it may decay or be replaced due to interference from other stimuli. Accordingly, it is possible that a representation of T2 is formed in working memory, but that the later stage processing of T1, potentially to develop or select a response, interferes with the ability of T2 to be properly encoded in working memory, or that the processing of T2 is delayed while T1 is being processed (Vogel et al., 1998). Therefore, during the attentional blink, the presentation of distractors following T2 overwrites the processing of T2, so that rather than just being delayed by T1 processing, the late stage processing of T2 might not occur at all (Vogel & Luck, 2002). A reworked combination of the two limited capacity theories seems to adequately address the major issues with both individual theories.

Overinvestment Theory. Another theory, however, asserts that the attentional blink is not due to a limited cognitive capacity, but rather due to an overinvestment of resources in T1. According to the overinvestment theory, participants pay more attention than is needed to the first target, thus diverting attention away from the upcoming target (Colzato, Spapé, Pannebakker, & Hommel, 2007). This idea of allocating too much attention to the RSVP stream is an important component of the attentional blink. The finding that participants who are instructed to concentrate less on the task actually perform better and are more likely to detect the second targets, whereas participants who are instructed to concentrate more perform worse, provides support for the overinvestment explanation (Olivers & Nieuwenhuis, 2006). Similarly, participants actually perform better when placed under cognitive load, and the attentional blink is attenuated. As Olivers and Nieuwenhuis (2006) mentioned, these results are at odds with the limited capacity explanation for the attentional blink. Yet, both theories may be accurate to a certain extent. It may be the case that capacity for processing is limited, but that this capacity would not be reached if not for the overinvestment of resources to T1.

Regardless of which of these theories most accurately explains how the interference of the processing of T2 occurs, they all seem to support the same underlying pattern. Stimuli in the attentional blink are first visually processed, and this perceptual processing can take place outside of awareness and without attention. Under normal conditions, T2 should then be encoded into working memory so that a durable, reportable representation is created. However, if there is interference from T1, whether due to limited capacity or overinvestment, then the second stage of processing might not occur for T2, at least not in its entirety, leaving T2 undetected.

Effect of Emotion on Cognition and Attention

Emotional stimuli can have a significant effect on attention and cognition. Emotional information is better encoded into working memory than non-emotional (Kanske, Schönfelder, & Wessa, 2013), and is therefore more likely to be processed at later stages and to subsequently enter into conscious awareness. This effect may be related to connections between the amygdala, a medial temporal lobe structure involved in emotion, and the visual cortex (Vuilleumier, 2005). The amygdala processes positive and negative information, yet studies have shown more consistent amygdala activation for negative than for positive information (Hamann, Ely, Hoffman, & Kilts, 2002; Liberzon, Phan, Decker, & Taylor, 2003). The negativity bias, which is the tendency for a faster and larger response to negative information than for positive or neutral information, is one possible explanation for this (Liberzon et al., 2003). Behavioral studies have demonstrated that negative stimuli, in particular threatening images, tend to capture attention better than positive stimuli (Lundqvist & Öhman, 2005). This makes sense evolutionarily, as the rapid processing of negative information allows for greater odds of survival if it is essential to avoid a negative stimulus (Hilgard, Weinberg, Hajcak Proudfit, & Bartholow, 2014; Liberzon et al., 2003).

Emotion and the Attentional Blink

Emotion can additionally affect the attentional blink. When T1 is emotional, the magnitude of the attentional blink tends to be greater as participants are less likely to identify T2 (de Jong, Koster, van Wees, & Martens, 2010). This suggests that emotional T1 stimuli capture and maintain attention more than do non-emotional stimuli, taking resources that might otherwise be available for T2. Even more interestingly, when T2 is

emotional, there is an attenuation of the attentional blink as participants are much more likely to identify second targets (Kihara & Osaka, 2008; Maratos, Mogg, & Bradley, 2008; Ogawa & Suzuki, 2004). An emotional second target may capture attention even as T1 is still being processed. Therefore, an emotional T1 is able to negate the attenuation of the attentional blink normally caused by an emotional T2 (Schwabe & Wolf, 2010). In other words, when both targets are emotional, their effects cancel each other out, and the attentional blink occurs like it would without the emotional stimuli.

Valence and Arousal. There is a debate over whether all emotional stimuli affect the attentional blink equally, regardless of valence, or whether negative information has a greater impact. Some studies have shown effects on the attentional blink with any emotional stimuli, positive or negative. For example, both positive and negative T2 stimuli have been shown to attenuate the attentional blink (Anderson, 2005; de Jong, Koster, van Wees, & Martens, 2009). However, other studies have only found these effects with negative stimuli (Ogawa & Suzuki, 2004). For example, Kihara and Osaka (2008) showed that identification of T2 was greatest when it was a negative word, compared to positive and neutral, thus supporting the negativity bias. Some studies have even found a greater effect with positive than with negative T1 stimuli (Srivastava, Kumar, & Srinivasan, 2010), which contradicts the previously described findings. Yet, these findings could be due to the use of sad words as the negative T2 stimuli, which do not have the evolutionary significance that angry and fearful stimulation might. For instance, according to the anger superiority hypothesis, both positive and negative information are given preferential processing over neutral information, but when attentional competition is high, priority is given to arousing negative information, like an

angry face (de Jong et al., 2010; Simione et al., 2014). De Jong et al. (2009) argued that the anger superiority effect only emerges when positive and negative stimuli are in direct competition for resources, but that, otherwise, negative stimuli have no processing advantage over positive stimuli. However, in many of these studies, participant-reported stimulus arousal, or the degree of emotionality, was not accounted for. Therefore, arousal, rather than valence, may be responsible for the differential impact on the attentional blink.

There is also uncertainty over whether arousal, in addition to valence, has an impact on the attentional blink. Some studies indicate that emotional valence is important, regardless of arousal (Kihara & Osaka, 2008; Srivastava et al., 2010). However, others have demonstrated an increase in the attentional blink when T1 was arousing (Mathewson, Arnell, & Mansfield, 2008). Similarly, the attentional blink may be attenuated due to an arousing T2. More arousing emotional T2s may have a particularly strong effect because they may stay active in the first stage of processing longer than non-arousing stimuli, thus being less likely to fade before gaining access to working memory and more available for processing in the second stage when T1 is done being processed (Anderson, 2005). Anderson contends that valence may be processed automatically, but it is arousal that receives access to conscious awareness by overcoming the limited capacity for processing and consequently contributes to attenuation of the attentional blink. It may be the case that angry and fearful stimuli, like faces, are more arousing because of their significance for evolutionary survival mechanisms. Therefore, keeping arousal constant, it seems most likely that negative stimuli have the greatest

impact on the attentional blink. However, it still may be the case that arousal, rather than valence is most responsible for this effect.

Task Relevance. Some studies indicate that the improved processing of emotional stimuli (e.g., non-verbal facial cues or verbal semantic information) occurs at an early perceptual stage of processing, before attention comes into play (Anderson, 2005), suggesting the involvement of an automatic, bottom-up process. Bach et al. (2014) found that task-irrelevant emotion did affect the attentional blink, which is consistent with the idea that emotion captures attention automatically. However, it has also been posited that increased attention to emotional stimuli is not automatic, but rather task dependent (Stein, Zwickel, Ritter, Kitzmantel, & Schneider, 2009). Stein et al. (2009) displayed RSVPs with either a neutral, fearful, or no T1 face stimulus, and either an indoor or outdoor scene as a T2 face stimulus. Participants were instructed to report the gender of T1, report the emotion of T1, or to ignore T1 altogether. Fearful faces affected the attentional blink more than neutral faces or no face only when the emotion judgment was made. When the gender judgment was made, or when the T1 was to be ignored (both making emotion irrelevant to the task), there was no difference in the attentional blink between the three conditions of T1. Such findings that emotion only affects the attentional blink when the emotion is task-relevant, but not when task-irrelevant, support the notion that emotion does not always automatically capture attention. It therefore seems that emotion might not be processed automatically, but instead that attention plays a crucial role, and has to be directed toward the emotion.

Emotional Faces. Whereas emotional stimuli in general impact attention and the attentional blink, emotional faces can enhance this effect. It is thought that people can

quickly and efficiently process faces and their emotions (de Jong et al., 2009), although the precise mechanisms for this effect are not well known. Generally speaking, there are two approaches to stimulus perception that contribute to attention: bottom-up, which occurs unconsciously by involuntarily diverting attention to perceptually salient stimuli, and top-down, which occurs by voluntarily diverting attention toward motivationally relevant stimuli (Mohanty & Sussman, 2013). It is unknown whether enhanced processing of emotional information is due to the bottom-up saliency of the features of negative faces or to a top-down choice to attend to this potentially important emotional face. In conveying emotion, facial expressions act as social cues. These social cues can be extremely important, especially in times of danger.

Evolutionarily, facial expressions are important for survival. An angry face could signify an upcoming act of aggression, and a fearful facial expression could indicate the anticipation of aggression or a dangerous event. Therefore, the ability to quickly recognize and respond to these cues in others could be the difference between life and death, which has great evolutionary significance. Although the characteristics of faces could lead to a bottom-up capture of attention (Anderson, 2005), it seems that the increased attention to emotional faces is largely top-down, as indicated by the crucial role of task-relevance (Mohanty & Sussman, 2013). If emotional faces are irrelevant to or interfere with the task, then they do not capture attention (Stein et al., 2009). This enhanced attentional response to faces can be attributed to the fusiform gyrus. The fusiform gyrus, particularly the fusiform face area, is a medial temporal lobe structure specialized for the processing of faces (Halgren, Rajj, Marinkovic, Jousmaki, & Hari, 2000; Kawasaki et al., 2012). The fusiform gyrus interacts with the amygdala in order to

direct attention to emotional faces (Halgren et al., 2000), implying that the brain has been specialized to quickly identify faces and their emotions, further indicating the evolutionary importance of and offering support for a mechanism that processes faces in a top-down fashion.

Given their salience, emotional faces may have an even greater impact on the attentional blink than other types of emotional stimuli. Presenting an image of a negative face outside of the RSVP stream can affect the attentional blink. Qian, Meng, Chen, and Zhou (2012) found that when they presented a fearful face before the RSVP, the magnitude of the attentional blink was much greater (i.e., performance was worse), suggesting that being aware of a fearful face caused the participants to pay more attention to the upcoming RSVP stream. Consistent with this finding is the idea that positive faces contribute to a broadening of attention, in what is called global processing, whereas negative faces lead to a narrowing of attention, or local processing (Srinivasan & Hanif, 2010).

Although emotional faces affect the attentional blink, there is some debate over whether pictures of faces or schematic representations of faces should be used in studies of the attentional blink. Emotion can be more salient within images than in word stimuli, yet it has been suggested that pictures have various features that could confound the effect of the emotion itself (Anderson, 2005). For example, happy faces tend to show more teeth, and perhaps this difference in brightness or angles is what is attracting attention, rather than the emotion. Researchers began using schematic faces in order to control for these confounding facial features. However, schematic faces introduce a whole new set of confounds, despite their high degree of control. Studies that use

schematic faces reduce the salience of facial stimuli (Bach et al., 2014) as well as their ecological validity (Kanske et al., 2013), which supports the notion that it is better to use pictures of faces as stimuli to get an accurate representation of the effect of emotional faces on attention.

Aging and the Positivity Effect

There are many known cognitive differences between younger and older adults. With age, adults experience declines in their fluid cognitive functioning. For example, older adults tend to have poorer memory, selective attention, and reaction time compared to younger adults (Alperin et al., 2013; Svärd, Fischer, & Lundqvist, 2014). Another major difference is that unlike the previously discussed negativity bias seen in younger adults, older adults tend to focus more on positive information. In this positivity effect, older adults often display better attention to and memory for positive than for negative information. For example, Mather and Carstensen (2003) showed that older adults have better memory for faces presented with positive expressions than for faces presented with negative expressions. Although the positivity effect is fairly widely accepted, some studies have not found such a positivity effect in older adults (Leclerc & Kensinger, 2010). Charles, Mather, and Carstensen (2003) did not find a significant difference between memory for negative and positive images for older adults, although older adults did remember fewer negative images than did younger adults, highlighting the importance of the definition of the positivity effect.

Reasons for Discrepant Findings. There are two prominent definitions of the positivity effect displayed by older adults. The first views the positivity effect as purely an enhancement in the processing of positive information, whereas the other interprets it

as either the enhancement in the processing of positive information or simply a decrease in the negativity bias accompanied by the preservation of the processing advantage for positive information (Reed & Carstensen, 2012). Addis, Leclerc, Muscatell, and Kensinger (2010) found that, although older adults' memory for negative and neutral information was worse compared to younger adults, their memory for positive information was maintained. Due to the varying definitions, some researchers might interpret the latter as an absence of the positivity effect because positive processing in older adults was not superior to that of younger adults, whereas others might interpret this as the presence of the effect because positive processing did not decline along with the decline in negative processing. Similarly, as Charles et al. (2003) showed, even though both age groups spent more time attending to the negative images, this only resulted in greater memory for negative images in younger adults. Although this study did not find a positivity effect under the constraints of the first definition, it still found worse memory for negative information in older adults when compared to younger adults (Charles et al., 2003), suggesting the decline of the negativity bias, and can thus be interpreted as the positivity effect by the latter definition. Therefore, this difference in how the positivity effect is defined can account for some of the conflicting findings regarding the effect. However, Reed and Carstensen (2012) say that the enhancement of the processing of positive information and the decline of the negativity bias are both forms of the positivity effect.

Another possible explanation for differences in findings regarding the positivity effect is the manner in which stimuli are presented, and the activity required by participants. Studies that require participants to actively process information differently

than they would normally (e.g., directing participants' attention towards stimuli of a certain valence, asking them to judge or indicate something about the stimuli, or informing participants of a memory test before the task) are not likely to display a positivity effect (Kehoe, Toomey, Balsters, & Bokde, 2013; Mather & Knight, 2006; Reed, Chan, & Mikels, 2014; Sasse, Gamer, Büchel, & Brassen, 2014). Instead, passive tasks (i.e., ones in which attention is not instructed or controlled, there are other types of stimuli that can be attended to other than the negative stimulus, and in which participants are not made aware of any memory tests before the task) are much more likely to result in the positivity effect than tasks which limit cognitive and attentional resources (Kehoe et al., 2013; Reed et al., 2014; Sasse et al., 2014). Even when the manner of presentation is controlled with attention focusing instructions (e.g., emotion relevant judgment), having the ability to choose which stimulus to attend to is more consistent with real-world emotion processing, and older adults are therefore more likely to display the positivity effect (Sasse et al., 2014). Experimental designs that allow passive viewing or require unconstrained responses are more likely to result in the positivity effect in older adults, presumably because they are not being restricted from regulating emotional information.

The perceived arousal level of stimuli may further contribute to differences in the occurrence of the positivity effect between studies. There are differences in the way that older and younger adults process arousing information. Mather et al. (2004) found that older adults not only rate negative images as less arousing, but they also display less activation in the amygdala than younger adults for negative images. This difference is most noticeable for angry or threatening stimuli (Svård et al., 2014). In response to negative pictures, older adults' arousal ratings and amygdala responses are reduced

relative to those of younger adults, which Mather et al. (2004) interpreted as older adults' amygdalae shifting to become less reactive to high arousal images. Furthermore, when comparing older adults with a subset of younger adults who rated negative images similarly to the older adults, there was no difference in amygdala activation levels (i.e., both groups were low), which suggests that differences in amygdala activation may be a function of how arousing people find the stimuli (Mather et al., 2004).

Interestingly, although arousing stimuli elicit activation of the amygdala in both younger and older adults, low-arousal stimuli are associated with less activation of the amygdala in older adults (Dolcos, Katsumi, & Dixon, 2014). Older adults experience less activation of the amygdala in response to low-arousal stimuli, yet they experience more activity in areas associated with emotional control (PFC and ACC) than do younger adults, suggesting that these emotion regulation regions are recruited in response to low arousal negative images to reduce attention to negative information and to increase attention to positive information (Dolcos et al., 2014). Therefore, it seems that a strong automatic response is elicited from the amygdala that is maintained with age for high arousing stimuli, whereas, with low arousing stimuli, emotion regulation overcomes this prepotent response to negative stimuli in older adults (Dolcos et al., 2014). It is also possible, however, that the amygdala in older adults is not as responsive to low-arousal stimuli as it once was due to degeneration (Dolcos et al., 2014). Kehoe et al. (2013) posited that the positivity effect may be due to the combination of an increased focus on positive and a decreased processing of arousing information. Thus, older adults are less responsive to arousing stimuli than younger adults, which may partially explain the reduced attention to negative information in older adults. Emotion regulation is therefore

more likely when stimuli are arousing because older adults are not as responsive to low-arousal stimuli (Kehoe et al., 2013). Note that this is the opposite of what other researchers have posited, as mentioned above. Despite the debate, the evidence supports the existence of the positivity effect. Assuming researchers use a standardized operational definition of the positivity effect, do not use an experimental design that constrains emotional processing, and consider arousal along with valence, researchers should detect a positivity effect in older adults.

Theories for the Occurrence of the Positivity Effect. Not only is there debate over whether the positivity effect is a real and reliable phenomenon, but there is also uncertainty over the reason for the effect. There are two primary theories for the positivity effect. According to the socioemotional selectivity theory (SST), younger adults have an emphasis on learning and knowledge acquisition in order to prepare for the future, and this becomes less important over time (Carstensen, 1995). Older adults are better at and more focused on regulating their emotions, and they place a greater emphasis on emotional well-being (Carstensen & Charles, 1994). In particular, older adults seem to experience a decrease in amygdala activation as well as arousal in response to negative information (Cacioppo, Berntson, Bechara, Tranel, & Hawkley, 2011). Although lifetime experiences may contribute to this shift in priority towards emotion regulation, it is largely the result of the perception of the future as being limited (Carstensen, 1995; Charles et al., 2003). This shortened perception of the time that one has remaining until death changes motivation in older adults, which in turn affects not only goals, but cognitive processes as well (Carstensen, 2006). As a result, older adults focus on positive information in order to maximize their emotional well-being in the

present. Therefore, SST stresses that the positivity effect is due to motivational goals instead of being due to structural changes in the brain or cognitive decline.

The other major theory is the aging brain model (ABM). Like SST, the ABM also states that older adults display less amygdala activation in response to negative information and likely accounts for lower arousal ratings provided for negative stimuli by older adults relative to younger adults (Cacioppo et al., 2011). Unlike SST, the ABM states that age differences are the result of structural changes and functional neural declines, especially in the tracks that link the amygdala to sensory regions of cortex (Cacioppo et al., 2011). Accordingly, any changes in emotional processing, as seen in the positivity effect, are said to be due to deterioration of the brain with age. Therefore, whereas SST claims that the positivity effect is due to an enhancement of positive processing for motivational reasons, the ABM claims it is due to a reduction of the propensity for processing negative information. Underlying the difference between these two theories is the source of the adaptive tendency to avoid negativity in one's environment. SST pins this tendency on choice via motivation to consciously set goals to reduce one's exposure and reactivity to negative stimulation. The ABM pins this tendency on the biological consequences of physiological degradation of the nervous system, which consequently delivers less reactivity to negative stimulation.

Support for SST

Automatic and Motivated Responses. Recently, research seems to show that when assessing automatic reactions, both younger and older adults display a negativity bias (Mather & Knight, 2006). It may be the case that older adults still experience an automatic response to negative information like younger adults, but that they will

regulate the emotional information when given the time and freedom to do so (Jing et al., 2015). This suggests that cognitive decline may not be the reason for the positivity effect, as older adults are just as able to process negative information initially, when automatic reactions are measured. Therefore, motivation does seem to have an important role in the occurrence of the positivity effect. For example, Depping and Freund (2013) found that when it is important to avoid losses, such as when making a decision about which vacation or hospital to choose, older adults remember more negative information than positive information, even compared to younger adults. But again, when the task only requires evaluating the readability of text, older adults displayed the positivity effect, remembering more of the positive information. It may, therefore, be the case that if emotion is relevant to a very important task, such as one crucial to well-being, then the positivity effect in older adults disappears. This further supports the notion that older adults can process negative information, and do so automatically, but that, when possible, they regulate their emotions and focus on positive information (Depping & Freund, 2013). For example, Foster, Davis, and Kisley (2013) found a negativity bias in older adults, and concluded that older adults with greater cognitive ability were more likely to attend to negative stimuli than were other older adults. Even though the authors say their results support the ABM over SST, they acknowledge the possibility that the older adults with greater cognitive abilities may attend to negative information initially, and then, at later stages of emotion processing, emotion regulation occurs such that a positivity effect emerges (Foster et al., 2013).

Both younger and older adults are quicker to identify discrepant angry faces than to identify discrepant happy or sad faces, regardless of whether the faces are schematic

representations or true face images (Mather & Knight, 2006; Ruffman, Ng, & Jenkin, 2009). Interestingly, however, older adults are worse than younger adults when it comes to labeling angry face stimuli (Ruffman et al., 2009). However, studies also show that age differences are minimized when participants are asked to detect differences between emotional faces instead of labeling them with a verbal label (Mienaltowski et al., 2013; Orgeta & Phillips, 2007). The ability to make a same-different judgment or to detect emotion in target expressions may be unaffected in older adults because threat detection is relatively automatic and older adults have a lot of experience recognizing threat. On the other hand, the ability to label faces with a specific emotion requires more time and places additional cognitive demands on the participants, as they have to hold in mind the key features that they might use to apply the appropriate label from one trial to the next (Orgeta, 2010). Additionally, the time that participants have to view and gather information about a stimulus may interact with other task demands to impact older adults' behavioral responses to emotional stimuli. At shorter time periods, the salience of facial features may constrain processing success, whereas, with enough time, more elaborative processing allows for the enhanced processing of positive stimuli (Svård, Wiens, & Fischer, 2012) and reduced processing of negative (Isaacowitz, Allard, Murphy, & Schlangel, 2009). Mather and Knight (2006) interpreted their similar evidence as support for the notion that threat detection is an automatic process that does not decline with age. Rather, older adults' selective attentional avoidance of negative stimuli seems to be linked to later stages of processing that include emotion regulation, occurring more than 500 ms after stimulus presentation (Isaacowitz et al., 2009; Mather & Knight, 2006).

Similarly, Mather et al. (2004) interpreted the decreased reaction of older adults to negative information as evidence against the general decline in amygdala function with age, because no such decline occurred in response to positive information. It is possible that only the neural routes responsible for processing of negative information are affected. However, there is evidence that this is not the case. Younger adults can experience positivity biases by taking the perspective of older adults and older adults can experience negativity biases by taking the perspective of younger adults (Lynchard & Radvansky, 2012). Similarly, older adults can be trained to attend more to negative stimuli. Isaacowitz and Choi (2012) found that although they attended to more negative information after training, which resulted in worse mood, older adults still attended to the negative less than younger adults. This suggests that older adults use avoidance of negative information as a means of regulating affect, and that the positivity effect can be changed to an extent. The occurrence of these motivational shifts by perspective and training argues against the positivity effect being due to deficits in the aging brain. Thus, rather than being driven by cognitive declines in the aging brain, changes in the way information is processed may be responsible for the positivity effect (Mather et al., 2004). Although more evidence seems to support SST, it is possible that emotion regulation is a compensatory mechanism, and therefore the positivity effect may not be strictly due to SST or ABM. Further research is needed to determine whether the positivity effect could be the result of emotion regulation as compensation for declines in the aging brain (Waring, Addis, & Kensinger, 2013).

Physiological differences. Physiological differences further contribute to the debate over whether the positivity effect in older adults is the result of deliberate

selection of positive and avoidance of negative information or the result of a decline in the neural mechanisms associated with the processing of negative information (Mather & Knight, 2006). Even when studies do not find evidence for a positivity effect in older adults and demonstrate equivalent outcomes for younger and older adults, the underlying neural mechanisms for these outcomes are different for each age group (Leclerc & Kensinger, 2010). Are these differences due to a strategic change in processing or due to declines with age?

The brain undergoes structural and functional changes in connectivity with age. In general, older adults have greater prefrontal connectivity than younger adults for both positive and negative stimuli (Waring et al., 2013). Lee, Ratnarajah, Tuan, Chen, and Qiu (2015) suggested that these changes in prefrontal cortex (PFC) connectivity with age could reflect compensatory mechanisms following the reception of less specific information from posterior sensory cortical regions. Recent studies using fMRI have shown a positive relationship between this resting connectivity of the ventral and medial PFC (vPFC and mPFC) and anterior cingulate cortex (ACC) with the amygdala and the occurrence of the positivity effect (Ford & Kensinger, 2014; Sakaki, Nga, & Mather, 2013). For healthy older adults retrieving positive information, greater structural integrity is correlated with positive functional connectivity between the amygdala and the ventral PFC (vPFC; Ford & Kensinger, 2014). In fact, Sakaki et al. (2013) found that this connectivity is stronger in those older adult participants who display more of a positivity effect. Because this association was not present for younger adults, it has been interpreted as a possible top-down emotion regulation mechanism initiated within the PFC in service of the positivity effect (Sakaki et al., 2013). Ford and Kensinger (2014) acknowledged

that this enhanced connectivity between the vPFC and amygdala may be the result of recruitment of the vPFC to promote a motivationally driven response in the amygdala to positive information. Consistent with this, Waring et al. (2013) showed that older adults with stronger frontal connections have better memory for emotional items and their backgrounds, which they interpreted as older adults recruiting frontal regions to sufficiently widen attention enough to encode not only the emotional part of the scene, but also the background. When older adults only remembered the item and not the background, activation looked more similar to activation in younger adults, whereby this frontal activation pattern did not occur, and instead older adults displayed more posterior activation (Waring et al., 2013). Therefore, healthy older adults with sound structural neural pathways have greater functional connectivity between the vPFC and the amygdala when enhancing the processing of positive information (Ford & Kensinger, 2014).

Unlike with positive information, when retrieving negative information, greater structural connectivity is associated with less functional connectivity between the amygdala and emotion regulation regions like the dACC in older adults (Ford & Kensinger, 2014). Instead, the positivity effect in older adults is associated with an inverse functional connectivity between the mPFC and the amygdala in response to negative faces (Sakaki et al., 2013). Again, this pattern was only found for older adults (Ford & Kensinger, 2014). The enhanced structural connectivity between the dACC and the amygdala in healthy older adults, which results in less functional connectivity between these regions when viewing and retrieving negative information may be responsible for the absence of the negativity bias. Consequently, older adults display less

amygdala activation and a corresponding reduced emotional response towards negative information relative to younger adults (Ford & Kensing, 2014). In this way, the differential recruitment of the PFC and emotion regulation regions in response to positive and negative information seems to support SST over the ABM.

Aging and the Attentional Blink

Studies on the attentional blink are presumed to measure automatic responses to stimuli because the rate of stimulus presentation in the RSVP task during the attentional blink period is too fast to employ regulatory strategies. As a result, older adults should not be able to regulate their reactions to emotional stimuli presented during the attentional blink given its prevalence within the 500 ms interval following the presentation of an emotional stimulus. If this is true, then studies of the impact of aging on the attentional blink with emotional stimuli could reveal differences in how older and younger adults process emotional stimuli automatically.

Although there have been fewer than a dozen studies on the attentional blink in older adults, all have shown an increase in the magnitude of the attentional blink with age such that older adults perform worse on the RSVP task and display a lower accuracy than do younger adults when reporting on T2 (Georgiou-Karistianis et al., 2007; Jain & Kar, 2014; Jeffries et al., 2013; Lee & Hsieh, 2009). Older adults are much less likely to identify T2, not only compared to younger adults, but compared to middle-aged adults as well (Georgiou-Karistianis et al., 2007). In addition to displaying a greater magnitude of the attentional blink, older adults also show a longer attentional blink period, with the attentional blink occurring for a greater number of lags (Langley et al., 2008; Male,

Sheppard, & Bradshaw, 2009). Male et al. (2009), for example, found that it took older adults over 900 ms to reach peak accuracy, compared to 300 ms for younger adults.

In addition to needing more time to attend to targets, older adults may be less able to inhibit post-perceptual processing of the distractors due to a decrease in cognitive control (Georgiou-Karistianis et al., 2007; Jain & Kar, 2014; Langley et al., 2008). For example, there are two types of RSVP tasks: the commonly used dual-attend task, which requires attention to both targets, and the less frequently used single-attend task, which requires participants to ignore the first target and attend solely to the second target (Maciokas & Crognale, 2003). Younger adults are able to ignore the first target in the single-attend task, and therefore do not display an attentional blink like in the dual-attend task, suggesting that the interference in the dual-attend task condition is not perceptual (Maciokas & Crognale, 2003). Older adults, however, do display the attentional blink on the single-attend task across all lags, which is consistent with older adults being less able to inhibit distractors. The worse performance overall for older adults was at all lags in the dual-attend task, but especially during the attentional blink period. Older adults also display their worst performance when attempting to ignore T1 in the single-attend task. Ultimately, older adults' attention is involuntarily captured by T1 making it more difficult to inhibit distractors and select targets (Maciokas & Crognale, 2003). Consistently, greater perceptual load, as indicated by the length of the RSVP stream, resulted in worse distractor inhibition and target selection in older adults (Jain & Kar, 2014). Therefore, cognitive and attentional declines contribute to the increased magnitude and longer latency attentional blink in older adults.

Given the limited literature on the attentional blink with older adults, even fewer studies have been conducted on the attentional blink with emotional stimuli in older adults. In fact, only one study has looked at the emotional attentional blink in older adults, and this study used words. Whereas the attentional blink is thought to occur most strongly in younger adults when the emotion of T1 is negative, there may be a very different effect with older adults. As discussed, older adults tend to display a positivity effect. However, with the rate at which information is presented in the RSVP task during the attentional blink period, there is not enough time for older adults to consciously decide to avoid or ignore negative stimuli. Therefore, during the attentional blink at those early lags, older adults should show better performance for all emotional stimuli, regardless of valence (Langley et al., 2008). If older adults do respond less to negative information, then it is either due to a top-down, motivational shift or a decline in the neural network involved in signaling the possibility of threat, both of which result in the reduction of arousal to negative stimuli.

The study on the attentional blink with emotional stimuli in older adults tells a similar story. Langley et al. (2008) found a general emotion enhancing effect, but not a specific positivity effect, such that older adults did perform better for all emotional stimuli, relative to neutral stimuli. Both older and younger adults were more accurate in detecting a positive T2 relative to a neutral T2, but only older adults, surprisingly, were more accurate in detecting a negative T2 relative to a neutral T2. These findings support the notion that processing of general emotional information is relatively automatic, a finding that typically emerges when simply examining younger adult samples. Here older

adults did not show a positivity effect, which is consistent with the idea that automatic tasks should result in similar performance between age groups (Langley et al., 2008).

Current Study

The purpose of this study was to investigate the impact of emotional faces on the attentional blink in younger and older adults using photo-realistic faces with angry, happy, and neutral expressions, with the expectation that threatening expressions would be most salient for younger adults, and positive expressions would be most salient for older adults. Although there are many potential explanations for the attentional blink, the most logical theories support a mechanism by which information is processed to a certain extent automatically without attention. However, attention becomes crucial for the selection of information for later processing, resulting in the identification and report of targets. Attention can override the influence of the attentional blink effect, as seen in the dependence of the link between emotion and the attentional blink upon emotion's relevance to judgments performed in the RSVP tasks. Emotional faces are particularly salient stimuli and can have a substantial impact on the attentional blink either by increasing or decreasing the magnitude of the blink when presented at T1 or T2, respectively. However, the use of schematic faces in some studies may not give a true indication of the effect of emotional faces on the attentional blink, and therefore call into question the salience and ecological validity of face stimuli used in attentional blink research. Therefore, one goal of this study was to see if pictures of faces affect the attentional blink differently than the schematic representations used by Maratos, et al. (2008) for younger adults. If not, then the results for younger adults on the neutral-emotional trials should replicate their findings that, for younger adults, detection of T2 is

better when T2 is negative than when it is positive, and better when T2 is positive than when it is neutral.

Although there is still controversy over the differential impact of positive and negative valence on the attentional blink, it seems most likely that arousing negative (especially threatening) faces are more likely to enhance the attentional blink when they serve as the first target and attenuate the attentional blink when they serve as the second target when younger adults are examined. For older adults, however, the effect of emotional facial expressions on the attentional blink is still unknown. Although older adults generally exhibit a positivity effect, this effect may not influence the attentional blink. As with younger adults, happy faces may enhance the attentional blink displayed by older adults when they appear as the first target and they may attenuate the attentional blink when appearing as the second target. It is not clear how negative emotional faces will impact older adults' attentional blink. If older adults display a reduced reactivity to angry facial expressions, regardless of whether due to a motivational shift away from investing resources into negativity or due to neural degeneration of threat sensitive brain regions, older adults might show a reduced enhancement to angry expressions or no attentional blink enhancement at all relative to neutral when angry expressions serve as the first target. Similarly, when angry expressions appear as the second target, they might not capture older adults' attention in the same manner that they capture younger adults' attention, resulting in a failure to attenuate the attentional blink.

Hypotheses for Emotional-Neutral Trials. Given that the attentional blink is operationalized as a decrease in the likelihood of detecting T2 when T2 follows roughly 180 to 450 ms after T1, any effects of the attentional blink for younger adults were

expected at lags 2 and 3 for younger adults, and for several extended lags for older adults. Given that emotional stimuli as T1 can further worsen the attentional blink, it follows that the emotions that are most salient are likely to increase the attentional blink more than other emotions. Therefore, given the negativity bias in younger adults, when the first target face was angry relative to when it was neutral, younger adults were expected to be less accurate at detecting a neutral second target face (Hypothesis 1). Similar findings were expected to emerge on trials in which happy faces were used as T1, with less accuracy relative to a neutral T1 (Hypothesis 2a); however, given the anger superiority effect in younger adults, angry faces were also expected to elicit a larger attentional blink compared to when T1 was happy (Hypothesis 2b).

Given age differences normally observed in the attentional blink, it was not entirely clear if older adults would display the same magnitude effects as younger adults. For instance, if older adults do prioritize happy stimuli more so than do younger adults, perhaps this motivational effect would boost older adults' performance to be similar to those of younger adults with respect to stimulus pairings that include happy faces. On the other hand, given neurological, motivational, and cognitive changes that take place with age, older adults were not expected to show the same findings as younger adults when angry faces were used as first and second targets, such that when angry faces appeared as the first target in the RSVP stream, they were expected to elicit an attentional blink in older adults similar in magnitude to neutral first targets (Hypothesis 3). Conversely, because of the positivity effect, older adults were expected to be worse at identifying a neutral T2 when T1 was a happy face than when it was a neutral face (Hypothesis 4).

Hypotheses for Neutral-Emotional Trials. Again, given that younger adults tend to display a negativity bias, after seeing a neutral first target face, younger adults were expected to be more accurate at detecting the second target face if it was angry relative to when it was neutral (Hypothesis 5). Similar findings were expected to emerge on trials in which happy faces were used as T2, with greater accuracy compared to when T2 was neutral (Hypothesis 6a). Again, however, given the anger superiority effect, happy faces were also expected to elicit a smaller effect on the attentional blink of younger adults compared to when T2 was angry (Hypothesis 6b).

When angry faces appeared as T2 in the RSVP stream, they were expected to be less effective at capturing older adults' attention than they were at capturing the attention of younger adults (Hypotheses 7), thus suppressing the attenuation of the attentional blink usually seen with emotional T2s. However, when a happy T2 followed a neutral T1, older adults' accuracy was expected to be better than when T2 was neutral (Hypothesis 8).

Chapter 2: Method

Design

A 2 (Age Group: younger/older adults) x 7 (T1-T2 Pairing Trial Type: angry-happy/angry-neutral/happy-angry/happy-neutral/neutral-angry/neutral-happy/neutral-neutral) x 8 (Lag: 1/2/3/4/5/6/8/9) mixed model design was used. Age group was a between-subjects quasi-experimental variable and trial type and lag were within-subjects variables. The dependent variable was percent accuracy, or the percentage of trials for each trial type at each lag that participants were correct in answering all three of the questions.

Participants

Participants initially included 24 younger adults and 27 older adults, however two younger adults were removed for not following instructions and five older adults were dropped due to computer or software malfunction. The remaining participants included 22 younger adults (9 Male/13 Female; ages 18-22 years, $M = 18.7$, $SD = 1.2$) and 22 older adults (12 Male/10 Female; ages 62-78 years, $M = 69.8$, $SD = 4.1$). Younger adult participants were students at Western Kentucky University recruited through an online research scheduling system that awarded students course credit for their participation. Older adults were recruited from the community by sending recruitment letters to a random sample of older adults listed on voter registration records. Older adult participants were compensated for their time with a \$25 gift card. Older adults were screened for mild cognitive impairment using the Telephone Mini Mental Status Exam (TMMSE; Folstein, Folstein, & McHugh, 1975; see Appendix A). In order to participate, older adults must have had normal cognitive functioning, as indicated by a score in the

range of 22 to 27, on a scale that ranges from 0 to 27. Visual acuity was assessed by the Colenbrander Visual Acuity Test (www.ski.org). Younger and older adults were also screened for depression using the Center for Epidemiological Studies Depression (CES-D) scale (Radloff, 1977).

Stimuli and Materials

Two-hundred and nineteen pictures of faces taken from the NimStim facial stimulus set (Tottenham et al., 2009) were used as the target faces. Target images included 73 faces with three different emotional expressions: angry, neutral, and happy. Distractor images were created by randomly shuffling rectangular segments of the images of thirty of the face pictures using GIMP 2 photo-editing software (<http://www.gimp.org/>). Both target faces and distractor images appeared in the shape of an 8.3° (w) \times 11.3° (h) oval against a black background. The tasks were presented through EPrime software (PsychologySoftware Tools, Pittsburgh, USA) on an ASUS 24-inch 1920×1080 full HD LCD monitor with a 144 Hz refresh rate. Participants were seated approximately 57.3 cm away from the monitor.

Center for Epidemiological Studies Depression (CES-D) Scale. Participants completed the CES-D scale (Radloff, 1977) to ensure that depression was not a confounding factor. The scale includes 20 statements that could describe participants' emotional status (see Appendix B). Participants had to indicate the extent to which they have felt that way during the past week, using a four-point rating scale: 1. "Rarely or none of the time (less than one day)", 2. "Some or a little of the time (1-2 days)", 3. "Occasionally or a moderate amount of time (3-4 days)", or 4. "Most or all of the time (5-

7 days).” The responses for each statement were added, so that each participant had a total score. Internal consistency on the CES-D was .94.

Demographic Questionnaire. Participants completed a demographic questionnaire (see Appendix C) in order to gauge the representativeness of the sample of Warren County, Kentucky and the United States. The demographic questionnaire included 23 questions about participants’ gender, marital status, age, family background, ethnicity, religious background, education, employment status, health, etc.

Snellen Visual Acuity Test. The Colenbrander 1-meter chart was used to assess visual acuity with corrected vision when applicable. Standing one meter from the chart, participants were asked to say out loud the smallest row of letters that they could read. Individual scores were transformed to log MAR (minimum angle of resolution).

Procedure

This study was approved by Western Kentucky University’s Institutional Review Board (IRB; WKU IRB #15-171). Upon entering the lab, participants were randomly assigned to a testing room and seated approximately 57.3 cm away from the computer screen. After reading and signing the informed consent document, participants completed a brief screening task in order to ensure that participants were able to discriminate between emotional expression types when there was only a single target in the RSVP stream. For this initial task, participants were presented up to 50 trials of single target RSVP streams (see Figure 2). These streams were comprised of a central fixation point presented for 210 ms followed by 19 items presented for 126 ms each, 18 of which were distractors, and one of which was a target face with an angry, neutral, or happy expression. The target face was interspersed randomly between items 5 and 17 in

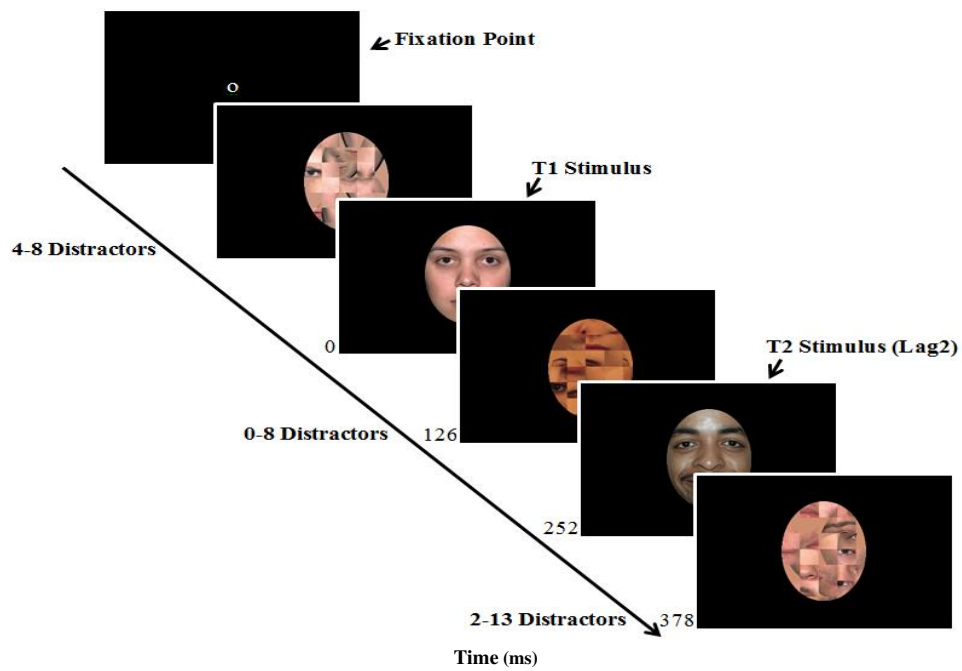


Figure 2. Diagram of a double target RSVP trial used in the main task, with the fixation point presented for 210 ms and each subsequent item presented for 126 ms. Note that any single target trials used in the main task or in the screening task have this same format, except that one of the target faces is replaced by a distractor image.

the stream. At the end of each trial, participants were prompted to respond what the emotional expression of the face in the stream was by pressing a key on a keyboard: “j” for angry, “k” for neutral, and “l” for happy. Nine consecutive correct responses were required to be able to continue on with the experiment. None of the participants failed to successfully complete the screening task.

The main task included 12 blocks of 53 trials, with breaks between each block. Test trials included 156 single target filler trials and 480 double target trials. Single target trials included 52 angry, 52 happy, and 52 neutral trials. Trial order was random. Double target trials included two target faces presented between items 5 and 17 in the RSVP stream. The second target (T2) followed the first target (T1) at a lag of 1, 2, 3, 4, 5, 6, 8, or 9. Double target trials included 40 trials in which the first target was angry and the second was happy, 40 happy-angry, 80 angry-neutral, 80 happy-neutral, 80 neutral-angry, 80 neutral-happy, and 80 neutral-neutral. Participants were instructed to pay attention to the number of faces as well as to the emotional expressions of those faces, but that correctly reporting the emotions should be their main priority. At the end of each trial on the main task, participants were prompted to answer either two or three questions. Participants were first asked: “How many faces did you see?” If participants responded that they saw two faces, then they were asked two additional questions: “What was the emotional expression of the first face you saw?”, and “What was the emotional expression of the last face that you saw?” If, however, participants responded that they only saw one face, then they were only asked one additional question: “What was the emotional expression of the last face that you saw?” Participants responded by pressing keys on a computer keyboard: “s” for one, “d” for two, “j” for angry, “k” for neutral, and

“l” for happy. In order to reduce the likelihood of fatigue effects, participants were given the CES-D scale (Radloff, 1977) and demographics questionnaire to complete when they reached the break halfway through the main task. Doing so ensured that all participants took a substantial break from the task. Participants then completed the rest of the main task.

Following the remainder of the main task, participants completed an emotion recognition task, in which each of the faces used as targets in the main task was presented individually in the center of the screen and participants simply had to identify the emotional expression of the face using the same keys as in the main task: “j” for angry, “k” for neutral, and “l” for happy. Each image remained on the screen until a response was made. After identifying the emotional expression of each face, participants rated the intensity of the emotional expression of each face, using the following scale: 1: Emotion not expressed at all; 2: Emotion expressed at low intensity; 3: Emotion expressed at moderate intensity; 4: Emotion expressed at high intensity. Participants then completed the brief Colenbrander Visual Acuity Test and were debriefed and thanked for their participation.

Chapter 3: Results

Demographic Comparisons

Independent samples t-tests were conducted to compare CES-D scores, visual acuity, and subjective health ratings between age groups. Visual acuity was significantly better in younger adults ($M = .01$, $SD = .03$) than in older adults ($M = .11$, $SD = .11$), $t(42) = -4.04$, $p < .001$, $d = 1.24$. However, inclusion of visual acuity in the analyses as a covariate did not affect the results. There was not a significant difference in CES-D scores between younger and older adults, $t(42) = 1.15$, $p = .258$. Younger and older adults did not differ in ratings of their overall health, $t(42) = 0.66$, $p = .514$; or of their self-report on how much health problems interfered with what they want to do, $t(42) = -1.13$, $p = .264$.

RSVP Accuracy

Three-Question Accuracy. The data for the main task were transformed into percent accuracies for each condition as a function of lag. For double target trials, accuracy for a given trial reflects the fact that participants were 100% correct on that trial when answering the number question and two emotion questions. Given that the hypotheses entering into this study involved making comparisons among the conditions of the emotional-neutral trial types and also making comparisons among the neutral-emotional trial types, the accuracy data were subjected to two 2 (Age Group: young/old) x 3 (Trial Type) x 8 (Lag:1/2/3/4/5/6/8/9) within-subjects ANOVAs. That is, separate ANOVAs were conducted to examine the attentional blink given the appearance of emotional stimuli as either the first target (emotional-neutral) or the second target

(neutral-emotional). Post-hoc comparisons were performed using Sidak tests that correct the family-wise error rate per the number of comparisons specified per model.

Emotional T1-Neutral T2. For the trials in which T1 was emotional and T2 was neutral, a 2 (Age Group: young/old) x 3 (Trial Type: angry-neutral/happy-neutral/neutral-neutral) x 8 (Lag:1/2/3/4/5/6/8/9) mixed model ANOVA was run. There was a main effect of lag, $F(7, 294) = 91.01, p < .001, \eta_p^2 = .68$, indicating lower accuracy at early lags and greater accuracy at later lags (see Table 1). There was a main effect of trial type, $F(2, 84) = 13.61, p < .001, \eta_p^2 = .25$. Means and standard errors for trial type are listed in Table 2. Sidak post-hoc comparisons showed that accuracy for the angry-neutral trials was significantly worse than for happy-neutral trials ($p < .001$) and neutral-neutral trials ($p < .001$). Accuracy was slightly less for the happy-neutral trials than for the neutral-neutral trials, but this difference was not significant ($p = .266$). Only the angry T1 was able to significantly increase the magnitude of the attentional blink when T2 was neutral, as indexed by the reduction in accuracy.

There was a trial type x lag interaction, $F(14, 588) = 4.64, p < .001, \eta_p^2 = .10$, indicating that there was a larger difference between trial types at early lags than at later lags (see Figure 3). One-way (Trial Type: angry-neutral/happy-neutral/neutral-neutral) ANOVAs were then run for each lag individually. These indicated that there were significant differences between the three trial types at lag 1, $F(2, 86) = 7.07, p = .001, \eta_p^2 = .14$; at lag 2, $F(2, 86) = 23.87, p < .001, \eta_p^2 = .36$; at lag 3, $F(2, 86) = 15.26, p < .001, \eta_p^2 = .26$; and at lag 4, $F(2, 86) = 8.13, p = .001, \eta_p^2 = .16$. Sidak post-hoc comparisons showed that accuracy on angry-neutral trials was worse than on neutral-neutral trials at lag 1 ($p = .002$), at lag 2 ($p < .001$), at lag 3 ($p < .001$), and at lag 4 ($p = .002$). Angry-

neutral trial accuracy was worse than happy-neutral trial accuracy at lag 1 ($p = .006$), at lag 2 ($p = .007$), and at lag 3 ($p < .001$). Finally, accuracy on happy-neutral trials was significantly worse than on neutral-neutral trials only at lag 2 ($p = .002$). These results suggest that, regardless of age, angry T1 stimuli impaired neutral T2 detection for the first four lags, and happy T1 stimuli did so only at lag 2.

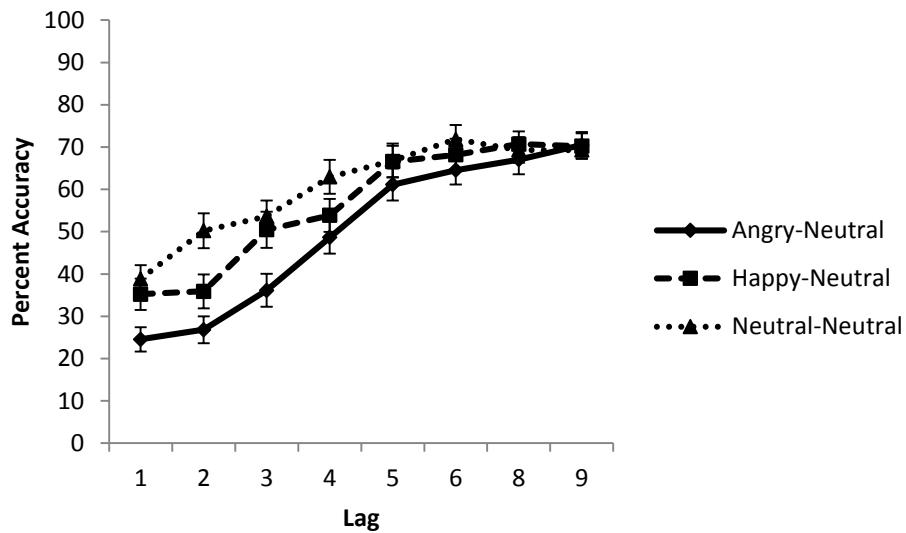


Figure 3. Mean percent accuracy for the emotional-neutral trials (i.e., double target trials with an emotional T1 and a neutral T2), collapsed across age groups. Accuracy was defined as correctly identifying the number of targets and the emotional expressions of both T1 and T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

Table 1

Main Effect of Lag on Percent Accuracy in Emotional-Neutral Trials

Lag	Mean	SE
1	32.9	2.4
2	37.7	3.2
3	46.7	3.5
4	55.2	3.3
5	64.8	3.3
6	68.2	3.1
8	69.0	2.6
9	70.0	2.5

 $p < .05$

Table 2

Main Effect of Trial Type on Percent Accuracy in Emotional-Neutral Trials

Trial Type	Mean	SE
Angry-Neutral	49.9	2.8
Happy-Neutral	56.4	3.0
Neutral-Neutral	60.4	2.9

 $p < .05$

There was also a main effect of age group $F(1, 42) = 16.13, p < .001, \eta_p^2 = .28$, indicating that younger adults ($M = 66.1, SE = 3.7$) were more accurate overall than older adults ($M = 45.0, SE = 3.7; p = .000$). The analyses also revealed a significant lag x age group interaction, $F(7, 294) = 5.69, p < .001, \eta_p^2 = .12$, indicating that the difference between younger adult and older adult performance was greater at early lags than at later lags (see Figure 4). The trial type x age group, $F(2, 84) = .105, p = .901, \eta_p^2 = .00$, and trial type x lag x age group, $F(14, 588) = 1.20, p = .272, \eta_p^2 = .028$, interactions were not significant. Given that prior research (Bach et al., 2014; de Jong et al., 2010; Kihara & Osaka, 2008) did find an interaction between trial type and lag when using facial stimuli as T1 and T2 and that no other study has reported on possible age differences in the

attentional blink for this type of experiment, Figure 5 has been included to depict the trial type x lag interaction separately for each age group even though the three-way interaction was not significant.

In summary, for the emotional-neutral trials, hypothesis 1, which stated that younger adults would display an increased attentional blink when T1 was angry was supported. Hypothesis 2b was also supported, because younger adults displayed a larger attentional blink for trials in which the emotional T1 was an angry expression than on trials in which the emotional T1 was a happy expression. Hypothesis 2a for the younger adults and hypothesis 4 for older adults, which both predicted that there would be an increase in the attentional blink when T1 was happy, were both supported. However, the support for these hypotheses was limited to a single lag: lag 2. The final hypothesis for the older adults (i.e., hypothesis 3) was not supported, as the effect of the angry T1 was different than that of the neutral T1.

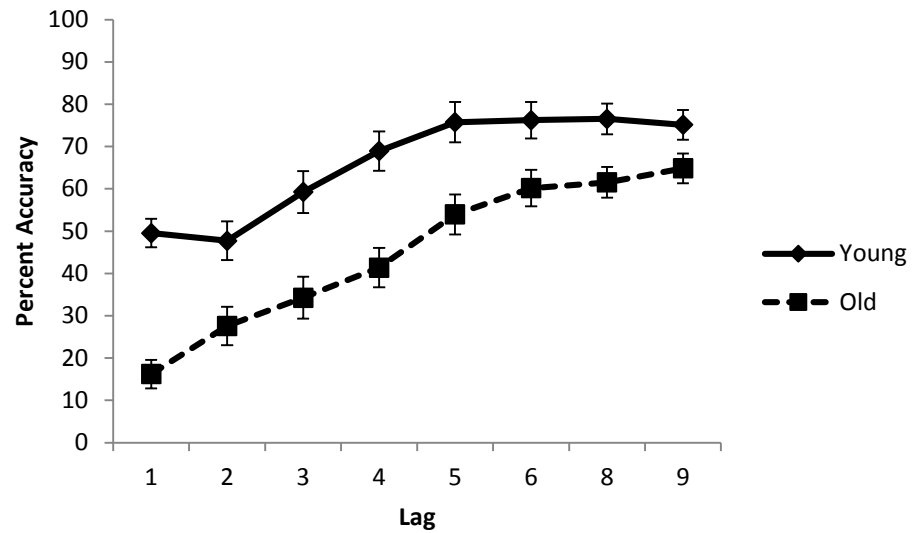
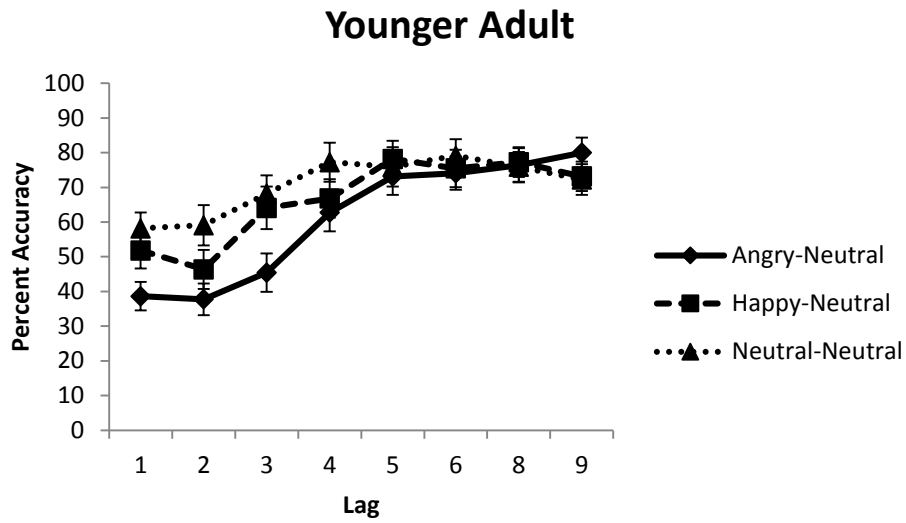


Figure 4. Mean percent accuracy for each age group on double target emotional-neutral trials at each lag, collapsed across trial type. Accuracy was defined as correctly identifying the number of targets and the emotional expressions of both T1 and T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

a.



b

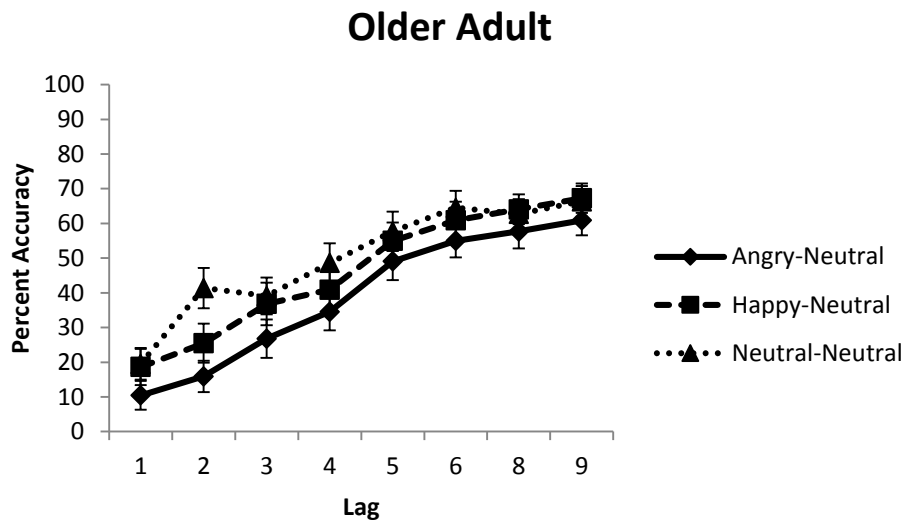


Figure 5. Percent accuracy for each of the emotional-neutral trial types at each lag in (a) younger adults and (b) older adults. Accuracy was defined as correctly identifying the number of targets and the emotional expressions of both T1 and T2. Chance performance would be around 5% accuracy. Error bars represent standard error. Note that this three-way interaction was not significant.

Neutral T1-Emotional T2. For the trials with a neutral T1 and an emotional T2, a 2 (Age Group: young/old) x 3 (Trial Type: neutral-angry/neutral-happy/neutral-neutral) x 8 (Lag: 1/2/3/4/5/6/8/9) mixed model ANOVA was run, revealing a main effect of lag, $F(7, 294) = 49.92, p < .001, \eta_p^2 = .54$, indicating better performance on the early lags than later lags (with the exception of lags 8 and 9, see Table 3). As seen in Table 4, there was also a main effect of trial type, $F(2, 84) = 3.61, p = .031, \eta_p^2 = .08$. Sidak post-hoc comparisons showed that accuracy for the neutral-angry trials was significantly worse than for the neutral-happy trials ($p = .003$). However, accuracy was not significantly different between neutral-happy trials and neutral-neutral trials ($p = .755$) or between neutral-angry trials and neutral-neutral trials ($p = .382$). Therefore, a happy T2 was more likely than an angry T2 to be detected, but there was no difference between the likelihood of an angry and neutral or happy and neutral T2 of being detected.

There was a trial type x lag interaction, $F(14, 588) = 1.87, p = .027, \eta_p^2 = .04$ (see Figure 6). One-way (Trial Type: neutral-angry/neutral-happy/neutral-neutral) ANOVAs were then run on percent accuracy for each lag individually to examine the trial type by lag interaction, which indicated significant differences between the three trial types at lag 3, $F(2, 86) = 5.32, p = .007, \eta_p^2 = .11$; lag 5 $F(2, 86) = 8.33, p < .001, \eta_p^2 = .16$; and lag 8, $F(2, 86) = 6.07, p = .003, \eta_p^2 = .12$. Sidak post-hoc comparisons showed that neutral-happy accuracy was better than neutral-neutral accuracy at lag 3 ($p = .023$) and at lag 5 ($p = .004$). Neutral-happy accuracy was better than neutral-angry accuracy at lag 3 ($p = .010$), at lag 5 ($p = .002$), and at lag 8 ($p = .006$). Finally, neutral-angry accuracy was worse than neutral-neutral accuracy at lag 8 ($p = .042$). In summary, these results suggest that happy T2 stimuli improved T2 detection for some lags, but not necessarily in a

manner consistent with the expectation that the benefit would be mainly limited to early lags. Therefore, neither type of emotional T2 was able to attenuate the attentional blink.

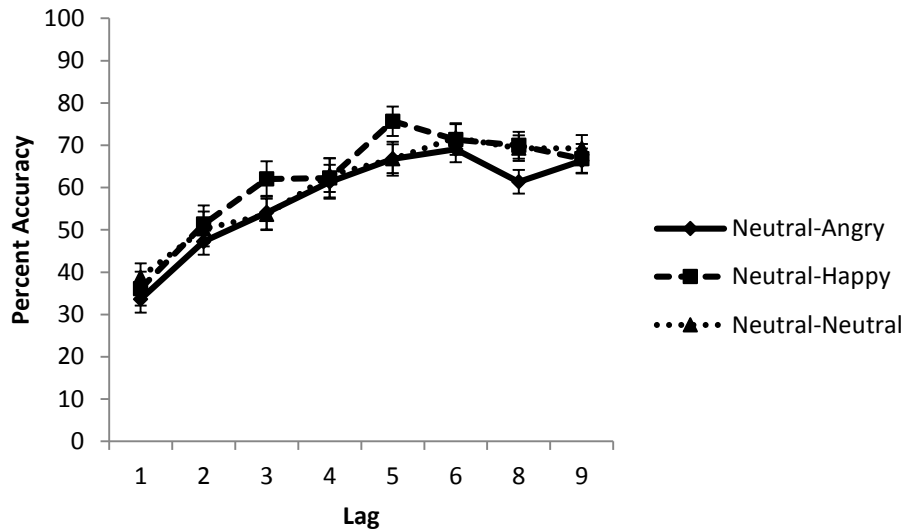


Figure 6. Mean percent accuracy for the neutral-emotional trials (i.e., double target trials with a neutral T1 and an emotional T2), collapsed across age groups. Accuracy was defined as correctly identifying the number of targets and the emotional expressions of both T1 and T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

Table 3

Main Effect of Lag on Percent Accuracy in Neutral-Emotional Trials

Lag	Mean	SE
1	36.2	2.9
2	49.6	3.4
3	56.6	3.6
4	62.2	3.8
5	69.8	3.4
6	70.8	2.9
8	66.9	2.6
9	67.5	2.6

 $p < .05$

Table 4

Main Effect of Trial Type on Percent Accuracy in Neutral-Emotional Trials

Trial Type	Mean	SE
Neutral-Angry	57.5	2.6
Neutral-Happy	62.0	3.2
Neutral-Neutral	60.4	2.9

 $p < .05$

There was also a main effect of age group $F(1, 42) = 16.38, p < .001, \eta_p^2 = .28$, indicating that younger adults ($M = 71.06, SE = 3.9$) were more accurate overall than older adults ($M = 48.8, SE = 3.9; p < .001$). The analyses also revealed a significant lag x age group interaction, $F(7, 294) = 6.78, p < .001, \eta_p^2 = .14$, indicating that the difference between younger adult and older adult performance was greater at early lags than at later lags (see Figure 7). The trial type x age group, $F(2, 84) = .33, p = .721, \eta_p^2 = .01$, and trial type x lag x age group, $F(14, 588) = 1.55, p = .089, \eta_p^2 = .04$, interactions were not significant. Given that prior research has not reported on possible age differences in the attentional blink for this type of experiment, Figure 8 has been included to depict the trial type x lag interaction separately for each age group even though the three-way interaction was not significant.

In summary, neither the angry nor the happy T2 were capable of attenuating the attentional blink. None of the hypotheses for the neutral-emotional trials in younger or older adults (i.e., hypotheses 5, 6a, 6b, 7, or 8) were supported.

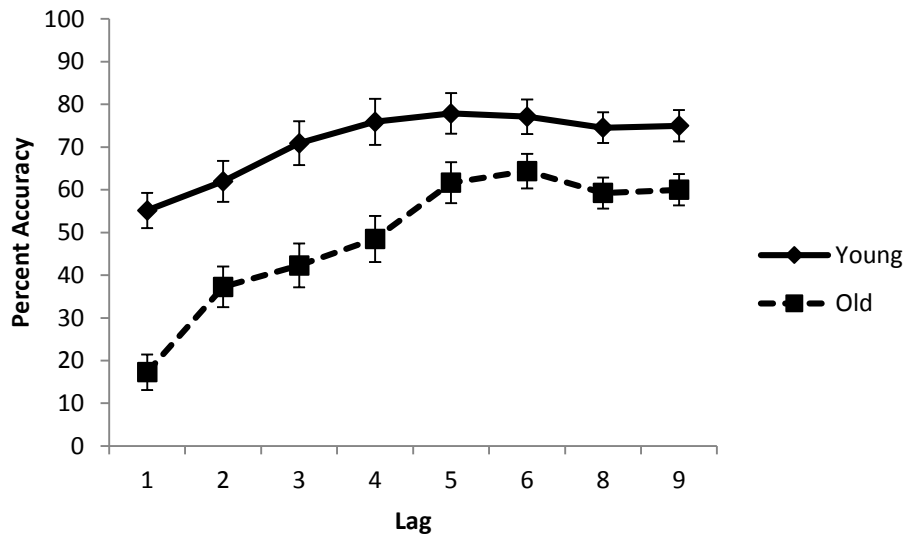
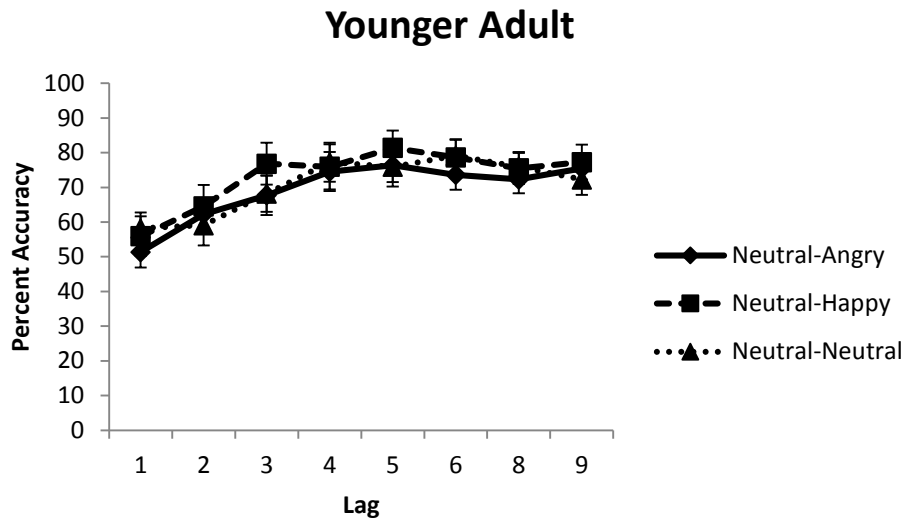


Figure 7. Mean percent accuracy for each age group on double target neutral-emotional trials at each lag, collapsed across trial type. Accuracy was defined as correctly identifying the number of targets and the emotional expressions of both T1 and T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

a.



b

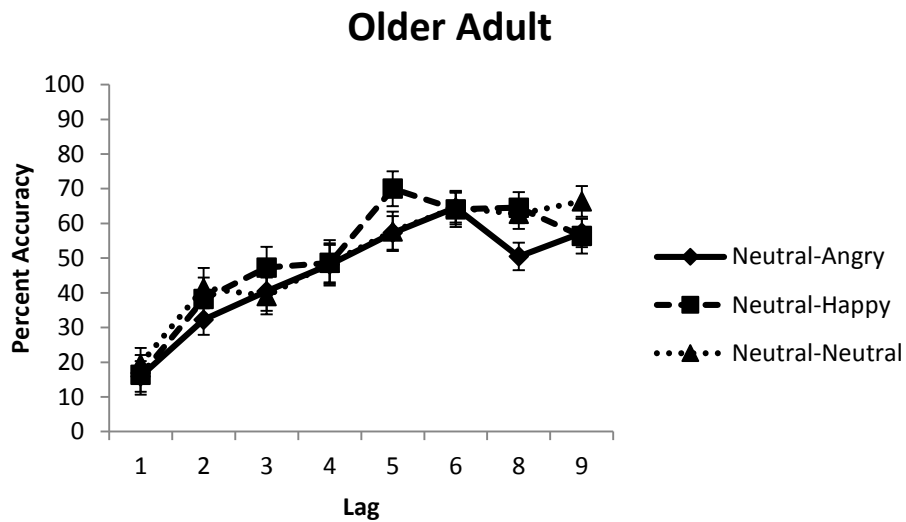


Figure 8. Percent accuracy for each of the neutral-emotional trial types at each lag in (a) younger adults and (b) older adults. Accuracy was defined as correctly identifying the number of targets and the emotional expressions of both T1 and T2. Chance performance would be around 5% accuracy. Error bars represent standard error. Note that this three-way interaction was not significant.

Two-Question Accuracy. Given that prior studies (Maratos et al., 2008) operationalized trial accuracy simply by calculating the percentage of trials on which participants correctly answered the number question and the last emotion question, the data for the current study were recoded to reflect this operationalization and were subjected to two 2 (Age Group: young/old) x 3 (Trial Type) x 8 (Lag: 1/2/3/4/5/6/8/9) mixed model ANOVAs. The same main effects and interactions observed when accuracy was operationalized with respect to responding correctly to all three questions also emerged here.

Emotional T1-Neutral T2. For the emotional-neutral trials, the 2 (Age Group: young/old) x 3 (Trial Type: angry-neutral/happy-neutral/neutral-neutral) x 8 (Lag: 1/2/3/4/5/6/8/9) revealed a main effect of lag, $F(7, 294) = 63.53, p < .001, \eta_p^2 = .60$ (see Table 5), indicating worse accuracy at early lags and better accuracy at later lags. There was also a main effect of trial type, $F(2, 84) = 15.19, p < .001, \eta_p^2 = .27$, with Sidak post-hoc comparisons showing that both angry-neutral accuracy ($p < .001$) and happy-neutral accuracy ($p = .006$) were worse than neutral-neutral accuracy, but were not significantly different from each other ($p = .355$; see Table 6). Therefore, under this more lenient accuracy criterion, both emotion types increased the magnitude of the attentional blink when set as T1 relative to when T1 was neutral.

There was a trial type x lag interaction, $F(14, 588) = 3.17, p < .001, \eta_p^2 = .07$, which indicated that there was a larger difference between trial types at early lags than at later lags (see Figure 9). One-way (Trial Type: angry-neutral/happy-neutral/neutral-neutral) ANOVAs were then run on percent accuracy for each lag individually to examine the trial type x lag interaction, which indicated significant differences between

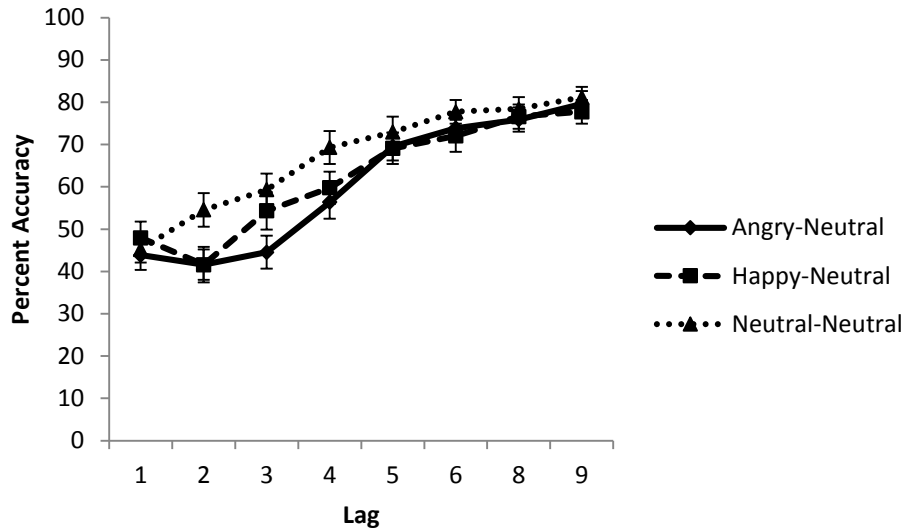


Figure 9. Mean percent accuracy for the emotional-neutral trials (i.e., double target trials with an emotional T1 and a neutral T2), collapsed across age groups. Accuracy for this analysis was defined as correctly identifying the number of targets and the emotional expression of T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

the three trial types at lag 2, $F(2, 86) = 11.46$, $p < .001$, $\eta_p^2 = .21$; at lag 3, $F(2, 86) = 11.38$, $p < .001$, $\eta_p^2 = .21$; and at lag 4, $F(2, 86) = 13.65$, $p < .001$, $\eta_p^2 = .24$. Sidak post-hoc comparisons showed that accuracy on happy-neutral trials was worse than on neutral-neutral trials at lag 2 ($p = .001$) and at lag 4 ($p = .003$). Accuracy on angry-neutral trials was worse than on neutral-neutral trials at lag 2 ($p < .001$), at lag 3 ($p < .001$), and at lag 4 ($p < .001$). Angry-neutral accuracy was worse than happy-neutral accuracy at lag 3 only ($p = .010$). These results suggest that both angry and happy emotional T1s had the potential to impair T2 detection at the early lags, although the number of lags in which the happy T1 had this effect was limited. Recall that when accuracy was defined as

correctly answering all three questions, rather than just the number and last emotion question, the angry face T1 stimuli significantly impaired detection of the neutral T2 more than the happy T1 stimuli did. Under the two-question criterion, the difference between these trials was limited to lag 3, suggesting more of a general effect of emotion.

Table 5

Main Effect of Lag on Percent Accuracy in Emotional-Neutral Trials, Two-Question Criterion

Lag	Mean	SE
1	45.7	3.0
2	45.9	3.5
3	52.7	3.6
4	61.8	3.6
5	70.5	3.1
6	74.5	2.8
7	77.0	2.5
8	79.5	2.3

$p < .05$

Table 6

Main Effect of Trial Type on Percent Accuracy in Emotional-Neutral Trials, Two-Question

Criterion

Trial Type	Mean	SE
Angry-Neutral	60.7	2.7
Happy-Neutral	62.4	2.9
Neutral-Neutral	67.3	2.6

$p < .05$

There was also a main effect of age group, $F(1,42) = 15.85, p < .001, \eta_p^2 = .27$, indicating that younger adults ($M = 73.9, SE = 3.7$) were more accurate overall than older adults ($M = 53.0, SE = 3.7; p < .001$). The main effect of age group was qualified by a significant lag x age group interaction, $F(7, 294) = 6.87, p < .001, \eta_p^2 = .14$, indicating

that the difference between younger adult and older adult performance was greater at early lags than at later lags (see Figure 10). The trial type x age group, $F(2, 84) = .646$, $p = .527$, $\eta_p^2 = .02$, and trial type x lag x age group, $F(14, 588) = 1.11$, $p = .342$, $\eta_p^2 = .03$, interactions were not significant. Given that prior research (Bach et al., 2014; de Jong et al., 2010 ; Kihara & Osaka, 2008) did find an interaction between trial type and lag when using facial stimuli as T1 and T2 and that no other study has reported on possible age differences in the attentional blink for this type of experiment, Figure 11 has been included to depict the trial type x lag interaction separately for each age group even though the three-way interaction was not significant.

In summary, for the emotional-neutral trials under two-question accuracy criterion, both angry and happy T1 were capable of increasing the attentional blink, with the effect of the happy T1 limited, like before. Furthermore, the increase in the attentional blink was greater for an angry T1 than for a happy T1 at lag 3 only, compared to lags 1 through 4 under the three-question accuracy criterion, suggesting more of a general effect of emotion than an anger superiority effect. Therefore, as before, all of the younger adult hypotheses (hypotheses 1, 2a, and hypothesis 2b at lag 3 only) were supported under two-question accuracy for the emotional-neutral trials. For the older adult hypotheses for the emotional-neutral trials, like before, hypothesis 3 was not supported, but hypothesis 4 was supported. Therefore, although the specific lags at which accuracy differed across trial types varied, the same hypotheses were supported under both criteria of accuracy.

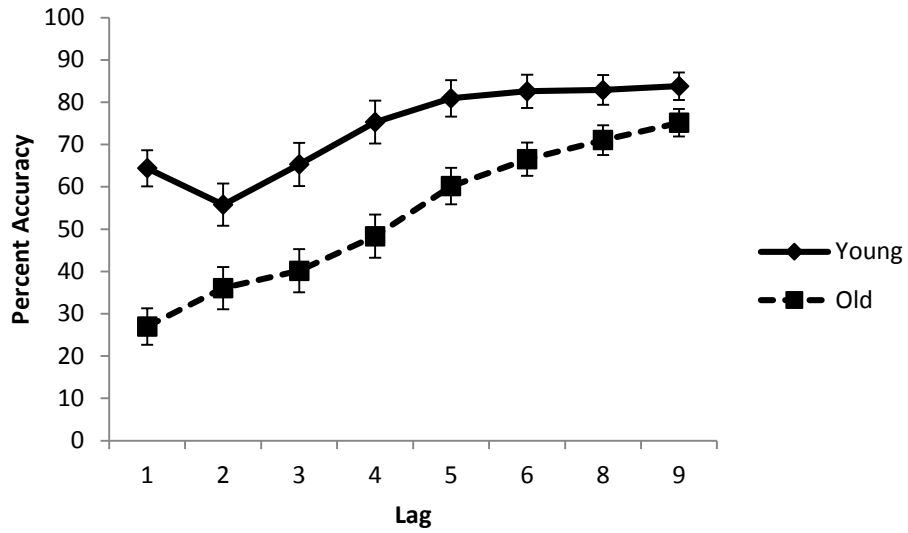
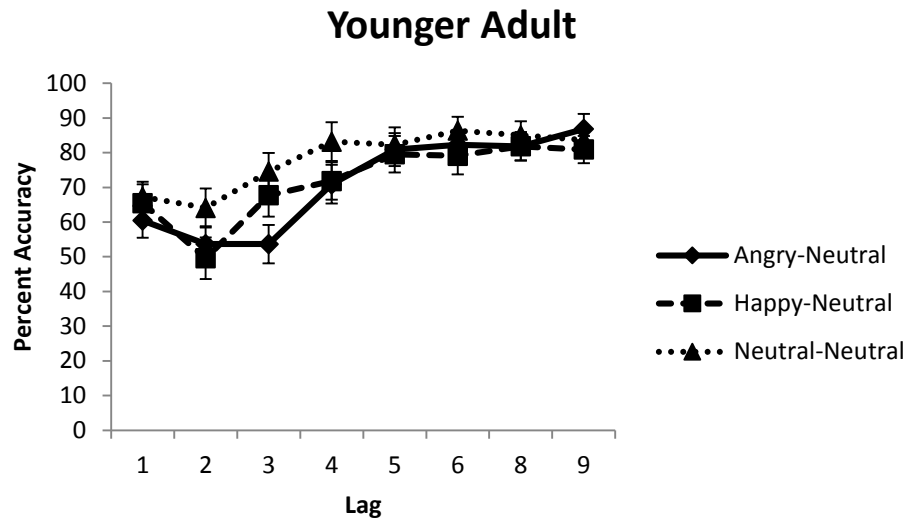


Figure 10. Mean percent accuracy for each age group on double target emotional-neutral trials at each lag, collapsed across trial type. Accuracy for this analysis was defined as correctly identifying the number of targets and the emotional expression of T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

a.



b

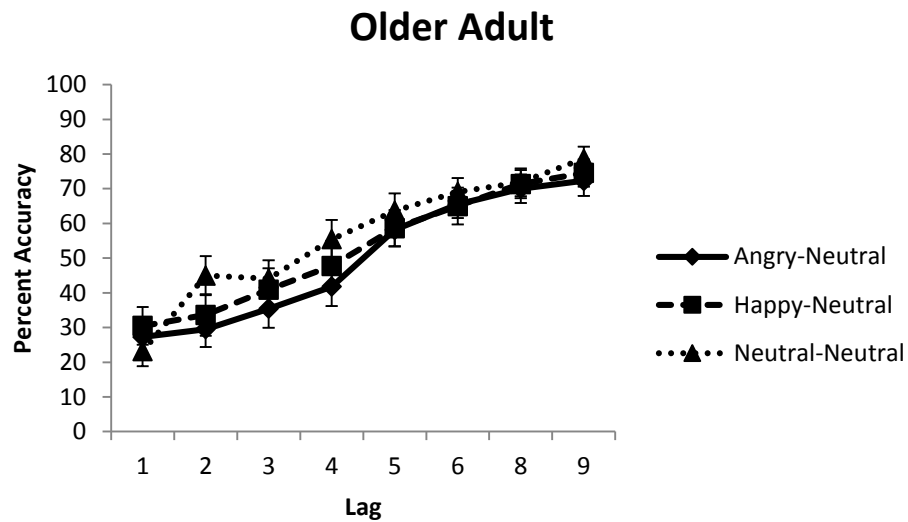


Figure 11. Percent accuracy for each of the emotional-neutral trial types at each lag in (a) younger adults and (b) older adults. Accuracy for this analysis was defined as correctly identifying the number of targets and the emotional expression of T2. Error bars represent standard error. Chance performance would be around 5% accuracy. Note that this three-way interaction was not significant.

Neutral T1-Emotional T2. For the neutral-emotional trials, a 2 (Age Group: young/old) x 3 (Trial Type: neutral-angry/neutral-happy/neutral-neutral) x 8 (Lag: 1/2/3/4/5/6/8/9) ANOVA revealed another main effect of lag, with worse accuracy at early lags and greater accuracy at later lags, $F(7, 294) = 56.49, p < .001, \eta_p^2 = .57$ (see Table 7). There was a main effect of trial type, $F(2, 84) = 8.54, p < .001, \eta_p^2 = .17$ (see Table 8), with Sidak post-hoc comparisons indicating that accuracy for the neutral-happy trials was better than for the neutral-angry trials ($p < .001$). As before, there was not a significant difference in accuracy between the neutral-angry and neutral-neutral trials ($p = .482$) or between the neutral-happy and neutral-neutral trials ($p = .056$).

Finally, there was another trial type x lag interaction, $F(14, 588) = 2.07, p = .012, \eta_p^2 = .047$ (see Figure 12). One-way (Trial Type: neutral-angry/neutral-happy/neutral-neutral) ANOVAs were then run on percent accuracy for each lag individually to examine the trial type x lag interaction, which indicated significant differences between the three trial types at lag 2, $F(2, 86) = 3.29, p = .042, \eta_p^2 = .07$; at lag 3, $F(2, 86) = 8.33, p < .001, \eta_p^2 = .16$; at lag 5, $F(2, 86) = 6.92, p = .002, \eta_p^2 = .14$; and at lag 8, $F(2, 86) = 7.58, p = .001, \eta_p^2 = .15$. Sidak post-hoc comparisons showed that neutral-happy accuracy was better than neutral-neutral accuracy at lag 3 ($p = .009$) and at lag 5 ($p = .009$). Accuracy on neutral-angry trials was worse than on neutral-happy trials at lag 2 ($p = .040$), at lag 3 ($p < .001$), at lag 5 ($p = .008$), and at lag 8 ($p = .001$). There were no longer any differences between the neutral-angry and neutral-neutral trials. As before, these results suggest that only the trials with a happy T2 were capable of improving T2 detection, but the improvements were not at lags consistent with the attenuation of the attentional blink.

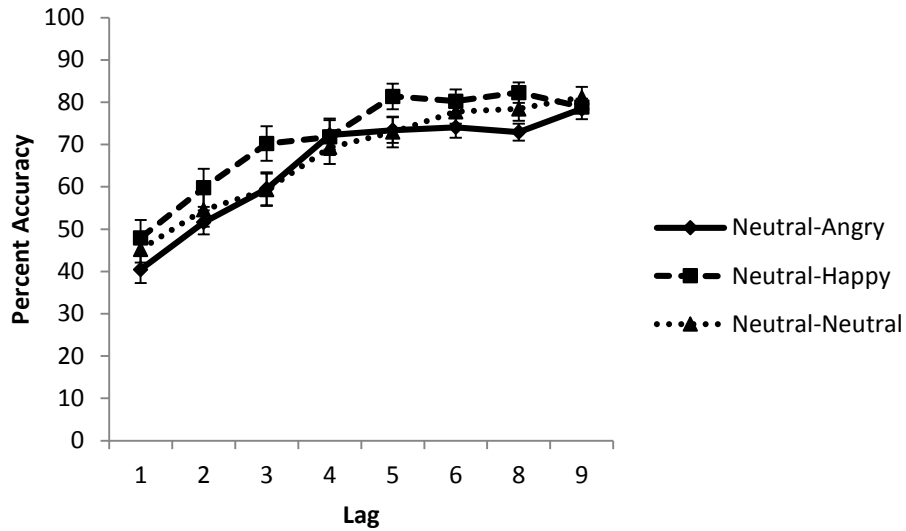


Figure 12. Mean percent accuracy for the neutral-emotional trials (i.e., double target trials with a neutral T1 and an emotional T2), collapsed across age groups. Accuracy for this analysis was defined as correctly identifying the number of targets and the emotional expression of T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

Table 7

Main Effect of Lag on Percent Accuracy in Neutral-Emotional Trials, Two Question Criterion

Lag	Mean	SE
1	44.5	2.9
2	55.3	3.3
3	63.0	3.5
4	71.1	3.6
5	75.9	2.9
6	77.3	2.2
7	77.9	2.0
8	79.5	2.1

 $p < .05$

Table 8

Main Effect of Trial Type on Percent Accuracy in Neutral-Emotional Trials, Two Question Criterion

Trial Type	Mean	SE
Neutral-Angry	65.3	2.3
Neutral-Happy	71.6	2.8
Neutral-Neutral	67.3	2.6

 $p < .05$

There was also a main effect of age group, $F(1,42) = 14.32, p < .001, \eta_p^2 = .25$, indicating that younger adults ($M = 77.2, SE = 3.4$) were more accurate overall than older adults ($M = 59.0, SE = 3.4; p < .001$). The main effect of age group was qualified by a significant lag x age group interaction, $F(7, 294) = 9.91, p < .001, \eta_p^2 = .19$, indicating that the difference between younger adult and older adult performance was greater at early lags than at later lags (see Figure 13). Note that the trial type x age group, $F(2, 84) = 2.28, p = .108, \eta_p^2 = .05$, and trial type x lag x age group, $F(14, 588) = 1.24, p = .240, \eta_p^2 = .03$, interactions were not significant. Given that prior research has not reported on possible age differences in the attentional blink for this type of experiment,

Figure 14 has been included to depict the trial type x lag interaction separately for each age group even though the three-way interaction was not significant.

In summary, the results from the neutral-emotional trials with the two-question accuracy definition are consistent with those from the three-question accuracy definition. Neither type of emotional T2 attenuated the attentional blink, which does not support any of the hypotheses (5, 6a, 6b, 7, or 8) for younger or older adults.

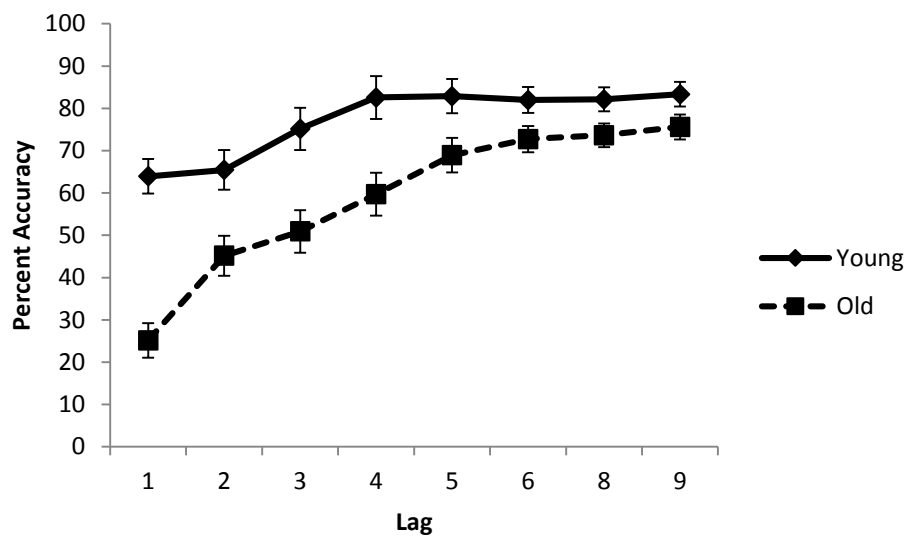
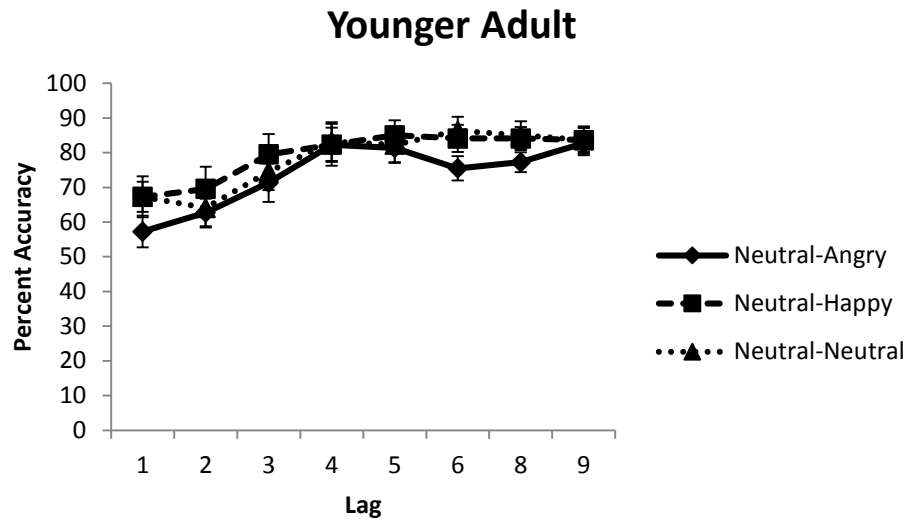


Figure 13. Mean percent accuracy for each age group on double target neutral-emotional trials at each lag, collapsed across trial type. Accuracy for this analysis was defined as correctly identifying the number of targets and the emotional expression of T2. Chance performance would be around 5% accuracy. Error bars represent standard error.

a.



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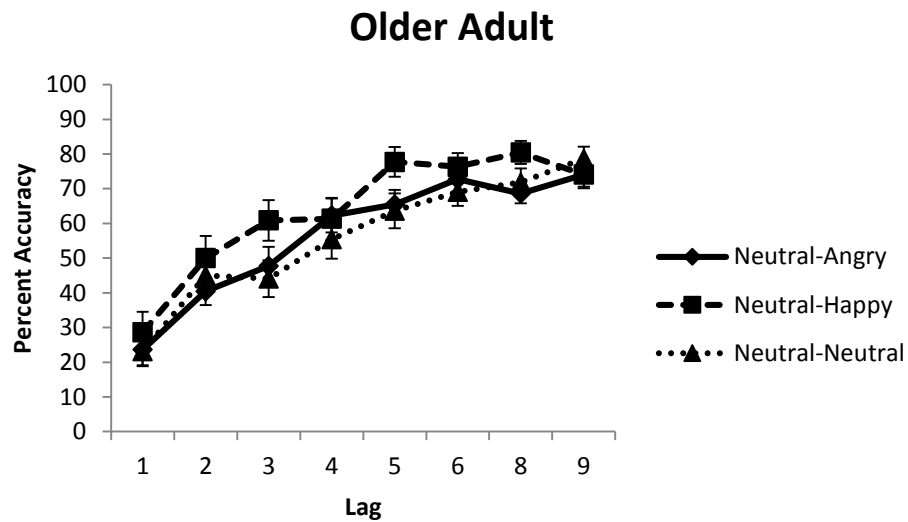


Figure 14. Percent accuracy for each of the neutral-emotional trial types at each lag in (a) younger adults and (b) older adults. Accuracy for this analysis was defined as correctly identifying the number of targets and the emotional expression of T2. Chance performance would be around 5% accuracy. Error bars represent standard error. Note that this three-way interaction was not significant.

Emotion Recognition Task

A 2 (Age Group: young/old) x 3 (emotion: angry/happy/neutral) mixed model ANOVA was run on the emotion responses from the emotion recognition task to see if there were differences in the ability of participants to recognize emotional facial expressions between emotion types and between age groups. There was a significant main effect of emotion, $F(2, 84) = 3.70, p = .029, \eta_p^2 = .08$, which was driven by participants correctly labeling significantly less of the angry ($M = 90.5, SE = 2.0$) than the happy ($M = 95.5, SE = 0.9$) facial expressions ($p = .008$), as indicated by Sidak post-hoc comparisons. There was not a significant difference in the percentage of correctly recognized neutral faces compared to angry ($p = .454$) or happy faces ($p = .578$). There was also no effect of age, as younger adults and older adults identified the emotional expressions equally well, $F(1, 42) = 0.003, p = .956, \eta_p^2 = .00$. Similarly, there was no emotion x age group interaction, $F(2, 84) = .386, p = .605, \eta_p^2 = .009$.

Emotional Intensity Rating Task

A 2 (Age Group: young/old) x 3 (emotion: angry/happy/neutral) mixed model ANOVA was run on the intensity ratings from the emotion recognition task to see whether there were any differences between the intensity ratings of each emotion type and if they differed as a function of age. There was a significant main effect of emotion, $F(2, 84) = 368.15, p < .001, \eta_p^2 = .90$. Sidak post-hoc tests showed that angry faces ($M = 2.9, SE = 0.07$) were rated as more intense than neutral faces ($M = 1.2, SE = .04; p < .001$). Happy faces ($M = 3.0, SE = .07$) were also rated as more intense than neutral faces ($M = 1.2, SE = .04; p < .001$). There was no difference, however, in the intensity ratings for angry and happy facial expressions ($p = .211$). There was not a significant effect of

age group, $F(1, 42) = .109, p = .742, \eta_p^2 = .003$, as younger adults and older adults gave similar intensity ratings. There was also not a significant emotion x age group interaction $F(2, 84) = .002, p = .998, \eta_p^2 = .000$ (see Table 9).

Table 9

Emotion Intensity Ratings

Emotion	Younger Adults		Older Adults	
	<u>Mean</u>	<u>SE</u>	<u>Mean</u>	<u>SE</u>
Angry	2.9	.10	2.9	.10
Happy	3.0	.10	3.0	.10
Neutral	1.2	.06	1.3	.06

$p < .05$

Chapter 4: Discussion

Within the current study, the impact that the emotional nature of facial stimuli has on the attentional blink in younger and older adults was examined using angry, happy, and neutral facial stimuli as either target 1 or target 2 stimuli within a rapid serial visual presentation of facial stimuli and distracting scrambled facial stimuli. As in other studies of the attentional blink, a blink emerged at early lags (mostly at lags 2 and 3) and disappeared at later lags. Although stimulus identification accuracy was expected to be high at lag 1 relative to lags 2 and 3 due to lag-1 sparing (Hommel & Akyürek, 2005), this phenomenon did not emerge. Rather, recognition of the second target immediately after the first target tended to be at the lowest accuracy level regardless of the emotionality of the facial stimuli used (for review, Shapiro et al., 1997). The absence of lag-1 sparing in the current study is not altogether that surprising considering that such an absence is common when T1 and T2 stimuli are different enough from each other that a shift in attention is necessary (i.e., picture vs. letter; de Jong et al., 2009; Hommel & Akyürek, 2005), or when the target stimuli are complex (Kihara & Osaka, 2008). Therefore, the absence of lag-1 sparing could be due to the difference in faces, considering T1 and T2 were never faces of the same individual. Alternatively, the absence of lag-1 sparing could be the result of facial stimuli being very complex.

Past research on aging and the attentional blink demonstrates that older adults display a larger and longer lasting blink than do younger adults (Georgiou-Karistianis et al., 2007; Jain & Kar, 2014; Jeffries et al., 2013; Langley et al., 2008; Lee & Hsieh, 2009; Male et al., 2009). In other words, older adults tend to perform worse than younger adults overall, and thus their attentional blink should have had a greater magnitude and occur

for a greater number of lags. Consistent with the literature, older adults did perform significantly worse than younger adults, as evidenced by worse accuracy (greater magnitude attentional blink), as well as reduced accuracy through more lags (a prolonged attentional blink period). In this study, it took older adults about 250 ms longer to reach a plateau in accuracy in the neutral-emotional trials, and about 500 ms longer in the emotional-neutral trials. This is similar to the findings of Male et al. (2009) who found that OA took around 600 ms longer to reach peak accuracy. However, there were no age differences in the effect of emotion on the attentional blink. A lack of an age-related emotion effect on the attentional blink runs counter to predictions that stem from lifespan developmental theories on emotion processing. On the other hand, the absence of an age-related emotion effect is consistent with prior research on the attentional capture properties of emotional stimuli on younger and older adults' visual attention (Mather & Knight, 2006; Ruffman et al., 2009).

Emotional first target enhancing the attentional blink

When emotional faces served as T1 and preceded neutral faces as T2, there was an expectation that, for younger adults, the attentional blink would be larger when T1 was an angry face than when T1 was a neutral face, especially at the early lags during the attentional blink period (Hypothesis 1). In other words, younger adults were expected to be less accurate at correctly identifying that T2 with a neutral expression when T1 was an angry face relative to when T1 was neutral. Hypothesis 1 was supported, as accuracy was worse for the angry-neutral trials than for the neutral-neutral trials, especially during the early lags. Therefore, it seems that the angry T1 greatly reduces the availability of resources to process T2 and enhances the attentional blink, which is consistent with other

studies finding this effect (Bach et al., 2014; de Jong et al., 2010) as well as with the negativity bias frequently seen in younger adults in general (Lundqvist & Öhman, 2005).

When emotional faces served as T1 and preceded neutral faces at T2, younger adults were also expected to exhibit a larger attentional blink when T1 was a happy face than when it was neutral (Hypothesis 2a), but a smaller attentional blink compared to when T1 was angry (Hypothesis 2b). In other words, younger adults should have been less accurate in detecting the neutral T2 when T1 was a happy face than when it was neutral, but more accurate than when it was angry. Hypothesis 2b was supported because accuracy was worse on angry-neutral trials than on happy-neutral trials. Hypothesis 2a was also supported; however, the difference in accuracy between when T1 was a happy face and when it was a neutral face was limited to lag 2. Despite this effect occurring during the attentional blink period and being consistent with Maratos et al.'s (2008) criteria for support (i.e., lags 2 and 3), happy T1 did not impair detection of T2 throughout all of the attentional blink period. Although the limited effect of the happy T1 is inconsistent with studies finding an increase in the attentional blink for both angry and happy T1 (Bach et al., 2014), it is not surprising given other studies that only found an increase in the attentional blink with an angry T1 (de Jong et al., 2010; Kihara & Osaka, 2008). Regardless, this limited effect of the happy T1 may suggest that there is a potential for happy faces to increase the magnitude of the attentional blink during the time that accuracy is most impaired.

The effect of angry faces on the attentional blink was expected to be different in older adults than in younger adults, such that angry faces should have had much less of an effect and should have been less able to capture attention compared to in younger

adults. The reasoning for such an expectation was that the positivity effect seen in many studies of visual attention and memory (Mather & Carstensen, 2003), should have left older adults attending less to the angry T1, and because this T1 should not have received much attention, it would not be able to further impair detection of T2. As such, no difference in the attentional blink was expected when T2 was neutral between when T1 was angry and when it was neutral (Hypothesis 3). Instead, the attentional blink was actually much larger when T1 was an angry face than when T1 was neutral. Although this finding does not support the hypothesis, it is uncertain whether it is entirely inconsistent with the reasoning for this hypothesis. For example, it could be the case that seeing the angry face at the beginning of the trial caused an avoidance response in older adults that, instead of being confined to T1, decreased the amount of attention paid to the rest of the stream in order to avoid the first negative target. Alternatively, it could be interpreted as older adults seeing the negative T1 and processing it so much that they were unable to detect the neutral T2, suggesting that older adults process negative information in the same way as younger adults do (showing the same pattern), just less efficiently and slowed in general, across both emotions. Interestingly, younger and older adults provided equivalent intensity ratings for angry expressions, suggesting that the stimuli were equally arousing to members of both age groups, on average. As mentioned earlier, under equivalent arousal conditions, younger and older adults often display similar amygdala activation and possibly, as a result, a similar behavioral consequence.

In addition to the overall decline in performance previously discussed, older adults also tend to display a positivity effect, associated with a decreased responsiveness to negative information and potential increased responsiveness to positive information,

relative to younger adults (Reed & Carstensen, 2012). The effect of happy faces on the attentional blink was, therefore, hypothesized to be similar in older adults as in younger adults. Therefore, as in younger adults, when T2 was a neutral face, a larger attentional blink was expected when T1 was a happy face than when it was neutral (Hypothesis 4). As with younger adults, this hypothesis was supported, but the difference in accuracy between a neutral and a happy T1 was limited to lag 2. Furthermore, like in the younger adults, accuracy was actually significantly better when T1 was happy than when it was angry. As with the angry T1, this result can be interpreted in different ways. Although it was expected that seeing a happy face early in the stream would capture attention, leaving less attention available to process the neutral T2, it is possible that seeing the initial happy face actually led participants to pay more attention to the upcoming target, allowing the T2 to be identified better than when T1 was angry. This possibility is consistent with the broaden-and-build theory, whereby positive stimuli broaden attention (Fredrickson, 2004; Fredrickson & Branigan, 2005; Srinivasan & Hanif, 2010). Alternatively, it is more likely the case that older adults were simply processing information in the same way as the younger adults. Although this result contradicts the hypothesis and is inconsistent with studies finding a positivity effect in older adults (Mather & Carstensen, 2003; Ruffman et al., 2009), recall that studies that limit cognitive and attentional resources are less likely to find a positivity effect than are studies that involve passive viewing or choosing to which stimulus they will attend (Kehoe et al., 2013; Mather & Knight, 2006; Reed et al., 2014; Sasse et al., 2014). The present RSVP task most definitely limited cognitive and attentional resources, which could explain why this study did not find a positivity effect in older adults.

Emotional second target attenuating the attentional blink

When T1 was a neutral face and T2 was emotional, it was hypothesized that there would be an attenuation of the attentional blink in younger adults when T2 was angry, relative to neutral (Hypothesis 5). Hypothesis 5 was not supported, as there was no difference in accuracy of T2 detection between these two conditions, and the angry T2 stimulus did not attenuate the blink. The absence of anger superiority is not consistent with the negativity bias seen in younger adults, and is therefore surprising given the predominance of this effect in the literature (Bach et al., 2014; Kihara & Osaka, 2008; Ogawa & Suzuki, 2004). The inability of the angry T2 to attenuate the attentional blink could be due to the facial stimuli used as targets in the current study, whether because of the difference between the photographs used in the current study compared to the schematic representations used by Maratos et al. (2008), or because the angry faces were more difficult to identify in the current study.

If either of these alternatives were to blame, then there likely would have been no effect of an angry T1, which was not the case, leading to the question of whether the angry T1 had more of an attention maintaining effect, rather than an attention capturing effect. Had it been an attention capturing effect, then the angry T2 should have captured attention away from the neutral T1, attenuating the blink, as seen before (Bach et al., 2014; Kihara & Osaka, 2008; Maratos et al., 2008; Ogawa & Suzuki, 2004). Instead, an attention maintenance effect, whereby the angry T1 did not capture attention, but instead maintained attention, preventing attention from being given to the neutral T2, could explain why there was an effect of an angry T1, but no effect of an angry T2 (i.e., an angry T2 being unable to capture attention from the neutral T1 and attenuate the blink).

Because no response is required after T2, if an angry T2 maintained attention, the effect of that maintenance would not be seen in the current study. Thus, it is impossible to know whether this is the reason for the present results. If this is the case, future studies could introduce another stimulus following T2, to which participants are supposed to make an additional response whenever it is present. If the angry T2 impairs performance of the response to the additional stimulus because it contributes to the cognitive load (Jain & Kar, 2014) experienced by the participant on a given trial, then this would support the effect of emotion in the current study being to maintain attention rather than to capture attention. The idea of an attention maintenance effect is not new, as others have suggested that an emotional T1 captures and holds attention (Heim, Benasich, & Keil, 2013; Schwabe & Wolf, 2010). However, the current study may be novel in suggesting that maintenance of attention, rather than capture of attention, may be the reason for the effect of emotion on the attentional blink. This is still surprising given studies finding an attenuation of the blink with emotional T2s (de Jong et al., 2009; Kanske et al., 2013). It is possible that this is an effect of the greater salience of photorealistic emotional faces, and the use of such faces as both targets, given how few studies have used faces as both targets in the attentional blink.

It was also expected that for younger adults when T1 was neutral, the attentional blink would be smaller when T2 was a happy face than when it was neutral (Hypothesis 6a), and even smaller when T2 was an angry face than when neutral (Hypothesis 6b). However, these hypotheses were not supported either. Not only was there no difference in the magnitude of the attentional blink between when T2 was happy and when it was neutral, but there was also no difference between when T2 was happy and when it was

angry, which was opposite of what was expected. Both types of emotional T2 were expected to be given priority over neutral information and thus attenuate the blink (de Jong et al., 2009; Kanske et al., 2013), but with the happy T2 to a lesser extent due to the negativity bias in younger adults. The lack of an anger-superiority effect may be related to the maintenance of attention versus capturing of attention idea posited earlier.

A larger attentional blink was expected when an angry face as T2 followed a neutral T1 in older adults compared to that seen in younger adults (Hypothesis 7). Hypothesis 7 was not supported, because although the attentional blink was larger when T2 was an angry face than when it was a happy face, there was no difference in the magnitude of the attentional blink between when T2 was angry and when it was neutral, and there was no difference between the magnitude of the attentional blink between younger and older adults. Again, it is possible that this is due to older adults processing emotional information in the same way as younger adults in the early time period of the attentional blink in the current study. Alternatively, these results could be due to the current study being unable to capture age differences in emotional processing that actually do exist or due to the younger and older adults' equivalent subjective experience when rating the intensity of the emotional expressions.

Similarly, when T1 was a neutral face and T2 was emotional, the attentional blink was expected to be most attenuated (i.e., better accuracy for T2 detection) when T2 was a happy face, compared to when it was neutral in older adults (Hypothesis 8). Although the attentional blink was attenuated when T2 was happy relative to when it was angry, there was no difference in accuracy between when T2 was happy and when it was neutral. The lack of a difference in accuracy between neutral-happy and neutral-neutral trials could

have provided support for the idea that the positivity effect is due to a decrease in the processing of negative information, rather than an increase in the propensity for processing positive information. However, given that this effect was seen in younger adults as well, this assumption cannot be made.

Replicating the study using schematic faces

The inability of the present study to replicate previous studies like Maratos et al. (2008) in terms of the emotional T2 attenuating the attentional blink in younger adults could be due to several different reasons. First, there is the possibility that the results are due to the pictures of faces being processed in a completely different way than the schematic faces used by Maratos et al. (2008). Many studies have suggested that schematic faces are not processed in the same way as real faces (Halgren et al., 2000; Purcell & Stewart, 2010). In fact, Halgren et al. (2000) found that activation of the fusiform gyrus was 30% less for schematic faces than for photographic images of faces. However, a difference in how schematic and photographic images are processed would only explain differences between that study and the present one. The results are still inconsistent with other studies that have found the attenuation of the attentional blink with an emotional second target (Bach et al., 2014; de Jong et al., 2009; Kanske et al., 2013; Kihara & Osaka, 2008; Ogawa & Suzuki, 2004).

Another possibility is that the differences were due to the number of questions asked and/or the way accuracy was defined. In the present study, participants were asked about the number of faces they saw, as well as about the emotion of each face they saw. Therefore, on the double target trials, participants were asked three questions, and accuracy was based on answering all three of these questions correctly. Maratos et al.

(2008) only asked participants how many faces they saw and to identify the emotion of the last face they saw, and thus accuracy was based on just answering these two questions correctly. Exploratory analyses using the two-question accuracy used by Maratos et al. (2008) showed some differences for the emotional-neutral trials. Under this new criterion, the effect of T1 seemed to be moving more toward a general emotion effect, compared to the strong anger superiority effect seen under the three-question criterion.

Although exploratory analyses were run using the two-question accuracy used by Maratos et al. (2008), it is likely that these analyses did not capture the full extent of the difference. In these exploratory analyses in the current study, even though accuracy was based on the two-questions, it does not change the fact that participants were still required to answer three questions. Answering three questions and having to maintain those three responses in mind was likely more taxing than only having to maintain the responses for two questions. For example, Maciokas and Crognale (2003) showed that when younger adult participants were told to ignore the first target, the attentional blink did not occur. Although the attentional blink did occur in the study by Maratos et al. (2008), it is possible that it would have occurred very differently if participants had to make a response for both targets, rather than just the last one.

One limitation of the study therefore was not being able to replicate the study by Maratos et al. (2008). Although the third question was added to get a better representation of how participants process the targets during RSVP tasks, it did deviate from the original study in a way that could have prevented replication. Future studies could therefore either maintain the same two-question methodology so that the type of face used is the only difference from the study by Maratos et al. (2008), or they could continue to use the more

informative three-question methodology, and use both schematic and photo-realistic faces in order to do a direct comparison of the two types of stimuli. Another limitation is that there are aspects of the current study that are difficult to interpret, namely the lack of an attenuating effect of the emotional T2. As mentioned earlier, future studies could add a stimulus after T2 on some trials that requires a response to see if the effect of emotion in the current study was the result of emotion holding attention, rather than capturing attention.

Conclusion

The results of the present study were somewhat surprising given the expected effects of emotion for each age group. As expected, the angry T1 did increase the attentional blink the most, followed by the happy T1 in younger adults. However, the same effect was found in older adults. Furthermore, the increase in the attentional blink with the happy T1 was limited to lag 2. Neither of the emotional T2s attenuated the blink for either age group. Therefore, the younger (and older) adults displayed the negativity bias only in the emotional-neutral trials, and older adults did not display the positivity effect under either the emotional-neutral or neutral-emotional trials. This may suggest that the nature of attentional blink studies using the rapid serial visual presentation may be too constraining for older adults to display a positivity effect, directing them to attend to the stimuli in ways other than how they would have passively. Finally, this study using pictures of emotional faces was unable to replicate the results of Maratos et al. (2008) who found an attenuation of the attentional blink with emotional schematic T2 faces in younger adults. However, given the difference between the two studies in the number of

responses required, it cannot presently be concluded that actual faces affect the attentional blink differently than schematic faces.

Although the results were not entirely as expected, it is possible that they were still informative about the way emotion is processed in younger and older adults. The lack of age differences may reflect older adults' ability to process emotional information in the same way as younger adults if assessed early enough in the process before emotion regulation strategies can be employed. However, there is still the possibility that the present study failed to find age differences that actually do exist in emotion processing and the attentional blink. Additionally, the finding that an angry T1, and to a lesser extent a happy T1, led to an increase in the attentional blink, whereas neither of the emotional T2 were able to attenuate the attentional blink may suggest the possibility that the effect of emotion during the attentional blink, or at least in the conditions of the current study, is to maintain attention, rather than to simply capture attention.

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APPENDIX A
TELEPHONE SCREENING PROTOCOL

Instructions for Interviewer: Read only those parts in bold to the respondent.

I will be asking you several questions over the course of this telephone interview. All of the information that you give me will remain confidential. No one other than the individuals working in the Lifespan Social Cognition Laboratory will see your answers to these questions. You may decline to answer any of the questions and you may stop this interview at any time. Do you have any questions?

First I would like to get some basic information about you.

Name: _____

Address: _____

Phone: _____

Age: _____ Date of Birth: _____

Level of Education: _____

How did you find out about our research? _____

Other researchers at the Center for Research on Aging are recruiting participants for different studies.

Can we give them your name? _____

If a respondent asks to stop the interview at any point during the screening, ask if they would be willing to answer questions in a personal interview with the research assistant.

TELEPHONE SCREENING PROTOCOL MINI MENTAL STATE EXAM (TMMSE)

Now I am going to ask you some questions that will allow me to determine whether you meet the requirements for participation in this research. Again, all of the information that you give me will remain confidential. You may decline to answer any of the questions and you may stop this interview at any time. Do you have any questions?

ORIENTATION

What is the date today? (See answer sheet for additional orientation questions.) Ask the respondent for any omitted parts. Give one point for each correct answer.

REGISTRATION

May I test your memory? Then say the names of three unrelated objects, clearly and slowly, about one second for each: **Apple, lamp, tower.** After you have said all three, ask the respondent to repeat them. This first repetition determines the score but keep saying them until the respondent can repeat all three; give up to six trials. If the respondent does not eventually learn all three words, recall cannot be meaningfully tested.

ATTENTION & CALCULATION

Now begin with 100 and count backward by 7. Stop the respondent after five subtractions (93, 86, 79, 72, 65). Score the total number of correct answers.

If the respondent cannot or will not perform this task, ask: **Please spell the word “world” backwards.** The score is the number of letters in correct order; e.g. dlrow = 5.

RECALL

Can you tell me the three words that I asked you to remember?

LANGUAGE

Please repeat the following: No ifs, ands, or buts.

Tell me, what is the thing called that you are speaking into as you talk to me?

If the respondent does not meet the requirements for participation, say: **Thank you very much for your time. Your name will be entered into our files.** Enter name, final TMMSE score into the database and check the NO CALL BACK box.

If the respondent does meet requirements continue on to the Medical History Questionnaire.

ORIENTATION (total pts. 8)

Response

Score

What is the date?	_____	_____ (1)
What is the day?	_____	_____ (1)
What is the month?	_____	_____ (1)
What is the year?	_____	_____ (1)
What is the season?	_____	_____ (1)
Where are we:		
State	_____	_____ (1)
County	_____	_____ (1)
Town	_____	_____ (1)
REGISTRATION (total pts. 3)		
	_____	_____ (1)
	_____	_____ (1)
	_____	_____ (1)
ATTENTION & CALCULATION (total pts. 5)		
	_____	_____ (1)
	_____	_____ (1)
	_____	_____ (1)
	_____	_____ (1)
	_____	_____ (1)
RECALL (total pts. 3)		
	_____	_____ (1)
	_____	_____ (1)
	_____	_____ (1)
LANGUAGE (total pts. 2)		
	_____	_____ (1)
	_____	_____ (1)
Total Score		_____
(at least 17 pts. required)		

TELEPHONE SCREENING PROTOCOL MEDICAL HISTORY QUESTIONNAIRE

Read the following instructions to the respondent: **Now I am going to ask you some questions about your medical history. Again, if you do not feel comfortable answering any of these questions, you may refuse at any time. All of the information that you give me will remain confidential. Do you have any questions?**

*(If the respondent does not agree to answer questions ask: **Would you be willing to answer questions about your medical history in a personal interview with a research assistant? If the respondent says yes, say: Thank you for your time. A research associate from the Lifespan Social Cognition Laboratory will call you to schedule the interview.**)*

If the respondent agrees to answer questions say: **For the next few questions you may answer yes or no. Do you have...**

Yes	No	
_____	_____	High Blood pressure
_____	_____	Stroke
		If yes, when? _____
		Do you have impairment from the stroke? _____
_____	_____	Heart disease
_____	_____	Kidney disease
_____	_____	Neurological disease
_____	_____	Head Injury
		If yes, was there loss of consciousness? _____
		For how long? _____
_____	_____	Other (specify) _____
_____	_____	Have you received treatment for psychological problems in the past 2 years (e.g. depression, anxiety)
_____	_____	Have you had any difficulty sleeping in the past 2 weeks?
_____	_____	Have you experienced any change in your sleeping patterns within the last 3 months?
_____	_____	Have you experienced any change in you eating patterns within the last 3 months?
_____	_____	Have you experienced any major change in your weight within the past 3 months?
_____	_____	Have you had any difficulty with unexplained tiredness Within the past 3 months?
_____	_____	Have you had any difficulty with unexplained crying or Irritability within the past 3 months?
_____	_____	Do you use tobacco products?
		What product? _____
		How much per day? _____

If the respondent does not meet the requirements, say: **Thank you very much for your time. Your name will be entered into our files.** Enter name, final TMMSE score and medical history into database and check the NO CALL BACK box.

If the respondent does meet the requirements, say: **Finally, are you currently taking any medications? This includes prescription drugs, vitamins, aspirin, antacids, etc. Please indicate all recreational drugs and alcoholic beverages. This information will remain confidential.**

Name of Medication	Amount of use (regular or occasional)

If the respondent does not meet the requirements, say: **Thank you very much for your time. Your name will be entered into our files.** Enter name, final TMMSE score, medical history, and medications into database and check the NO CALL BACK box.

APPENDIX B

Feelings Scale

Instructions: In this booklet, there are statements about the way that most people feel at one time or another. There is no such thing as a "right" or "wrong" answer because all people are different. All you have to do is answer the statements according to how you have felt during the past week. Don't answer according to how you USUALLY feel, but rather how you have felt DURING THE PAST WEEK. Each statement is followed by four choices. **Circle** the letter corresponding to your choice. Mark ONLY ONE letter for each statement. For example:

During the past week, I was happy.

- a. Rarely or none of the time (less than one day)
- b. Some or a little of the time (1 - 2 days)
- c. Occasionally or a moderate amount of time (3 - 4 days)
- d. Most or all of the time (5 - 7 days)

In the example, you could, of course, choose any ONE of the answers. If you felt really happy, you would circle "d". If you felt very unhappy, you would circle "a". The "b" and "c" answers give you middle choices. Keep these following points in mind.

1. Don't spend too much time thinking about your answer. Give the 1st natural answer that comes to you.
2. Do your best to answer EVERY question, even if it doesn't seem to apply to you very well.
3. Answer as honestly as you can. Please do not mark something because it seems like "the right thing to say".

1. During the past week, I was bothered by things that don't usually bother me.

- a. Rarely or none of the time (less than one day)
- b. Some or a little of the time (1 - 2 days)
- c. Occasionally or a moderate amount of time (3 - 4 days)
- d. Most or all of the time (5 - 7 days)

2. During the past week, I did not feel like eating. My appetite was poor.

- a. Rarely or none of the time (less than one day)
- b. Some or a little of the time (1 - 2 days)
- c. Occasionally or a moderate amount of time (3 - 4 days)
- d. Most or all of the time (5 - 7 days)

3. During the past week, I felt that I could not shake off the blues even with help from my family or friends.

- a. Rarely or none of the time (less than one day)
- b. Some or a little of the time (1 - 2 days)
- c. Occasionally or a moderate amount of time (3 - 4 days)
- d. Most or all of the time (5 - 7 days)

4. During the past week, I felt that I was just as good as other people.

- a. Rarely or none of the time (less than one day)
- b. Some or a little of the time (1 - 2 days)
- c. Occasionally or a moderate amount of time (3 - 4 days)
- d. Most or all of the time (5 - 7 days)

5. During the past week, I had trouble keeping my mind on what I was doing.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
6. During the past week, I felt depressed.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
7. During the past week, I felt that everything I did was an effort.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
8. During the past week, I felt hopeful about the future.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
9. During the past week, I thought my life had been a failure.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
10. During the past week, I felt fearful.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
11. During the past week, my sleep was restless.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
12. During the past week, I was happy.
 - a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)

13. During the past week, I talked less than usual.
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
14. During the past week, I felt lonely.
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
15. During the past week, people were unfriendly.
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
16. During the past week, I enjoyed life.
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
17. During the past week, I had crying spells.
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
18. During the past week, I felt sad.
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
19. During the past week, I felt that people dislike me.
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)
20. During the past week, I could not get "going".
- a. Rarely or none of the time (less than one day)
 - b. Some or a little of the time (1 - 2 days)
 - c. Occasionally or a moderate amount of time (3 - 4 days)
 - d. Most or all of the time (5 - 7 days)

11. What is your highest level of formal education (circle the highest level completed):

- A. Less than 12 years (How many of years completed? _____ years)
- B. GED (Age when you completed your GED: _____)
- C. High school diploma
- D. Technical/ Vocational/ Trade school diploma or certificate
- E. College Freshman
- F. College Sophomore
- G. College Junior
- H. Associate's Degree
- I. Bachelor's degree
- J. Master's degree
- K. J.D., M.D., or Ph.D.

12. Are you presently employed: 1. Yes - full time 2. Yes - part time 3. No

13. Are you presently retired? 1. Yes 2. No

14. If you are currently or have recently been employed, what field is your job in?

15. If you are currently or have recently been employed, please describe the duties of your job?

16. In the past 5 years, have you engaged in volunteer activities to assist or instruct young adults (i.e., individuals aged 18-30)? 1. Yes 2. No

17. To what extent do you interact with young adults throughout the course of a typical week (including time spent at work, in classes, and/or during volunteer or extracurricular activities)?

- 1. Rarely or none of the time (less than one day)
- 2. Some or a little of the time (1 - 2 days)
- 3. Occasionally or a moderate amount of time (3 - 4 days)
- 4. Most or all of the time (5 - 7 days)

18. How would you rate your overall health at the present time? (please circle one rating)

- 1. Poor 2. Fair 3. Good 4. Very Good 5. Excellent

19. How much do health problems stand in your way of doing things that you want to do?

(please circle one rating) 1. Not at all 2. A little 3. Moderately 4. Quite a bit 5. A great deal

20. Are you presently seeking psychological or psychiatric consultation and/or receiving therapy? 1. Yes 2. No

If yes...

a. Are you currently being treated for depression? 1. Yes 2. No

b. Are you currently being treated for excessive anxiety or nervousness? 1. Yes 2. No

21. Do you currently have any noticeable difficulty with vision for which correction, such as eyeglasses, has NOT been made? 1. Yes 2. No

22. Do you currently have any noticeable difficulty with hearing for which a correction, such as a hearing aide, has NOT been made? 1. Yes 2. No

23. Do you currently have any difficulty with writing? 1. Yes 2. No