Mechanisms of the Aging-Related Positivity Effect in Memory and Attention

by

Jennifer Christina Tomaszczyk

A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Psychology

Waterloo, Ontario, Canada, 2012

AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

According to the Socioemotional Selectivity Theory (SST), the normal aging process is associated with a greater emphasis on self-regulation of emotional states, and this fosters a bias in cognitive processing for information that is positively valenced (e.g., pleasant images and autobiographical events, happy faces), such that older adults have better memory for, and pay greater attention to, positive relative to negative valenced information (a “positivity effect”). Two hypotheses have recently emerged which differ in the cognitive mechanism proposed to account for the emergence of aging-related positivity effects. The first, termed the “cognitive control” hypothesis, suggests that positivity effects arise from older adults' directed application of cognitive efforts to preferentially process positive information, essentially a top-down explanation. The second is a bottom-up hypothesis, suggesting that positive information is relatively easier (more fluent) for older adults to detect and process, compared to negative information, due to changes in amygdala reactivity to negative stimuli, and is termed the "processing fluency" hypothesis. To evaluate these hypotheses, I conducted a suite of memory and attention experiments and compared performance of younger and older adults. I used five different tasks (three different memory tasks, and two different attention tasks) which varied with respect to the degree to which each allowed for the use of cognitive control, and was reflective in nature, or emphasized fluency (i.e., speed of processing and output). In Experiments 1 and 2, I examined the effect of age on two different types of memory task that differed with respect to the degree to which participants must rely on cognitive control/reflective processing or processing fluency to successfully complete the task. Clear positivity effects were found on the task that was reflective in nature (autobiographical memory task) but not on the task that relied more heavily on fluency (phonemic fluency task). In Experiment 3, I examined whether older adults strategically select positive information to later remember (i.e., use cognitive control to regulate encoding of positive material), by asking participants to judge the likelihood of remembering positive, negative, and neutral pictures for a later memory test. In line with a strategic bias, older, but not younger, adults showed a positivity effect in terms of the number of pictures selected as particularly memorable, though both age groups showed a positivity effect in picture recall. Within the domain of attention-based tasks, in Experiments 4a and 4b I used a Rapid Serial Visual Presentation (RSVP) paradigm to examine whether older adults were more likely to detect (or have attention captured by) rapidly presented positive, than negative or neutral, pictures compared to younger adults. Given the rapid rate of presentation in this paradigm, it is unlikely that participants would be able to use cognitive control to strategically direct attention to positive stimuli, thus performance was taken to measure fluency-mediated biases for the pictures of different valence. Results showed little evidence for a positivity effect. In Experiments 5a and 5b, again within the domain of attention, I examined whether older adults preferentially oriented attention toward positive, and/or away from negative, relative to neutral stimuli, on a dot probe task in which trial timings were long enough to allow for strategic control. Experiment 5a used faces whereas Experiment 5b used pictures as stimuli, in an effort to determine whether findings could generalize across different types of stimuli. Some evidence of positivity effects were found, as older adults were less biased to attend to negative (angry) faces compared to younger adults. Results across this series of experiments are consistent with the hypothesis that positivity effects in older adults' memory and attention stem from the strategic application of effortful, reflective, cognitive processing, rather than a bottom-up difference in processing fluency.

Acknowledgements

I would like to thank my supervisor, Dr. Myra A. Fernandes, for her patience, support, and wisdom throughout my years of graduate school. I also thank my committee members (Drs. Colin M. MacLeod and David Moscovitch) for their insightful comments and enthusiasm for my work, as well as my lab mates for their compassion and warmth. I thoroughly enjoyed working with numerous Research Assistants during the course of my studies; I thank them all for their dedication to, and interest in, my research. I acknowledge the financial support of the Natural Sciences and Engineering Research Council of Canada during my doctoral studies.

I am infinitely grateful for my family's encouragement in my pursuit of a personal dream, for all of the unfaltering love they have shown, and the sacrifices that they have made to help me along my academic journey. I am also immeasurably grateful for the love and support of my Adeel, in whom I find the rarest and most precious thing in life: a true kindred spirit. A kinder soul has not graced this mortal life.

Finally, I gratefully acknowledge the efforts of the doctors and nurses at the Credit Valley Hospital Cancer Centre, who pulled me from the claws of the Reaper. May I grow old and grey before he returns to claim his prize.

Dedication

This thesis is dedicated

to those souls

lost along the way:

Ross (d. 2009)

Kenny (d. 2009)

Edward (d. 2011)

The destiny of all things is annihilation.

Rest in Peace

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Chapter 1
General Introduction

Many cognitive abilities change during the course of the life span, and it is well-established that a general pattern of decline characterizes cognitive functioning during aging. However, researchers have begun to illuminate those aspects of cognitive functioning that are preserved or actually improve during aging. More specifically, a growing literature delineates the intrinsic characteristics of items which can boost cognitive processing in older adults. One such characteristic is emotional tone. Cognitive processing of items which evoke emotional reactions, such as pictures depicting pleasant or unpleasant events, is typically enhanced in younger adults, and recent research indicates that items which evoke positive emotions in particular often provide a comparatively larger enhancement to older adults' cognitive processing of those items. The purpose of my thesis is to examine the specific cognitive mechanisms that underlie older adults' superior cognitive processing of positive information, in order to determine the circumstances under which positive information is most likely to boost cognitive functioning.

The introduction to this thesis is organized into several sections. I begin with a discussion of the relevance of the study of cognitive aging and describe some of the common changes in cognitive abilities that occur during the aging process. Next, I introduce the socioemotional selectivity theory, a new major theory of aging which provides the theoretical basis for my thesis studies. I then outline aging-related changes in emotional experience and provide a background on the study of emotion and how it influences cognitive functions. In the next section, I proceed to describe the impact of emotions on aging-related changes seen in cognitive functions of attention and memory. This is followed by a discussion of the currently unresolved debate in the literature on aging-related cognition-emotion interactions, which provides the empirical motivation for my thesis. Finally, I give a brief overview of my thesis experiments.

1.1 The Importance of Research on Cognitive Aging

The “silver tsunami” is already upon us. Currently, adults aged 65 or older account for 14.1% of the Canadian population, and that value is expected to rise to about 25% by 2036 (Milan, 2011; Statistics Canada, 2010), with centenarians experiencing the fastest rate of growth of any age group (Milan, 2011). By comparison, “older adults” accounted for just 8% of the Canadian population in 1971, and the rate of population aging will accelerate during the coming decades as the large cohort of “baby boomers” born between 1946 and 1965 turn 65 years of age (Milan, 2011).The upshot of this demographic trend is that the number of older adults is projected to surpass the number of children aged 14 years or under in the population by 2021 (Milan, 2011). These changes in the age-stratification of society are being seen in developed and developing countries around the world (UNPF, 2011).

In the wake of these demographic changes, unprecedented in human history (UNPF, 2011), the percent of the general population living with the negative effects of normal aging-related decline in cognitive functioning will sharply rise. Moreover, in North America, older adults are taking a more active approach to managing cognitive decline and are taking advantage of cognitive training programs which hold the promise of staving off aging-related declines in cognitive abilities, such as video games which claim to improve cognitive performance, and memory clinics (e.g., Arnst, 2006; Mossman, 2009). Clearly, older adults are very concerned about the negative impact that aging has on many cognitive abilities, and they are not alone. Given the high average life expectancy at birth in developed nations (UNPF, 2011), most people can expect to grapple with normal aging-related declines in cognitive functioning at some point in their lives. As well, almost everyone will be faced, at some point, with a family relation or friend of this older generation before they become old themselves. As such, the identification of those factors which may boost cognitive performance in older adults is key to increasing quality of life and preserving dignity for those facing aging-related declines in cognitive abilities.

1.2 Aging-Related Changes in Cognitive Functioning

1.2.1 Declines in Cognitive Functioning

Older adults are right to be concerned about the changes in cognitive abilities that they are to expect as they age. It is well-established that a host of cognitive abilities decline during the aging process. There are declines in aspects of memory such as episodic memory (in recall more so than in recognition) (Craik & McDowd, 1987; Nyberg, Maitland, Rönnlund, Bäckman, Dixon, Wahlin, et al., 2003; Rönnlund, Nyberg, Bäckman, & Nilsson, 2005; Zelinski & Burnight, 1997), which may leave older adults more susceptible to developing false memories (e.g., Jacoby, 1999; Watson, McDermott, & Balota, 2004), prospective memory (Henry, MacLeod, Phillips, & Crawford, 2004), and source memory (memory for the source characteristics of information; Glisky, Polster, & Routhieaux, 1995; Glisky, Rubin, & Davidson, 2001). Also, there are aging-related declines in selective attention (e.g., Farkas & Hoyer, 1980), change detection, which can affect the ability to drive safely (e.g., Caird, Edwards, Creaser, & Horrey, 2005) and the ability to switch between performing two different tasks (Kray & Lindenberger, 2000). Furthermore, aging is accompanied by declines in executive functions/cognitive control processes such as working memory (Daigneault & Braun, 1993; Park, Lautenschlager, Hedden, Davidson, Smith, & Smith, 2002), allocation of attention to multiple tasks simultaneously (e.g., Holtzer, Stern, & Rakitin, 2004), inhibition of irrelevant information (Hasher & Zacks, 1988), verbal fluency (Axelrod & Henry, 1992; Daigneault, Braun, & Whitaker, 1992), mental flexibility (Axelrod & Henry, 1992; Daigneault, Braun, & Whitaker, 1992), problem solving (Healey & Hasher, 2009; Yoon, Cole, & Lee, 2009), error monitoring (West, 2004), and self-initiated retrieval from memory (Craik, 1986). Moreover, decrements in the perceptual processing of information occur due to declines in visual acuity, ability of the eye to accommodate to low-light conditions, reduced ability to detect blue hues (Blanks & Dorey, 2009), decreased hearing acuity (Pichora-Fuller & MacDonald, 2009), especially for high pitched sounds crucial for speech perception (Schneider & Pichora-Fuller, 2000), ability to detect auditory signals in noisy backgrounds (Tun, 1998), and considerable increases in speed of processing/reaction times (e.g., Park et al., 2002; Salthouse, 1991, 1992, 1994, 1996). These declines in sensory functioning also affect older adults' ability to cognitively process information, and can at least partly account for decrements in cognitive performance that occur during aging (McDaniel, Einstein, & Jacoby, 2008; Schneider & Pichora-Fuller, 2000). For instance, when older adults' cognitive resources are taxed by attempts to compensate for deficits in sensory processing, performance on cognitive tasks can suffer (e.g., McCoy, Tun, Cox, Colangelo, Stewart, & Wingfield, 2005; Wingfield, Tun, & McCoy, 2005).

In addition, a number of changes in brain physiology and functioning occur during aging which may negatively impact cognitive functioning. For example, brain volume gradually shrinks beginning in young adulthood, and this shrinkage accelerates in middle-age (Raz, 2005). This shrinkage is most apparent in the frontal (which subsumes executive/cognitive control functions and the ability to flexibly guide behaviour in the face of unpredictability in the environment) and parietal regions of the brain, whereas the primary perceptual processing areas such as the occipital lobe experience little to no change (Pfefferbaum, Sullivan, Rosenbloom, Mathalon, & Lim, 1998; Raz, Lindenberger, Rodrigue, Kennedy, Head, Williamson, et al., 2005; Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003). Moreover, some areas of the temporal lobes which support memory and emotional functioning, such as the hippocampus and amygdala, respectively, show moderate levels of atrophy (Malykhin, Bouchard, Camicioli, & Coupland, 2008; Raz et al., 2005; Raz, Rodrigue, Head, Kennedy, & Acker, 2004). In addition, the fluid-filled ventricles of the brain expand to fill the space left by atrophied tissue, with a corresponding reduction in surrounding brain tissue (Raz, 2005), neurons lose myelination (Dennis & Cabeza, 2008) which may account for cognitive slowing, and there is a decrease in the synthesis of neurotransmitters such as dopamine, which is associated with decrements in cognition performance (Bäckman, Ginovart, Dixon, Wahlin, Wahlin, Halldin, et al., 2000; Volkow, Wang, Fowler, Ding, Gur, Gatley, et al., 1998). Together with the findings from the literature on aging-related changes in cognitive functioning, these changes in brain structure paint a very negative picture of cognitive ability in older age. However, a number of cognitive abilities are relatively spared.

1.2.2 Cognitive Functions that Remain Stable or Improve

In fact, a number of cognitive abilities can actually improve or remain relatively stable throughout midlife and into old age (although these abilities do tend to decline again after age 70, e.g., Schaie 1996a, 1996b, 2005), such as semantic memory (Rönnlund et al., 2005), general knowledge (Ackerman, 2008), and verbal abilities (Schaie 1996a, 1996b, 2005), procedural memory (e.g., Smith, Walton, Loveland, Umberger, Kryscio, & Gash, 2005), implicit memory (Monti, Gabrieli, Reminger, Rinaldi, Wilson, & Fleischman,1996), repetition priming (McCarley, Kramer, Colcombe, & Scialfa, 2004), and visual search efficiency for static displays (Whiting, Madden, Pierce, & Allen, 2005; Madden, Whiting, Cabeza, & Huttel, 2004). Indeed, when older adults can rely on accumulated experience and automatic influences to perform a task, age differences can be greatly reduced or eliminated (Castel, 2005; Clancy & Hoyer, 1994; Dollinger & Hoyer, 1996; Hoyer & Ingolfsdottir, 2003; Masson, Carroll, & Micco, 1995; Salthouse, 2012). Moreover, recent research suggests a number of cognitive tasks in which older adults either meet or outperform their younger adult (this age group is usually composed of 18-30 year olds) counterparts (e.g., Castel, 2005).

A growing body of evidence suggests that older adults can accurately remember whether an information source is truthful or trustworthy (Rahhal, May, & Hasher, 2002), are superior at making decisions which must take into account the way in which past choices can affect future rewards (e.g., Worthy, Gorlick, Pacheco, Schnyer, & Maddox, 2011), are better able to make effective decisions when loss aversion is salient, and as such are less susceptible to the sunk cost fallacy (e.g., Strough, Mehta, McFall, & Schuller, 2008). Researchers have also become interested in identifying the specific factors which lead to improvements in older adults' cognitive abilities. For instance, it has been found that the subjective value of information affects how well the information is later remembered, with age differences in memory being attenuated when information is deemed to be high-value (e.g., Castel, Humphreys, Lee, Galvan, Balota, & McCabe, 2011; Castel, Farb, & Craik, 2007). As discussed below, emotional information, specifically positive information, appears to be particularly high-value to older adults as they place a greater emphasis on regulating their affective state.

1.2.3 Improvements in Emotion Regulation: Cognitive Influences on Emotional Functioning

Research has further focused on older adults' superior emotion regulation relative to younger adults. Emotion regulation is defined as "how we try to influence which emotions we have, when we have them, and how we experience and express these emotions" (Gross, 1998b, p. 275). There are a number of strategies that can be used to regulate emotions, which vary with respect to their likelihood of successfully reducing the intensity of experienced or expressed emotion, as well as the physiological reactions involved in emotional experience (Gross, 1998a, 2008; McRae, Jacobs, Ray, John, & Gross, 2012). For instance, attempting to suppress outward displays of negative emotional state (called expressive suppression), is a poor strategy as it is not effective in reducing negative emotions, and in fact has been shown to increase negative emotions and physiological response to negative stimuli (e.g., Goldin, McRae, Ramel, & Gross, 2008; Gross, 1998a; Ochsner & Gross, 2005). However, strategies such as reappraisal (cognitively reinterpreting a negative situation such that it is viewed as less negative; Gross, 2008) are more effective (Goldin et al., 2008; Gross, 1998a; McRae et al., 2012). Moreover, the neural response differs between these two strategies; although the prefrontal cortex is more active when participants engage in both types of strategies, the amygdala becomes less active during reappraisal (Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner & Gross, 2005), but more active during expressive suppression (Goldin et al., 2008), in line with the decreases in subjective emotional response that follow use of the reappraisal, but not expression suppression, strategy.

Recent research confirms older adults' superior emotion regulation ability and knowledge of successful strategies. For example, older adults report that reappraisal strategies are more effective than expressive suppression (Shiota & Levenson, 2009), and older are more effective at using positive reappraisal (reinterpreting a negative event in a more positive light), as well as equally effective at using expressive suppression as compared with younger adults (Shiota & Levenson, 2009; Urry & Gross, 2010). That older adults prefer the use of reappraisal to expressive suppression is good news for those concerned with aging-related declines in cognitive functioning, as use of expressive suppression has been shown to decrease memory for emotional stimuli (Richards & Gross, 1999, 2000). Hence, older adults appear to prefer emotion regulation strategies that may preserve, rather than hinder, their cognitive abilities. Furthermore, one study has shown that the act of attempting to down-regulate negative emotional states while concurrently performing a cognitive task improves older adults' working memory performance, whereas it decreases working memory performance in younger adults, suggesting that emotion regulation is less cognitively taxing for older adults than for young (Scheibe & Blanchard-Fields, 2009). This is especially relevant as it implies cognitive control, and inhibition, believed to decline in aging, can in fact operate, depending on the task materials and motivation of the person.

Indeed, a major new theory has emerged which accounts for aging-related changes in social, emotional, and cognitive functioning, called the Socioemotional Selectivity Theory. It paints a much more positive view of the changes that accompany the aging process, and challenges previous conceptions of the adaptiveness of socioemotional functioning in aging. In my thesis experiments, I test predictions from the Socioemotional Selectivity Theory and as such it serves as a major theoretical framework for my thesis.

1.3 The Socioemotional Selectivity Theory: A New Perspective on Aging

The socioemotional selectivity theory (SST) is rooted in the field of social gerontology, rather than cognitive psychology and, as originally conceived, presents an explanation for the pattern of social interactions in aging. In her seminal paper introducing the socioemotional selectivity theory, Carstensen (1995) accounts for the well-established finding that frequency of social contact is much less in older adults than in younger adults. According to Carstensen (1995), other theories maintain that reductions in frequency of social contact in older adults are the result of either: 1) fewer opportunities to engage in social interactions due to societally imposed life events such as retirement (activity theory; Maddox, 1963), or 2) a process in which older adults psychologically prepare for death by focusing more on self-reflection and less on emotional state and social contact (disengagement theory; Cumming & Henry, 1961).

The socioemotional selectivity theory differs in keys ways from these theories in the way it accounts for aging-related changes in social activity. First, it assumes that different social motives drive social behaviour and that the salience of these motives changes over the course of the life span (see ***Figure 1***). As such, Carstensen (1995) characterizes the theory as a life-span developmental theory. I will focus on two of the three motives most pertinent to my thesis: emotion regulation (referred to here as maintenance of a positive affective state), and information seeking (learning new information). SST maintains that the salience of emotion regulation is highest during infancy and old age, whereas the salience of information seeking peaks in adolescence and young adulthood and declines during middle and old age. Carstensen (1995) purports that these changes in motive salience are moderated by the factors of experience and perception of time. In terms of the role of experience, information seeking is more relevant to young adults as they must gain new skills and information to become independent and in doing so must seek information from new social partners. On the other hand, older adults, who have accumulated much information, should be less likely to require information from novel social partners.

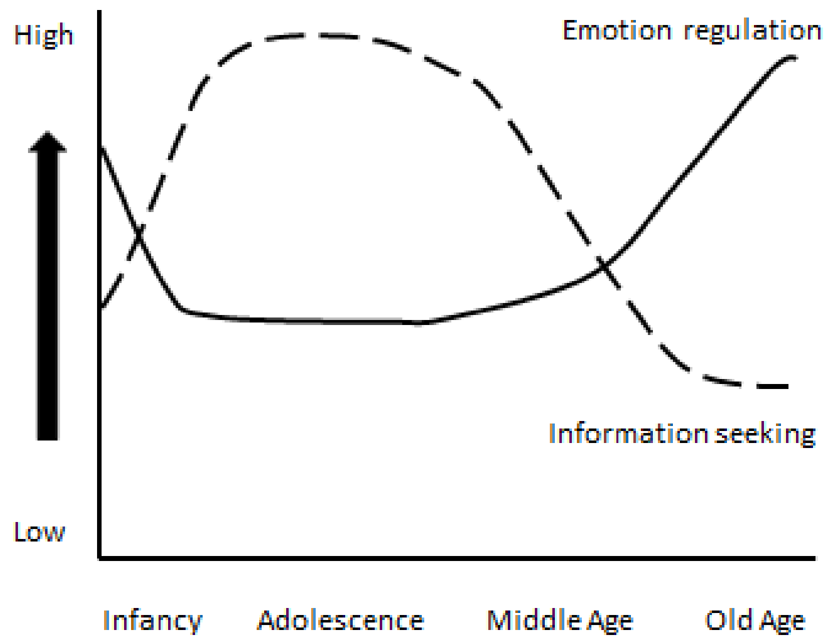

Figure 1. Salience of social motives across the lifespan (adapted from Carstensen, 1995).

According to Carstensen (1995), however, it is time perception that exerts the strongest influence on the salience of these social motives (Carstensen, 2006; Carstensen, Isaacowitz, & Charles, 1999). When time is perceived to be expansive (such as in young adulthood), information seeking goals are predicted to be more salient, and negative affective states can be tolerated if they advance the goal of acquiring new information to satisfy long-term goals. In contrast, when time is perceived to be limited (as in old age), emotion regulation goals are predicted to be more salient as it becomes more pressing to satisfy short-term goals of maintaining a positive affective state.

Given this logic, older adults are predicted to decrease contact with acquaintances and novel social partners relative to young adults, but increase frequency of social contact with emotionally meaningful partners such as family. Carstensen (1995) finds confirmation of this idea in a reanalysis of data from a longitudinal study (Carstensen, 1992), as well as in laboratory (Frederickson & Carstensen, 1990; Fung & Carstensen, 2004) and naturalistic (Fung & Carstensen, 2006; Fung, Carstensen, & Lutz, 1999) studies of social partner preferences. In this way, SST accounts for aging-related reductions in frequency of social contact by stating that it is not chronological age, or the biological changes that accompany aging, *per se* that drive this change, but time perception. Thus, circumstances which alter the perception of the expansiveness of time should also produce similar patterns of frequency of social behaviour. Indeed, a number of studies have shown this to be the case and also provide evidence consistent with the idea that selection of social partners according to the social motives of emotion regulation and information seeking is an active process (Lang & Carstensen, 2002). For instance, terminally ill younger adults (Carstensen & Fredrickson, 1998), as well as older adults, and younger adults under a perceived time constraint, (Frederickson & Carstensen, 1990; Fung & Carstensen, 2004, 2006; Fung, Carstensen, & Lutz, 1999) indicate preference for social partners who are familiar and who can contribute to a positive affective state.

In summary, SST postulates that the perception of the expansiveness of time determines the salience of motivational goals throughout the life span to either regulate emotion or acquire information, and the salience of these goals in turn drives socio-emotional, and cognitive, behaviour.

As intimated above, previous research had focused on documenting aging-related declines in cognitive and perceptual abilities, working on the implicit assumption that old age is a time of loss and misery (Carstensen & Charles, 1998). Of particular importance is that SST is the first socio-psychological theory of aging to emphasize growth and development of some of the positive aspects of growing older, namely, improvements in emotional functioning (Carstensen & Charles, 1998; Carstensen, Fung, & Charles, 2003).

1.3.1 Aging-Related Changes in Emotional Experience

A substantial literature documents aging-related improvements in emotional experience; both cross-sectional and longitudinal studies have shown that older adults experience less negative affect (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001; Griffin, Mroczek, & Spiro III, 2006; Gross, Carstensen, Pasupathi, Tsai, Skorpen, & Hsu, 1997; Kunzmann, Little, & Smith, 2000; Mroczek & Kolarz, 1998; Pethtel & Chen, 2010), or more positive affect (Carstensen et al., 2011; Mroczek & Kolarz, 1998, but see Griffin et al., 2006), relative to younger adults, at least until very old age (e.g., Griffin et al., 2006). As well, older adults report experiencing mixed emotional states more often than young (e.g., Carstensen et al., 2000; Carstensen et al., 2011), and better control over their emotional states relative to young (Carstensen et al., 2011; Gross et al., 1997; Lawton, Kleban, Rajagopal, & Dean, 1992; Phillips, Henry, Hosie, & Milne, 2006; Riediger, Schmiedek, Wagner, & Lindenberger, 2009; Rocke, Li, & Smith, 2009), and older adults have greater stability of their positive than negative affective states (Carstensen et al., 2000). Some evidence also suggests that older adults may reappraise memories of negative life events in a more positive light (Comblain, D'Argembeau, & Van der Linden, 2005).

The cause of this improved affect with age is unclear, and certainly stands in contrast to the realities of physical and cognitive decline that occur with the aging process. It is possible that older adults are more focused on regulating their emotions and so either use emotion regulation strategies more frequently (e.g., Phillips, Henry, Hosie, & Milne, 2006) or select more effective strategies to maintain a more positive affective state. For example, older adults use emotion regulation strategies to reduce feelings of anger more frequently than do younger adults (Phillips et al., 2006).

Importantly for the current thesis, older adults appear to be more skilled at applying those emotion regulation strategies, such as positive reappraisal, that are more effective (Gross, 2008; John & Gross, 2004) at decreasing emotional reactions to negative stimuli (Shiota & Levenson, 2009). It is also possible that older adults, many of whom are retired, free of child care duties, and do not have to care for an ailing partner, are less exposed to the acute stresses and uncertainties of young adulthood and middle age, and so it is easier to maintain a positive affective state (Almeida & Horn, 2004; Carstensen et al., 2011; Rocke, Li, & Smith, 2009). For example, older adults have been shown to prefer predictable daily routines (Bouisson & Swendsen, 2003), and many have the freedom to structure their days in a predictable fashion.

Moreover, it is possible that older adults are less physiologically reactive to emotional situations and stimuli, either due to increased psychological threshold for reactivity to negative situations that accompanies a lifetime of coping with repeated exposure to negative events (Lawton, 1996; Schulz, 1982), or due to lower physiological reactivity to emotional situations and events (e.g., Mroczek & Almeida, 2004). Findings from a number of studies support the idea of decreased physiological, but not psychological, reactivity to negative stimuli. Older adults have been shown to be less physiologically reactive to emotional stimuli used in laboratory tasks (for a review regarding aging-related differences in cardiovascular reactivity to emotional stimuli, see Uchino, Birmingham, & Berg, 2010), unless the stimuli are particularly age-relevant, such as film clips portraying loss of a spouse (Kunzmann & Grühn, 2005; Kunzmann & Richter, 2009). For instance, older adults have been shown to have lower cardiac reactivity in response to emotional autobiographical memories (Labouvie-Vief, Lumley, Jain, & Heinze, 2003), pictures (Smith, Hillman, & Duley, 2005), and film clips (Tsai, Carstensen, & Levenson, 2000). Regarding subjective psychological reactions to emotional stimuli, however, age differences are less often found (Charles & Carstensen, 2008; Tsai et al., 2000; but see Smith et al., 2005), but when they are present, older adults report less intense subjective emotional reactions to stimuli that induce anger (Charles & Carstensen, 2008; Labouvie-Vief et al., 2003) compared with younger adults.

However, studies also show that when exposed to stimuli or situations high in emotional arousal or stress, older adults are less able to regulate their emotional state. As such, older adults may be more effective at regulating normal day-to-day stresses relative to younger adults (Diehl, Coyle, & Labouvie-Vief, 1996), but less effective at dealing with highly stressful situations (Mroczek & Almeida, 2004, but see Rocke, Li, & Smith, 2009). Finally, cohort effects could account for these changes in emotional experience; the cohort of people who are now in the older adult demographic group may indeed experience less negative affect relative to younger cohorts (Carstensen, 2011). In sum, normal aging is accompanied by improvements in affect, which appear to be driven by an enhanced ability to regulate affective state, and/or changes in how emotional information is processed by the brain.

1.4 Background on the Study of Emotion

1.4.1 Definition of Emotion

Despite being a ubiquitous and highly intuitive phenomenon that is a fundamental part of the human experience, emotion is a complex topic of study and the literature on emotion is riddled with controversies. For the purpose of my thesis, I discuss aspects of emotion research that are generally agreed upon in the psychological literature, the first being the definition of the concept of emotion. "Emotion" (often, but not always, used interchangeably with the term "affect") is defined as a subjective psychological state of relatively brief duration, which results from combinations of physiological activations and cognitive appraisals (e.g., Davidson, Scherer, & Goldsmith, 2003; Fox, 2008; Schachter & Singer, 1962). Physiological activations refer to changes in the peripheral nervous system (nerves outside of the brain and spinal cord) such as changes in heart rate, breathing rate, and perspiration rate (e.g., Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990), whereas cognitive appraisals (e.g., Arnold, 1960; Lazarus, 1966; Scherer, 1984, 2001) refer to assessments of the "valence" of an emotion-eliciting event, i.e., whether the event is deemed "good" or "bad" (e.g., Davidson et al., 2003; Fox, 2008; Öhman, 2000; Rolls, 2005). For example, if a person on a walk through the woods encountered a large bear, that person would likely experience changes to his or her peripheral nervous system such as an increased heart rate, breathing rate, and rate of perspiration, while appraising the situation as dangerous, resulting in the subjective experience of the emotion fear. A change in facial expression would also occur, with the facial muscles being moved (unconsciously) so that the whites of the eyes are more exposed, eyebrows are raised, and the mouth is open with lips retracted, producing a fearful facial expression (e.g., Ekman, Friesen, & Ellsworth, 1972). Emotions differ from moods in that moods are usually defined as having a less specific cause and persist for much longer periods of time than emotions (e.g., Ekman, 1992a; Fox, 2008; Frijda, 1994; Morris, 1989; Rolls, 2005).

1.4.2 Characterizing Emotional Experience

Emotional experiences have been characterized and classified in a number of different ways. A good deal of work in the emotion literature has sought to classify emotional experiences into discrete categories of universally recognizable emotions, referred to as the "basic emotions" of happiness, anger, sadness, fear, disgust, and surprise (e.g., Ekman, 1992a, 1992b; Ekman & Friesen, 1971; Ekman, Sorenson, & Friesen, 1969; Tomkins & McCarter, 1964). These studies focused on recognition of emotional states in the context of human facial expressions. (Note that "neutral" facial expressions are defined as faces which lack any particular emotional expression.) Regarding whether older adults are as adept at identifying emotional states in others as younger adults, both age groups can identify with quite high accuracy (80-90% correct recognition) faces expressing the basic emotions of happiness, sadness, surprise, disgust, and anger, but are less accurate at recognizing faces portraying fear (e.g., Isaacowitz, Löckenhoff, Lane, Wright, Sechrest, Riedel, & Costa, 2007). However, a number of studies have found evidence of an aging-related decline in recognition accuracy of expressions of anger (e.g., Isaacowitz et al., 2007; Malatesta, Izard, Culver, & Nicolich, 1987; McDowell, Harrison, & Demaree, 1994; Phillips, MacLean, & Allen, 2002; Sullivan & Ruffman, 2004a, 2004b), sadness (MacPherson, Phillips, & Della Sala, 2002; Malatesta et al., 1987; McDowell et al., 1994; Moreno, Borod, Welkowitz, & Alpert, 1993; Phillips et al., 2002; Sullivan & Ruffman, 2004a), and fear (e.g., Calder, Keane, Manley, Sprengelmeyer, Scott, Nimmo-Smith, & Young, 2003; Isaacowitz et al., 2007; Malatesta et al., 1987; McDowell et al., 1994) whereas accuracy for expressions of happiness is spared (e.g., Borod, Yecker, Brickman, Moreno, Sliwinski, Foldi, et al., 1993; Sullivan & Ruffman, 2004a).

Other work, however, has sought to refine the characterization of emotional experience and expression by mapping degree of emotional experience on to continuous, Likert-type, scales (e.g., Feldman Barrett, 1998, 2006a, 2006b, 2006c; Russell & Feldman Barrett, 1999). When using continuous scales to quantify emotional experience, two aspects of emotion are typically considered: emotional valence and psychological arousal (e.g., Fox, 2008; Russell, 1980, 1983). Valence is conceptualized as the direction of the emotional experience (pleasant/positive or unpleasant/negative), whereas arousal is conceptualized as the intensity of the emotional experience (high or low) (e.g., Fox, 2008). Valence can be represented either on a bipolar scale (ranging from highly negative to highly positive; Russell, 1980), or two unipolar scales (negative and positive) (Diener & Emmons, 1985; Watson, Clark, & Tellegen, 1988; Watson & Tellegen, 1985). The absence of positive or negative emotion is defined as the neutral state, and lies in the centre of a bipolar scale.

In my thesis studies, I conceptualize the valence of emotional experience as consistent with a bipolar scale as I am less interested in examining ambivalent or mixed emotional states and more interested in understanding responses to the dominant emotion experienced by participants in response to experimental stimuli. The dominant emotional response to stimuli is even computed for purposes of comparison in studies which have participants rate items on separate unipolar scales for valence (e.g., Berntson, Bechara, Damasio, Tranel, & Cacioppo, 2007). Moreover, in terms of practical considerations, the widely-used databases of affective word (e.g., Affective Norms for English Words; ANEW; Bradley & Lang, 1999) and picture (International Affective Picture System; IAPS; Lang, Bradley, & Cuthbert, 2001) stimuli developed for use in psychological experiments use bipolar scales to evaluate peoples' emotional reactions to the stimuli, and by using these databases I am able to directly compare the emotional reactions of participants in my thesis studies to established normative ratings of valence and arousal.

1.4.3 The Brain Basis of Emotional Experience

A number of brain regions in the limbic system are heavily involved in the processing of emotional information. These include structures such as the orbitofrontal cortex (in the ventromedial prefrontal cortex of the frontal lobes; Bechara, 2004; Rolls, 2004; Wallis, 2007), cingulate cortex (e.g., Giuliani, Drabant, & Gross, 2011), insula, and subcortical structures such as the amygdalae (in the temporal lobes) (e.g., Berntson, Norman, Bechara, Bruss, Tranel, & Cacioppo, 2011; Kringelbach, 2005). In addition, recent neuroimaging studies suggest that a number of other regions in the prefrontal cortex are involved in emotion regulation processes and are thought to provide top-down control of emotions generated by the amygdalae (e.g., Ochsner & Gross, 2005).

It is well established in the scientific literature that the amygdalae are involved in the processing of emotional stimuli and the production of emotional states and reactions, and this brain region has received the lion's share of empirical attention relative to other brain structures involved in emotion processing. Specifically, the amygdalae are highly involved in the processing of fear-related stimuli as animal models and work with humans show the role of the amygdala in fear-conditioning (e.g., Bechara, Tranel, Damasio, Adolphs, Rockland, & Damasio, 1995; Funayama, Grillon, Davis, & Phelps, 2001; LeDoux & Phelps, 2004), and amygdala-damaged patients show specific deficits in being able to correctly identify faces with fearful expressions (Adolphs, Tranel, Damasio, & Damasio, 1994; Adolphs, Tranel, Damasio, & Damasio, 1995; Calder, Young, Rowland, Perrett, Hodges, & Etcoff, 1996), and in their ability to experience fear (Calder, Lawrence, & Young, 2001; Feinstein, Adolphs, Damasio, & Tranel, 2011; Weiskrantz, 1956). However, other work suggests that the amygdalae are also involved in the processing of other negative emotions such as disgust and sadness (e.g., Murphy, Nimmo-Smith, & Lawrence, 2003), and there is even some evidence that the amygdalae are responsive to positive emotion (e.g., Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002), although with less consistency compared with responsiveness to negative emotions (Zald, 2003).

Of particular importance to this thesis is that some studies have shown the amygdalae to be less active in response to negative information in older adults, compared with young adults. For example, Mather, Canli, English, Whitfield, Wais, Ochsner, Gabrieli, and Carstensen (2004) showed younger and older participants a series of positive, negative, and neutral pictures from the IAPS database mentioned above, while in a functional magnetic resonance imaging (fMRI) scanner. They found that older adults' amygdalae were less active when viewing negative pictures relative to positive pictures, whereas younger adults' amygdalae were equally active when viewing negative and positive pictures.

1.4.4 The Aging-Brain Model, an Alternative to SST

These findings have led to the development of an alternative account to the SST for the mechanisms that underlie the improved affective experience with aging, called the aging-brain model (Cacioppo, Berntson, Bechara, Tranel, & Hawkley, 2011). Rather than postulating the effect of different motivational forces on emotional states and the processing of emotional information, the aging-brain model takes a more biology-based approach. The aging-brain model posits that the amygdalae become less reactive to negative stimuli during aging, but maintain reactivity to positive stimuli, and so less psychological arousal is experienced by older adults when processing negative stimuli, compared with younger adults (Cacioppo et al., 2011). This reduction in psychological arousal is also expected to affect cognitive processing of negative material, such as a reduction in the memorial advantage for negative-arousing stimuli (Cacioppo et al., 2011) sometimes seen in young adults (for reviews see Baumeister, Bratslavsky, Vohs, & Finkenauer, 2001, and Rozin & Royzman, 2001).

As such, if the amygdalae deteriorate during the aging process, this model predicts a selective decrease in the processing of negative information in older adults. Furthermore, Cacioppo et al. (2011) cite findings from studies of neuropsychological patients with damage to the amygdalae to support their theory. They reason that if decrements in the functioning of the amygdalae are crucial to reductions in the processing of negative material, then patients with lesions to the amygdalae, regardless of age, should show this deficit. This idea was confirmed in a study (Berntson, Bechara, Damasio, Tranel, & Cacioppo, 2007) in which patients with damage to the amygdalae/anterior temporal lobe viewed and then rated negative, positive, and neutral IAPS pictures on the dimensions of valence and arousal. It was found that patients with amygdala damage rated negative, but not positive, pictures as less arousing compared with both the normative picture ratings and ratings of patients with damage to other brain areas not involved in emotion processing, despite the preserved ability to correctly categorize the pictures according to valence (Berntson et al., 2007). In this way, the aging-brain model views reduced amygdala activity to negative material as the cause of aging-related changes in processing of emotional stimuli (a bottom-up effect), whereas the

SST views the reduced amygdala activity as the consequence of older adults' prioritization of goals to regulate emotional state (a top-down effect).

1.5 The Effect of Emotion on Cognitive Processing of Information

A large literature exists documenting the memory boosting and attention capturing properties of emotionally valenced stimuli. It is important to first clarify what is meant by the term "emotionally valenced stimuli", as this may not be immediately apparent to those not engaged in the study of emotion. Emotionally valenced stimuli refer to items such as words, narratives/sentences, faces, pictures, and events that call up positive or negative feelings. Examples of positive stimuli include: words with a pleasant connotation (e.g., "love", "joy", "sunshine", "beautiful"), narratives about pleasant circumstances (e.g., a birthday party), faces expressing happiness, pictures of pleasant scenes (e.g., cute puppies, a wedding, beautiful garden, loving families, delicious food, people engaged in sporting activities, depiction of consensual erotic activities), and pleasant autobiographical and non-autobiographical events (e.g., graduating from university, a royal marriage). Examples of negative stimuli include: words with unpleasant connotations (e.g., "hate", "shame", "disease", "injury"), narratives about unpleasant circumstances (e.g., death of a spouse), faces expressing anger, pictures of unpleasant scenes (e.g., dead animals, war, dirty toilets, people in emotional distress, plane crashes, guns), and unpleasant autobiographical and non-autobiographical events (e.g., being laid off from a job, a train crash). In contrast, neutral stimuli are by definition devoid, or nearly devoid, of emotional content. Examples of neutral stimuli include: the words "box", "tool", "bush", "person", a narrative about a daily commute, a face with a neutral expression, pictures of chairs, light bulbs, people working at a computer or driving a car, and autobiographical and non-autobiographical events such as going grocery shopping or watching people waiting for a bus.

The effect of emotionality on cognitive processes has been well established, especially in the domains of memory and attention. Emotionally valenced items (such as words, pictures, film clips, and narratives), and events, are often more likely to be recalled and correctly recognized (e.g., Blake, Varnhagen, & Parent, 2001; Buchanan, Etzel, Adolphs,& Tranel, 2006; Cahill & McGaugh, 1995; Guy & Cahill, 1999; Kensinger & Corkin, 2003; Kulas, Conger, & Smolin, 2003; Levine & Pizarro, 2004; Talmi & Moscovitch, 2004) relative to items with a neutral valence. Attention is also more likely to be directed to, and captured by, emotionally valenced items (Huang, Baddeley, & Young, 2008; Ihssen & Keil, 2009) relative to neutral items. Emotional items are also more likely to distract attention from surrounding non-emotional items (e.g., Dolcos & McCarthy, 2006; MacKay, Shafto, Taylor, Marian, Abrams, & Dyer, 2004). A prominent finding in the emotion-cognition literature is that negatively valenced items or events are sometimes (e.g., Kern, Libkuman, Otani, & Holmes, 2005; Ochsner, 2000; Ogawa & Suzuki, 2004), but not always (e.g., Breslin & Safer, 2011; Brosch, Sander, Pourtois, & Scherer, 2008; Libkuman, Stabler, & Otani, 2004; Mogg & Bradley, 1999; Stein, Peelen, Funk, & Seidl, 2010; Yates, Ashwin, & Fox, 2010), better remembered and attended to than positive and neutral items or events. For example, studies which use visual search ("face-in-the-crowd") paradigms in which participants must identify a target face that has an emotional facial expression that is discrepant with the other faces in the surrounding matrix, often find that angry faces are detected more quickly than happy or neutral faces, indicating greater attention capture (e.g., Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001; Pinkham, Griffin, Baron, Sasson, & Gur, 2010). It is of particular interest to the current thesis, however, that older adults often do not show an enhancement in the cognitive processing of negative information as do younger adults. Rather, recent research indicates that older adults are often biased to preferentially cognitively process positive information, and this is referred to as the aging-related "positivity effect" (e.g., Tomaszczyk, Fernandes, & MacLeod, 2008).

Chapter 2

The Aging-Related Positivity Effect in Cognitive Performance

The SST highlighted the role of emotion in older adults' social behaviour. Within a few years, the assumptions of the SST were applied to cognitive psychology. Researchers, including Carstensen herself, began to ask the question of whether motivational goals could affect the way in which information is cognitively processed. It was reasoned that if emotion regulation goals are salient in older adults, then they may be more likely to preferentially cognitive process positive information, when compared with younger adults, to maintain a positive affective state. An earlier study of Carstensen's suggested the importance of emotion to older adults' memory performance: When asked to remember narratives composed of emotional- and neutral-toned sentences, older adults recalled a greater proportion of the emotional than neutral content, relative to younger adults (Carstensen & Turk-Charles, 1994).

Research on the effect of emotion on the cognitive performance of older adults in the context of SST began in earnest with the publication in the same year of two papers addressing the effect of emotion on memory (Charles, Mather, & Carstensen, 2003) and attention (Mather & Carstensen, 2003). Charles et al. (2003) compared recall and recognition of positive, negative, and neutral pictures in young, middle-aged, and older adults and found greater recall of positive, relative to negative, pictures in older and middle-aged adults, whereas younger adults recalled equal numbers of positive and negative pictures. Both age groups recalled greater numbers of emotional pictures relative to neutral pictures. To examine the effect of emotion on sustained attention, Mather and Carstensen (2003) showed younger and older adults pairs of faces, in which one face had a neutral expression and the other a happy, sad, or angry expression, and measured how quickly participants could detect a dot that replaced either the neutral or emotional face. Faster response times to detect a dot when it replaced an emotional face, compared with the neutral face with which it was paired, indicate that a participant's attention was directed at the emotional face. Mather and Carstensen (2003) found that older adults were slower to detect the dot when it replaced an angry or sad face compared to when it replaced the neutral face in the pair, suggesting that older adults are biased to orient attention away from negative stimuli. Younger adults did not show a bias in attention for emotional faces.

These two studies were the first to report what is now referred to as the aging-related “positivity effect”. The positivity effect is most often defined with respect to performance in memory and attention tasks, but is found in other cognitive domains as well. Generally, positivity effects in memory are defined as follows: The ratio of positive to negative items remembered is higher in older adults relative to younger adults. Positivity effects in attention can be defined in a similar way: Older adults pay proportionally more attention to positive relative to negative items, in comparison with younger adults. That is, studies cite evidence of aging-related positivity effects when older adults are shown to have better memory for, and pay greater attention to, positive information relative to negative information, and younger adults do not show this same pattern.

2.1.1 Definition of Aging-Related Positivity Effects

One issue with the definition of positivity effects is that it can be conceptualized as resulting from comparisons of performance between younger and older adult age groups, or within each age group separately (consistent with the definition presented above). For instance, sometimes studies will claim that a positivity effect has been found if older adults remember more positive, or fewer negative, items relative to younger adults, and may disregard the ratio of positive to negative items within each age group. Other studies may eschew direct comparisons between age groups, and claim that a positivity effect has been found when older adults remember greater numbers of positive items relative to negative items, and younger adults show a different effect of valence on memory. It is also common for studies to report comparisons both between age groups and within age groups when referring to positivity effects. Because no consensus has been reached in the literature regarding the way in which positivity effects should be reported, in my thesis I report both between age group and within age group comparisons, as appropriate.

2.1.2 Positivity Effects in Various Cognitive Domains

Despite some inconsistency in the way positivity effects are conceptualized, a growing literature shows evidence of aging-related positivity effects in a number of different cognitive domains (see Table 1). Positivity effects have been found in decision making studies (Kim, Healey, Goldstein, Hasher, & Wiprzycka, 2008; Löckenhoff & Carstensen, 2007; Mather & Johnston, 2000) in which older adults report greater satisfaction with chosen options as well as better memory for positive features of options, in tasks that rely on executive functions such as working memory (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005), in which older adults show enhanced performance for positive items, in tasks in which information is inhibited (Thomas & Hasher, 2006), and prospective memory, in which older adults show better prospective memory for positive events/cues under some conditions (Schnitzpahn, Horn, Bayden, & Kliegel, in press; Rendell, Phillips, Henry, Brumby-Rendell, de la Piedad Garcia, Altgassen, & Kliegel, 2011).

Positivity effects have been studied to a much greater extent in the domains of memory and attention. Older adults have shown positivity effects on various types of episodic memory tasks (e.g., Charles et al., 2003, Experiment 1; Kennedy, Mather, & Carstensen, 2004; Tomaszczyk, Fernandes, & MacLeod, 2008), and on attention tasks which have used eye tracking to assess gaze preferences for faces expressing different emotions (e.g., Isaacowitz, Wadlinger, Goren, & Wilson, 2006a).

Table 1 *Selected Studies Which Have Found Positivity Effects, by Cognitive Domain, Paradigm, and Stimulus Type*

Study	Cognitive Domain(s)	Paradigm(s)	Stimulus Type(s)
Mather & Johnson (2000)	Decision making	Recall	Written information
Charles, Mather, & Carstensen (2003)	Episodic Memory	Recall; recognition	IAPS Pictures
Mather & Carstensen (2003)	Attention; episodic memory	Dot probe; recognition	Faces
Kennedy, Mather, & Carstensen (2004)	Autobiographical memory	Recall	n/a
Leigland, Schulz, & Janowsky (2004)	Episodic memory	Recall, recognition	Words, faces
Comblain, D'Argembeau, & Van der Linden (2005)	Autobiographical memory	Recall	n/a
Mather & Knight (2005)	Episodic memory	Recall	IAPS pictures
Mikels, Larkin, Reuter-Lorenz, & Carstensen (2005)	Executive function	Working memory	IAPS pictures
Isaacowitz, Wadlinger, Goren, & Wilson (2006a)	Attention	Eye-tracking	Faces
Thomas & Hasher (2006)	Episodic memory	Recognition	Words
Grady, Hongwanishkul, Keightley, Lee, & Hasher (2007)	Episodic memory	Recognition	Faces

Grühn, Scheibe, & Baltes (2007)	Episodic memory	Recognition	IAPS pictures
Knight, Seymour, Gaunt, Baker, Nesmith, & Mather (2007)	Attention	Eye-tracking	Faces and IAPS pictures
Löckenhoff & Carstensen (2007)	Decision making	Recall	Written information
Serrano, Latorre, & Gatz (2007)	Autobiographical memory	Cue word method	n/a
Allard & Isaacowitz (2008)	Attention	Eye-tracking	Faces
Fernandes, Ross, Wiegand, & Schryer (2008)	Autobiographical and episodic memory	Recall	IAPS pictures, words
Isaacowitz, Toner, Goren, & Wilson (2008)	Attention	Eye-tracking	Faces
Kensinger (2008)	Episodic memory	Recall, recognition	words
Kim, Healey, Goldstein, Hasher, & Wiprzycka (2008)	Decision making	Choice selection	Common objects
Petrican, Moscovitch, & Schimmack (2008)	Episodic memory	Recall	n/a
Tomaszczyk, Fernandes, & MacLeod (2008)	Episodic memory	Recall	IAPS pictures
Isaacowitz, Allard, Murphy, & Schlangel (2009)	Attention	Eye-tracking	Faces

Isaacowitz, Toner, & Neupert (2009)	Attention	Eye-tracking	Faces
Kwon, Scheibe, Samanez-Larkin, Tsai, & Carstensen (2009)	Episodic memory	Recall, recognition	IAPS pictures
Langeslag & van Strien (2009)	Episodic memory	Recall	IAPS pictures
Schlagman, Kliegel, Schulz, & Kvavilashvili (2009)	Autobiographical memory (involuntary)	Recall	n/a
Lee & Knight (2010)	Attention	Dot probe	Faces
Ros & Latorre (2010)	Autobiographical memory	Cue word method	n/a
Shamaskin, Mikels, & Reed (2010)	Episodic memory	Recognition	Written information
Werheid, Gruno, Kathmann, Fischer, Almkvist, & Wingblad (2010)	Episodic memory	recognition	Faces
Rendell, Phillips, Henry, Brumby-Rendell, de la Piedad Garcia, Altgassen, & Kliegel (2011)	Prospective memory	n/a	n/a
Schnitzpahn, Horn, Bayden, & Kliegel (2011)	Prospective memory	n/a	n/a
Yang & Hasher (2011)	Semantic Memory	Implicit word stem task	Word fragments

2.1.3 What Are the Cognitive Mechanisms of Aging-Related Positivity Effects?

Although a number of studies have found evidence of aging-related positivity effects, the effect is actually inconsistent in the literature, and sometimes these inconsistencies occur within the same set of experiments. This occurs in the domains of both memory (e.g., Charles et al., 2003, Experiment 2; Emery & Hess, 2008; Denburg, Buchanan, Tranel, & Adolphs, 2003; Grühn, Smith, & Baltes, 2005; Kensinger, 2008; Kensinger, Garoff-Eaton, & Schacter, 2007; Kensinger, Growdon, Brierley, Medford, & Corkin, 2002; Schnitzpahn, Horn, Bayden, & Kliegel, 2011) and attention (e.g., Hahn, Carlson, Singer, Gronlund, 2006; Isaacowitz, Wadlinger, Goren, & Wilson, 2006a; Langley, Rokke, Stark, Saville, Allen, & Bagne, 2008; Leclerc & Kensinger, 2008, 2010; Lee & Knight, 2009; Mather & Carstensen, 2003, Experiment 2; Mather & Knight, 2006; Orgeta, 2011; Mickley Steinmetz, Muscatell, & Kensinger, 2010). It is currently unclear which methodological factors (e.g., type of task, or study material) most strongly influence the manifestation of these effects (for a review and meta-analysis, see Murphy & Isaacowitz, 2008). Knowing the circumstances or conditions that do and do not give rise to a positivity effect in aging can shed light on how the effect manifests. Most notably, a number of studies have demonstrated that experimenter-activated goals to regulate emotions, manipulated by asking participants to focus on their accuracy or on their emotions, make it more likely that a positivity effect will be observed (e.g., Holland, Tamir, & Kensinger, 2010; Kennedy, Mather, & Carstensen, 2004). Emotion-focus instructions also increase the likelihood of observing positivity biases in decision making (e.g., Löckenhoff & Carstensen, 2007). Furthermore, factors such as the personal relevance of study stimuli have been shown to modulate whether positivity effects are seen in episodic memory (Tomaszczyk et al., 2008).

More recently, two accounts have emerged regarding the cognitive mechanisms underlying positivity effects which seek to explain the variable emergence of positivity effects in the literature. These two accounts attempt to discern whether positivity effects are observable only on tasks which require older adults to engage in deliberate, strategic or reflective processes, or whether they are the result of greater processing fluency of positive material in older adults. The first, referred to as the 'cognitive control' account, suggests that positivity effects arise due to older adults' "top-down" application of cognitive control processes/executive functions mentioned above to achieve the goal of maintaining a positive affective state. In this literature, cognitive control is conceptualized as those processes involved in directing behaviour and use of attention resources, such as those required for goal maintenance (active/working memory) and representation, inhibition of goal-irrelevant responses, self-initiated retrieval, and selective attention (e.g., Miller, 2000).

Support for this account comes from two sets of behavioural studies. First, studies on the effect of individual differences in executive functions as measured by neuropsychological tasks, on performance in episodic memory or sustained attention tasks, have shown that older adults who perform better on the executive function tasks are also more likely to show positivity effects in the memory and attention tasks (e.g., Isaacowitz, Toner, & Neupert, 2009; Mather & Knight, 2005; Petrican, Moscovitch, & Schimmack, 2008). Second, positivity effects found when tasks are performed under full attention conditions are nullified or even reversed when performed under divided attention (Knight, Seymour, Gaunt, Baker, Nesmith, & Mather, 2007; Mather & Knight, 2005), suggesting that control processes, or attentional resources, disrupted under divided attention are required for the effect to emerge in older adults.

There is also evidence from neuroimaging studies that the brain basis for the positivity effect lies in control processes mediated by the prefrontal cortex. A number of studies have shown that when participants engage in emotion regulation strategies, such as reappraisal of emotion-eliciting events, activation increases in the dorsolateral prefrontal cortex, lateral prefrontal cortex, and medial prefrontal cortex, whereas activation in limbic structures such as the amygdalae decreases (for reviews see Green & Malhi, 2006, and Ochsner & Gross, 2005). In the context of the positivity effect literature, it is assumed that older adults' chronically activated goal to regulate their affective state motivates them to use cognitive control processes to engage in emotion regulation. Indeed, there is mounting evidence of the role of the prefrontal cortex in the involvement of positivity effects in a variety of cognitive tasks (e.g., Addis, Leclerc, Muscatell, & Kensinger, 2010; Kensinger &

Schacter, 2008; Leclerc & Kensinger, 2008; Leclerc & Kensinger, 2010; St. Jacques, Dolcos, & Cabeza, 2010).

The second account, in contrast, is a "bottom-up" view, and essentially suggests differences in relative processing fluency for positive, negative, and neutral information. Processing fluency is typically conceptualized as the subjective experience of being able to cognitively process something quickly and without great need for conscious elaboration. It is usually operationalized as the speed with which information can be cognitively processed (for a review, see Oppenheimer, 2008). The processing fluency account suggests that positive information may be more accessible to, or have a processing fluency advantage for, older adults, and/or that negative information may be less accessible to older than younger adults (e.g., Yang & Hasher, 2011). To the best of my knowledge, the first study which directly examined the processing fluency account of positivity effects in the memory domain, compared performance on a semantic retrieval task (speeded word fragment completion) for positive, negative, and neutral words, in younger and older adults (Yang & Hasher, 2011). In that study accessibility of words was operationally defined as the proportion of word fragments that participants could spontaneously solve, for words of different valence. They found that older adults completed a larger proportion of word fragments with neutral relative to negative and positive words, whereas younger adults completed a greater proportion of word fragments with negative than neutral words, providing some evidence for an aging-related negativity reduction in semantic memory (though no evidence of a positivity effect or enhancement). Yang and Hasher concluded that neutral words may be more accessible to older adults in the context of more automatic or implicit memory tasks.

2.1.4 Purpose of Thesis

In my thesis, I examine the extent to which processing fluency and cognitive control could account for the appearance of aging-related positivity effects in memory and attention performance. I hypothesize that positivity effects may emerge more reliably on tasks that allow for cognitive control processes to be used in service of goals to regulate emotion, in older adults, such as in tasks which lend themselves to a more reflective style of processing (e.g., Charles & Carstensen, 2009). It is important to note that by "reflective style of processing" I am referring to cognitive processing directed at personal assessment or evaluation, in the context of a cognitive task. As such, I argue that differences in task demands can explain the inconsistencies in past studies. I present evidence that the key factor that influences the manifestation of the effect is whether the cognitive task allows for the motivational goal to maintain a positive affective state to be displayed in cognitive processing. I argue that this is more likely to occur on tasks that are reflective in nature, and allow participants to use cognitive and strategic control processes to preferentially process positive information in accordance with this motivational goal.

I note that the cognitive control and processing fluency accounts are not necessarily mutually exclusive and it is likely that many of the cognitive tasks that have been used in the literature to assess aging-related positivity effects can be carried out through reliance on processing fluency of study materials and/or through use of strategic processes. Moreover, it is entirely possible that there may be individual differences in the extent to which these cognitive processes are used to carry out a given task. I argue, however, that some tasks more clearly lend themselves to the use of cognitive control processes (e.g., retrieval of autobiographical memories) or reliance on fluent processing (e.g., fluency tests) of stimuli.

As outlined above, the cognitive mechanisms that underlie the positivity effect are under debate. Few studies in the memory literature have entertained an alternate explanation to the cognitive control account: that positivity effects may result from an aging-related enhancement in processing fluency for positive items. This thesis evaluates these two accounts by comparing performance on a suite of memory and attention tasks that vary with respect to the degree to which they allow the use of cognitive control and are reflective in nature. This thesis seeks to identify the cognitive mechanism underlying observations of a positivity effect in cognitive processing associated with normal aging, and thus contributes to the determination of boundary conditions under which aging-related enhancements in the cognitive processing of emotional information will most likely be observed. To this end, I will first present a series of experiments on memory, followed by a series of experiments on attention orientation, which search for evidence of positivity effects, and create conditions that can be used to address whether the effect is based more in cognitive control or more in processing fluency differences across older and younger adult age groups.

Chapter 3
Experiments on Memory

3.1 Introduction to Memory Experiments

As mentioned in Chapter 2, positivity effects have primarily been studied in the context of memory paradigms. Older adults have shown positivity effects in recall and recognition of pictures and words (Charles, Mather, & Carstensen, 2003, Experiment 1; Grühn, Scheibe, & Baltes, 2007; Kensinger, 2008; Kwon, Scheibe, Samanez-Larkin, Tsai, & Carstensen, 2009; Langeslag & van Strien, 2009; Leigland, Schulz, & Janowsky, 2004; Mather & Knight, 2005; Thomas & Hasher, 2006; Tomaszczyk et al., 2008), recognition of faces (Grady, Hongwanishkul, Keightley, Lee, & Hasher, 2007; Leigland, Schulz, & Janowsky, 2004; Werheid, Gruno, Kathmann, Fischer, Almkvist, & Wingblad, 2010), recognition of valenced written information (Shamaskin, Mikels, & Reed, 2010), recall of emotional events as well as autobiographical memories (Comblain, D'Argembeau, & Van der Linden, 2005; Fernandes, Ross, Wiegand, & Schryer, 2008; Gallo, Korthauer, McDonough, Teshale, & Johnson, 2011; Kennedy, Mather, & Carstensen, 2004; Petrican, Moscovitch, & Schimmack, 2008; Ros & Latorre, 2010; Schlagman, Kliegel, Schulz, & Kvavilashvili, 2009; Serrano, Latorre, & Gatz, 2007), and in implicit semantic memory for words (Yang & Hasher, 2011). To evaluate the cognitive control and processing fluency hypotheses in the context of memory tasks, the following three experiments examine evidence for aging-related positivity effects in memory tasks that either encourage reflection and the use of cognitive control, or are more dependent on processing fluency.

3.2 Experiments 1 and 2: A Positivity Effect in Autobiographical Memory, But Not Phonemic Fluency, in Older Adults (Tomaszczyk & Fernandes, in press)

Introduction

In the following two experiments, I examine whether a task which arguably primes emotional goals, and reflective thinking—through use of emotional cue words and requirement to produce and classify autobiographical memories by valence—would lead to a positivity effect whereas a task which primes accuracy goals—output on the FAS task—would not. As mentioned in the General Introduction, a recent study which directly examined the processing fluency account of positivity effects in the memory domain compared performance on a semantic retrieval task (speeded word fragment completion) for positive, negative, and neutral words, in younger and older adults (Yang & Hasher, 2011). In that study, accessibility of words was operationally defined as the proportion of word fragments that participants could spontaneously solve, for words of different valence. They found that older adults completed a larger proportion of word fragments with neutral relative to negative and positive words, whereas younger adults completed a greater proportion of word fragments with negative than neutral words, providing some evidence for an aging-related negativity reduction in semantic memory (though no evidence of a positivity effect or enhancement). Yang and Hasher (2011) concluded that neutral words may be more accessible to older adults in the context of more automatic or implicit memory tasks. Experiment 1 (FAS test) of the current thesis allowed me to examine the generalizability of Yang and Hasher's (2011) findings, using a different measure of fluency.

In Experiments 1 and 2, I examined the extent to which processing fluency and cognitive control could account for the appearance of aging-related positivity effects in memory. I hypothesized that positivity effects may emerge more reliably on tasks that allow a more reflective style of processing (e.g., Charles & Carstensen, 2009). It is important to note that by "reflective style of processing" I am referring to cognitive processing directed at personal assessment or evaluation, in the context of a cognitive task. To this end, I compared performance within a sample of younger and older adults on a fluency task, as in Yang and Hasher (2011), albeit a different one, the FAS test. A different verbal fluency task was used to determine the generalizability of Yang and Hasher's (2011) results. Here participants are given letters one at a time and asked to say aloud as many words that begin with each of the target letters as they can in a short period of time. I predicted that, as in Yang and Hasher (2011), older adults would output more neutral words than emotional words. This prediction is also based on the assumption that because in the FAS test participants are instructed to focus on task accuracy (i.e., generating words that meet certain restrictions), goals to enhance emotional state would not be salient and thus no positivity effect would emerge.

I also compared performance on an autobiographical memory task, using a standard "cue-word" method (e.g., Conway & Bekerian, 1987; Jansari & Parkin, 1996; Rubin & Schulkind, 1997; Schlagman, Kliegel, Schulz, & Kvavilashvili, 2009), in which participants were first given positive, negative, and neutral cue words and were asked to generate memories that related to each cue word. I predicted that older adults would generate more autobiographical memories classified as positive, than negative or neutral, and that younger adults would generate more autobiographical memories classified as negative, consistent with previous studies of autobiographical memory (e.g., Gallo, Korthauer, McDonough, Teshale, & Johnson, 2011; Kennedy, Mather, Carstensen, 2004; Serrano, Latorre, & Gatz, 2007). This prediction is also based on the assumption that retrieval of autobiographical memories, in response to cue words, encourages a reflective processing style in which participants' emotional state is more salient as they write out their personal memories. This salience of emotional state may prompt older adults to regulate their emotions by strategically retrieving positive memories.

Additionally I asked participants to rate how they currently felt about the memories they generated. I included ratings of participants' current feeling about autobiographical memories as well as memory classifications by valence to address the idea that, particularly for older adults, there may exist discrepancies between how one would classify an autobiographical memory with respect to valence, and how one currently feels about that memory given that older adults may reappraise their autobiographical memories (e.g., Comblain, D'Argembeau, & Van der Linden, 2005; Levine & Bluck, 1997) in service of emotion regulation goals. Consistent with the logic presented above for classifications of memories, I predicted that older adults would generate more memories about which they currently felt positive than negative or neutral, particularly those generated in response to negative cue words. Based on these assumptions, instructing participants to think about how negative or positive they currently felt about their memories should in fact be more likely to prompt older adults to regulate their emotional state and rate memories as positive.

As outlined above, the cognitive mechanisms that underlie the positivity effect are under debate. Few studies in the memory literature have entertained an alternate explanation to the cognitive control account: that positivity effects may result from an aging-related enhancement in processing fluency for positive items. Experiments 1 and 2 of the current thesis evaluated this alternate hypothesis by comparing performance on two tasks in which participants must output information in response to verbal cues (phonemic fluency and cue word method autobiographical memory test), so as to allow for a more direct comparison of results than would be possible with retrieval protocols employed in previous studies of autobiographical memory in aging in which participants retrieved memories in response to open-ended questions (e.g., Kennedy et al., 2004).

Method

Participants

Fifty-five healthy community-dwelling older adults were recruited through the University of Waterloo's Research in Aging Participant pool (WRAP). The WRAP pool distributes recruitment flyers in the Kitchener-Waterloo area and potential participants must complete a phone interview about their demographic characteristics, medical status and history to determine their eligibility to participate in studies. Eligible participants are then entered into the pool and are contacted for individual studies for which they meet study-specific criteria. Fifty-five younger adults were recruited from undergraduate psychology classes into the University of Waterloo's Research Experience Group. Potential participants had to complete a mass testing and pre-screening questionnaire on an online study management system. Students who met the eligibility criteria for specific studies according to their responses on the pre-screen questionnaire could decide to sign up for a study of their choosing. Table 2 displays participant characteristics. Participants came into the lab for a study on attention to pictures and completed all of the tasks listed below. Older adults received $10/hour remuneration, and younger adults received course credit for participating. For both age groups, inclusion criteria were: fluency in English, normal or corrected-to-normal vision and hearing, no history of neuropsychological impairment, and no previous head injury. This information was obtained through self-report. For older adults, an additional exclusion criterion was a score of less than 26 (out of 30) on the Mini-Mental State Exam (MMSE, Folstein, Folstein, & McHugh, 1975). During the course of the study, participants of both age groups completed a battery of neuropsychological tasks (Trail Making Tests A and B, and Digit Span forward and backward). Scores on the Trail Making Tests and the Digit Span tasks were used to confirm that older adult participants were within normal range for cognitive functioning according to published norms (Spreen & Strauss, 1998; Wechsler, 1997). See Table 2 for neuropsychological test scores.[1]

[1] Consistent with literature indicating greater vocabulary with aging (e.g., Verhaeghen, 2003), the older adult group had a higher full scale IQ (FSIQ), t (108) = 8.06, $p < .0005$, as estimated by the National Adult Reading Test – Revised (NART-R, Nelson, 1992) than the younger adult group. (In the NART-R, participants are asked to read irregularly spelled words out loud.) Older adults also had a greater number of years of education, t (63) = 2.08, $p < .05$ (note that years of education data were missing for 4 older adults).

Table 2 *Experiments 1 and 2 Participant Characteristics. Mean Values with Standard Deviation in Parentheses*

	Age Group			
	Younger (17-23 years of age; 34 female)		Older (61-87 years of age; 38 female)	
Age in years	19.58	(1.50)	71.73	(6.53)
MMSE score	-	-	28.91	(0.89)
Years of education	14.38	(1.41)	15.58	(3.90)
FSIQ (NART-R)	105.05	(7.73)	116.13	(6.64)
PANAS-X (percent positive)	55.56	(11.11)	63.36	(12.68)
PANAS-X (percent negative)	34.22	(12.27)	29.05	(8.98)
Trails A (time in seconds)	18.32	(5.87)	30.52	(9.28)
Trails B (time in seconds)	36.99	(11.77)	74.09	(32.04)

Digit Span Forward	9.22	(2.10)	8.35	(1.98)
Digit Span Backward	7.53	(1.94)	7.20	(2.21)

Materials and Procedure

FAS test. To examine the contribution of processing fluency to positivity effects, I used the FAS test (Spreen & Strauss, 1998), a standard neuropsychological test of phonemic fluency (executive functioning). On this test, participants are given the letters F, A, and S one at a time and are asked to say aloud as many words that begin with each of the target letters as they can. Participants were given 1 minute for generation, per letter, and were instructed not to generate words that are proper names, place names, trademarked names, or the same word with a different ending (e.g., eat and eating). Participant responses were recorded both on paper and with an audio recording device. If a spoken word had multiple meanings (e.g., son and sun, or were homonyms) the experimenter inquired about the intended meaning after the minute had elapsed for the given letter and recorded it on the paper. Words output by participants were later coded as positive, negative, or neutral in one of two ways: 1) words that appeared in the ANEW database (Bradley & Lang, 1999; a database with normative ratings of English words by valence and arousal rated on a 1-9 scale) were coded based on their normative valence ratings (ranges were 1 - 3.66 for negative, 3.67 - 6.33 for neutral, and 6.34 - 9 for positive, words), and 2) words not in the ANEW (including different conjugations/pluralizations of words that appeared in the ANEW) were classified into one of three emotional valence categories (positive, negative, neutral) by two coders working independently. Coding discrepancies were resolved by a third coder. Coding discrepancies occurred for 27.6% and 20.1% of younger and older adults' word output for words not in the ANEW, respectively. Words that violated test instructions (including non-words and non-English words) were not coded and these comprised 0.49% and 2.2% of younger and older adults' word output, respectively. Repetitions of words were not included in the analyses. The mean number of errors produced on the FAS test was 0.22 (*SD* = .50) for younger adults, and 0.85 (*SD* = 1.14) for older adults.

Autobiographical memory task. Participants were given nine "cue words" selected from the ANEW database. There were 3 each of negative (Alone, Mistake, Discomfort; *M* = 2.49, *SD* = 0.34), neutral (Teacher, News, Market; *M* = 5.55, *SD* = 0.21), and positive (Home, Bunny, Cake; *M* = 7.47, *SD* = 0.38), words. Cue words were matched as closely as possible on arousal ($M_{negative}$ = 4.73, *SD* = 0.51, $M_{neutral}$ = 4.45, *SD* = 0.63, $M_{positive}$ = 4.42, *SD* = 0.51) and were selected based on presumed ease with which they could be associated with autobiographical memories. Cue words were presented in a random order for each participant on sheets of paper, with 10-13 lines under each cue word for the participant to write out their memory (one memory per cue word). Participants were instructed as follows: "Provide memories of *specific events from your life* that are related to each of the keywords below. You'll have 1 minute (or 2 if you really need it) to write down a brief description of the event. These memories can be from any time in your life (i.e., from childhood or from the recent past). We are interested in your *memories of specific events* that have occurred at a *specific point in time and place*". Although instructions indicated that participants had 1-2 min. to retrieve and write down their memories, in practice participants were allowed extra time to record their memories if necessary; this instruction was included to encourage participants to complete the task in a timely manner.

After participants wrote down their memories, the experimenter checked to make sure that they were specific (contained detail), and asked participants to provide additional information for productions that were general in nature. For example, if a participant wrote "I like bunnies" or "I used to have a bunny" in response to the cue word "Bunny" the experimenter would ask "Could you write about a time when you had a specific experience with a bunny or that involved bunnies?" If after probing a participant still could not generate a specific memory to the cue word, the memory was still included in the analyses, as I reasoned that such general or semantic memories are based upon the aggregate of a series of episodic memories of the participant's past.

Next, participants were asked to "Please classify each of the events you described above as positive, negative, or neutral"; they did so by placing a "+", "-", or "0" in the box on the left of each cue word. Finally, participants rated their memories on a Likert-type scale regarding how they currently felt about each memory. The instructions were: "For each of the events that you described, please rate how positive or negative you feel each event was, using the scale below (-3 being very negative, 0 being neutral and +3 being very positive). Please make these ratings based on how you feel *right now* about each event. Indicate this score in the box to the right of each description”.

Procedure

Participants were tested individually. Participants completed the NART-R as well as the Trail Making Tests A and B (Reitan & Wolfson, 1985), and Digit Span forward and backward tasks (Wechsler, 1997), which measure executive functioning. Scores on the Trail Making Tests and the Digit Span tasks were used to confirm that older adult participants were within normal range for cognitive functioning (see Table 2), according to published norms (Spreen & Strauss, 1998; Wechsler, 1997). Older adult participants completed the MMSE after the other neuropsychological tasks. To assess mood at time of test, participants also completed the Positive and Negative Affective Schedule – Expanded (PANAS-X, Watson & Clark, 1994). Participants then completed the FAS test and autobiographical memory task.

Results

Mood Measure

Raw PANAS-X scores were converted to percentages (see Table 2 for means). Each age group reported greater positive than negative affect $t_{younger}$ (54) = 9.71, $p < .0005$; t_{older} (54) = 14.45, $p < .0005$ at time of test. Older adults reported greater positive affect t (108) = 3.43, $p < .005$ and less negative affect t (108) = 2.53, $p < .05$ than did younger adults.

Three mixed ANOVAs were performed. The first was to analyze the number of positive, negative, and neutral words output in the FAS test. The second was to analyze the number of autobiographical memories that participants classified as positive, negative, and neutral. The third was to analyze the number of autobiographical memories that participants rated as “currently feel positive/negative/neutral about”, as there could be a difference in how participants currently felt about their autobiographical memories, and how they would generally classify the memories.

FAS Test

Number of words output in the FAS test was analyzed using a mixed ANOVA with the between-subjects factor of age group (younger, older) and the within-subjects factor of word valence (negative, neutral, positive). This tested whether older adults would output more positive than negative or neutral words (positivity effect), compared to younger adults.

Total number of words output did not differ between younger (*M* = 41.53, *SD* = 9.91) and older (*M* = 40.47, *SD* = 11.47) adults, F (1, 108) = 0.27, $p > .1$, $n_p^2 = 0.002$. There was a main effect of valence of words output, F (2, 216) = 343.90, $p < .0005$, $\eta_p^2 = .76$. Participants output greater numbers of neutral (*M* = 25.51, *SD* = 9.14) than positive (*M* = 9.40, *SD* = 5.18), t (109) = 14.80, $p < .0005$, or negative (*M* = 6.09, *SD* = 3.50), t (109) = 21.10, $p < .0005$ words, and greater numbers of positive than negative words, t (109) = 6.34, $p < .0005$. This main effect was qualified by a Word Valence x Age Group interaction, F (2, 216) = 25.37, $p < .0005$, $\eta_p^2 = .19$ (see Table 3) in which younger adults output a greater number of negative, t (108) = 1.99, $p < .05$, and positive words, t (86) = 6.48, $p < .0005$, than did older adults, whereas older adults output a greater number of neutral words, t (108) = 3.44, $p < .01$, than did young.[2]

[2] Comparisons within each age group indicated the same pattern of word output as in the main effect of Valence (*p*s < .05).

Table 3 *Experiment 1, Mean Number of Words Output in the FAS Test by Word Valence and Age Group. Standard Deviations in Parentheses*

	Age Group			
Word Valence	Younger		Older	
Negative	6.75	(3.31)	5.44	(3.58)
Neutral	22.65	(8.48)	28.36	(8.94)
Positive	12.13	(5.41)	6.67	(3.12)

Effects of mood and years of education on FAS test performance. To examine the effect of negative mood, positive mood, and years of education on the number of words output in the FAS test, the above analyses were conducted using these variables included as covariates; when included, the main effect of word valence became marginal (p = .07) and there was a significant main effect of positive mood $F(1, 101) = 7.02$, $p < .01$, $n_p^2 = .06$: participants who reported more positive affect output greater numbers of words overall, r = .23, $p < .05$. The Word Valence x Age Group interaction remained significant, F (2, 202) = 16.71, $p < .0005$, $\eta_p^2 = .14$. No other main effects or interactions reached significance.

Relation between NART-R reading test scores (FSIQ) and FAS test performance. As aging-related differences in vocabulary may have affected word output, correlations between raw scores on the NART-R reading test (number of pronunciation errors), and number of words output, were examined for each age group and word valence type. For younger adults, fewer NART-R errors was related to greater output of negative words, $r = -.30$, $p < .05$, and greater total word output, $r = -.31$, $p < .05$. For older adults, fewer NART-R errors was related to greater negative, $r = -.32$, $p < .05$, and neutral, $r = -.38$, $p < .005$, word output, and greater total word output, $r = -.41$, $p < .005$.[3]

Autobiographical Memory Task

Autobiographical memories classified according to valence. Number of memories classified by the participant according to valence in the Autobiographical Memory Task was analyzed with a mixed ANOVA with the between–subjects factor of age group (younger, older) and the within-subjects factors of memory valence (negative, neutral, positive) and cue word valence (negative, neutral, positive). This tested whether older adults would classify

[3] To examine whether performance on the neuropsychological tasks which assess executive function (Trails B and Digit Span backward) was related to retrieval of words, scores on these tests were correlated with number of words retrieved for each valence type and age group. These analyses revealed that for younger adults better performance on Digit Span backward (larger span) was related to retrieval of more negative words, $r = .27$, $p < .05$. For older adults, better performance on Digit Span backward was related to retrieval of more negative, r = .29, $p < .05$, neutral, $r = .29$, $p < .05$, and total, $r = .37$, $p < .01$, words, and better (faster) performance on Trails B was related to retrieval of more neutral words, $r = -.31$, $p < .05$.

more of their memories as positive, and fewer memories as negative (positivity effect), compared to younger adults.

Because all participants generated nine memories (one for each cue word) as instructed, there was no main effect of cue word valence, age group, or an Age Group x Cue Word Valence interaction in the analyses reported below. All *p*-values are reported with the Greenhouse-Geisser correction.

There was a main effect of memory valence F (2, 216) = 94.13, $p < .0005$, $n_p^2 = 0.47$: Participants generated greater numbers of memories classified as positive (M = 4.24, SD = 1.62), than negative (M = 3.44, SD = 1.41), t (109) = 3.02, $p < .005$, or neutral (M = 1.31, SD = 1.22), t (109) = 12.33, $p < .0005$, and greater numbers of memories classified as negative than neutral, t (109) = 10.67, $p < .0005$. This main effect was qualified by two 2-way interactions. First, there was a Memory Valence x Age Group interaction, F (2, 216) = 16.32, $p < .0005$, $n_p^2 = .13$ (see Figure 2). Older adults generated greater numbers of memories classified as both negative, t (54) = 8.07, $p < .0005$, and positive, t (54) = 15.36, $p < .0005$, than neutral, and generated greater numbers of memories classified as positive, than negative, t (54) = 5.05, $p < .0005$. Younger adults also generated greater numbers of memories classified as both negative, t (54) = 7.00, $p < .0005$, and positive, t (54) = 5.41, $p < .0005$, than neutral, but numbers of memories classified as negative and positive did not differ ($p > .1$).[4]

[4] Comparisons between age groups indicated that older adults classified greater numbers of their memories as positive, relative to young, t (108) = 5.25, $p < .0005$, whereas younger adults classified greater numbers of their memories as negative, t (108) = 2.06, $p < .05$, or neutral, t (108) = 4.00, $p < .0005$, relative to older adults.

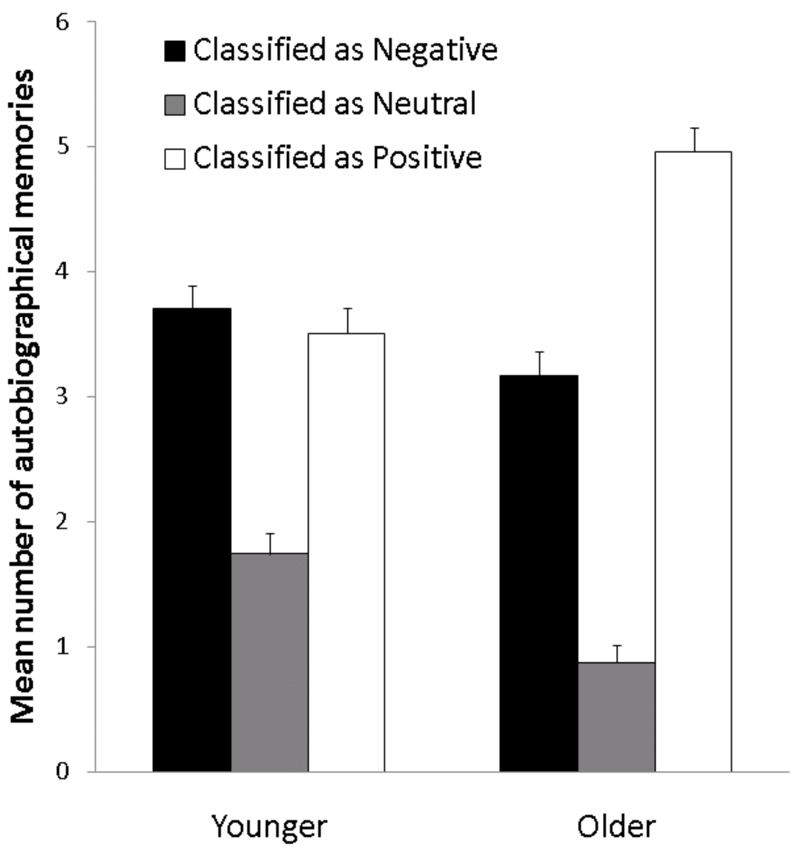

Figure 2. Experiment 2, mean number of autobiographical memories classified by participants as negative, neutral, or positive, by age group. Error bars are standard errors of their respective means.

Second, there was a Memory Valence x Cue Word Valence interaction, F (4, 432) = 120.91, $p < .0005$, $n_p^2 = 0.53$. Note that this interaction serves as a manipulation check that the cue words generally encouraged the generation of memories for which classified valence was congruent with cue word valence. For negative cues, participants generated greater numbers of memories classified as negative than positive, t (109) = 13.14, $p < .0005$, and neutral, t (109) = 16.81, $p < .0005$, but numbers of positive and neutral memories did not differ ($p > .05$). For neutral cues, participants generated greater numbers of memories classified as positive than negative, t (109) = 6.26, $p < .0005$, and neutral, t (109) = 8.54, $p < .0005$, but numbers of negative and neutral memories did not differ ($p > .05$). For positive cues, participants generated greater numbers of memories classified as positive than negative, t (109) = 11.16, $p < .0005$, and neutral t (109) = 13.90, $p < .0005$, but the difference between number of negative and neutral memories was not significant ($p > .1$).

Relation between mood and years of education and classification of autobiographical memories. To examine whether my reported effects were influenced by Mood at time of test, or by Education variables, the above analyses were run with negative mood, positive mood, and number of years of education as covariates. When these variables were included, the main effect of memory valence became non-significant ($p > .1$) and there were significant Memory Valence x Positive Mood, F (2, 202) = 5.46, $p < .01$, $n_p^2 = .05$, and Memory Valence x Years of Education, F (2, 202) = 4.34, $p < .05$, $n_p^2 = .04$, interactions. Importantly, the Memory Valence x Age Group interaction remained significant, F (2, 202) = 8.44, $p < .0005$, $n_p^2 = .08$, as did the Memory Valence x Cue Word Valence interaction, F (4, 404) = 3.19, $p < .05$, $n_p^2 = .03$. (Greenhouse-Geisser corrected p-values reported.) No other main effects or interactions reached significance.[5]

[5] To examine whether performance on the neuropsychological tasks which assess executive function (Trails B and Digit Span backward) was related to retrieval of autobiographical memories, scores on these tests were correlated with number of memories retrieved for each valence type and age group. These analyses revealed only that for older adults, better performance on Digit Span backward (larger span) was related to retrieval of fewer neutral memories, $r = -.31$, $p < .05$.

Ratings of current feelings about autobiographical memories ("feel now" ratings). To examine how participants currently felt about their autobiographical memories, I tabulated a count of memories that were given a negative, positive, or neutral "feel now" rating. Memories rated as -1, -2, or -3 were binned into a "negative-feeling" category and memories rated as +1, +2, or +3 were binned into a "positive-feeling" category. Memories rated as 0 comprised the "neutral-feeling" category. The number of memories in each of these three categories was analyzed with a mixed ANOVA with age group as a between–subjects factor and valence of "feel now" rating (negative, neutral, positive) and cue word valence (negative, neutral, positive) as within-subjects factors. This analysis tested whether older adults would currently feel more positive than younger adults about memories (i.e., show a positivity effect).

There was a main effect of valence of "feel now" rating, F (2, 216) = 78.31, $p < .0005$, $n_p^2 = .42$. Participants generated greater numbers of memories about which they currently felt positive (M = 4.61, SD = 1.70), t (109) = 11.16, $p < .0005$, and negative (M = 2.65, SD = 1.52), t (109) = 4.01, $p < .0005$, than neutral (M = 1.71, SD = 1.44), and generated greater numbers of memories about which they currently felt positive than negative, t (109) = 7.14, $p < .0005$.

This main effect was qualified by two 2-way interactions. First, there was a significant Valence of "feel now" Rating x Age Group interaction, F (2, 216) = 20.28, $p < .0005$, $n_p^2 = .16$. Younger adults generated greater numbers of memories about which they currently felt negative (M = 3.07, SD = 1.48), t (54) = 2.58, $p < .05$, and positive (M = 3.73, SD = 1.56), t (54) = 4.23, $p < .0005$, than neutral (M = 2.13, SD = 1.64). Older adults also generated greater numbers of memories about which they currently felt positive (M = 5.49, SD = 1.34), t (54) = 16.23, $p < .0005$, and negative (M = 2.22, SD = 1.46), t (54) = 3.18, $p < .005$, than neutral (M = 1.29, SD = 1.05), but importantly, they generated greater numbers of memories about which they currently felt positive, than negative, t (54) = 9.31, $p < .0005$.

Second, there was a significant Valence of "feel now" Rating x Cue Valence interaction, F (4, 432) = 89.20, $p < .0005$, $n_p^2 = .45$. This interaction serves as a manipulation check that the cue words generally encouraged the generation of memories for which "feel now" valence was congruent with cue word valence. For negative cues, participants generated greater numbers of memories about which they currently felt negative than positive, t (109) = 7.38, $p < .0005$, or neutral, t (109) = 7.72, $p < .0005$. For neutral cues, participants generated greater numbers of memories about which they currently felt positive than negative, t (109) = 9.88, $p < .0005$, and neutral, t (109) = 7.85, $p < .0005$. For positive cues, participants generated greater numbers of memories about which they currently felt positive than negative, t (109) = 14.09, $p < .0005$, and neutral t (109) = 12.72, $p < .0005$.

These 2-way interactions were qualified by the significant 3-way Valence of "feel now" Rating x Age Group x Cue Word Valence interaction, F (4, 432) = 6.71, $p < .0005$, $n_p^2 = .06$ (see Figure 3). For negative cues, younger adults generated greater numbers of memories about which they currently felt negative, compared to older adults, t (108) = 4.43, $p < .0005$, whereas older adults generated greater numbers of memories about which they currently felt positive, compared to young, t (108) = 4.69, $p < .0005$. Generation of memories about which participants currently felt neutral did not differ between age groups ($p > .1$).

For neutral cue words, older adults generated greater numbers of memories about which they currently felt positive, compared to young, t (108) = 4.55, $p < .0005$, whereas younger adults generated greater numbers of memories about which they currently felt neutral, compared to older adults, t (108) = 4.54, $p < .0005$. Generation of memories about which participants currently felt negative did not differ between age groups ($p > .1$).

Similarly, for positive cues, older adults also generated greater numbers of memories about which they currently felt positive, compared to young, t (108) = 3.00, $p < .005$, whereas younger adults generated greater numbers of memories about which they currently felt neutral, compared to older adults, t (108) = 2.80, $p < .01$. Generation of memories about which participants currently felt negative did not differ between age groups ($p > .1$).[6]

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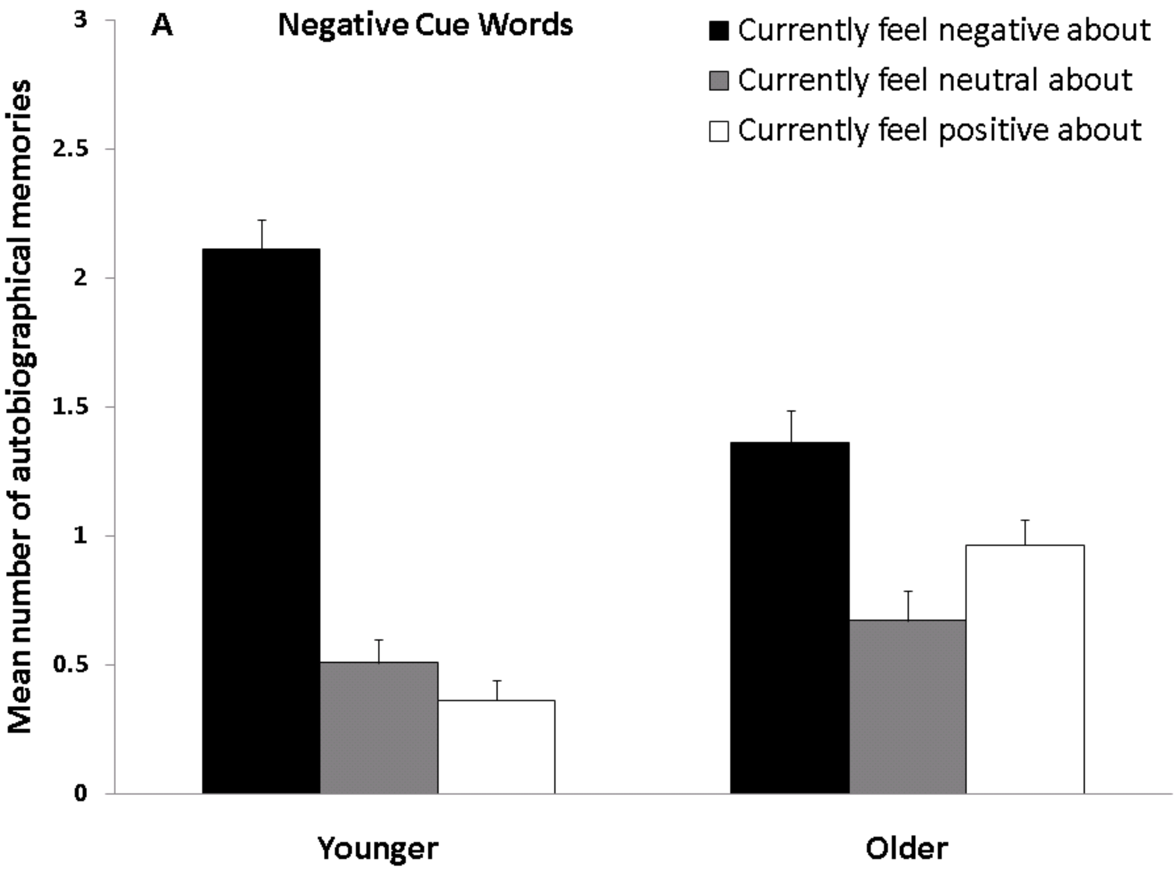
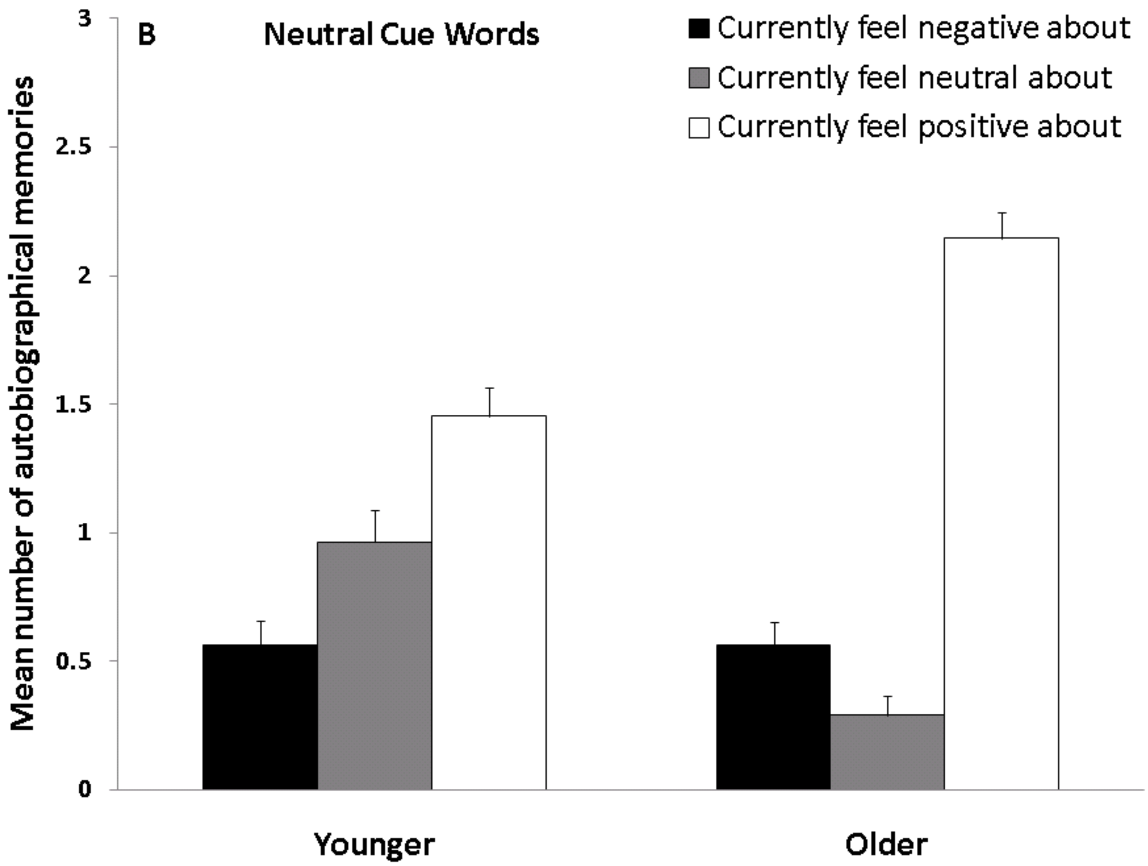
[6] Comparisons within each age group for "feel now" memories indicated that, for negative cues, number of memories generated followed the same pattern of results as in the Valence of "feel now" Rating x Cue Valence interaction. For neutral cues, younger adults generated more positive, than negative, t (54) = 5.32, $p < .0005$, or



neutral, t (54) = 2.23, $p < .05$, memories, and more neutral than negative, t (54) = 2.07, $p < .05$, memories. The pattern for older adults was the same as that for young, except that older generated more negative than neutral memories, t (54) = 2.08, $p < .05$. For positive cues, younger adults generated more positive, than negative, t (54) = 8.07, $p < .0005$, or neutral, t (54) = 6.45, $p < .0005$, memories, but numbers of neutral and negative memories did not differ ($p > .05$). The pattern for older adults was the same as that for young.


B
Neutral Cue Words
Currently feel negative about
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Mean number of autobiographical memories
0
0.5
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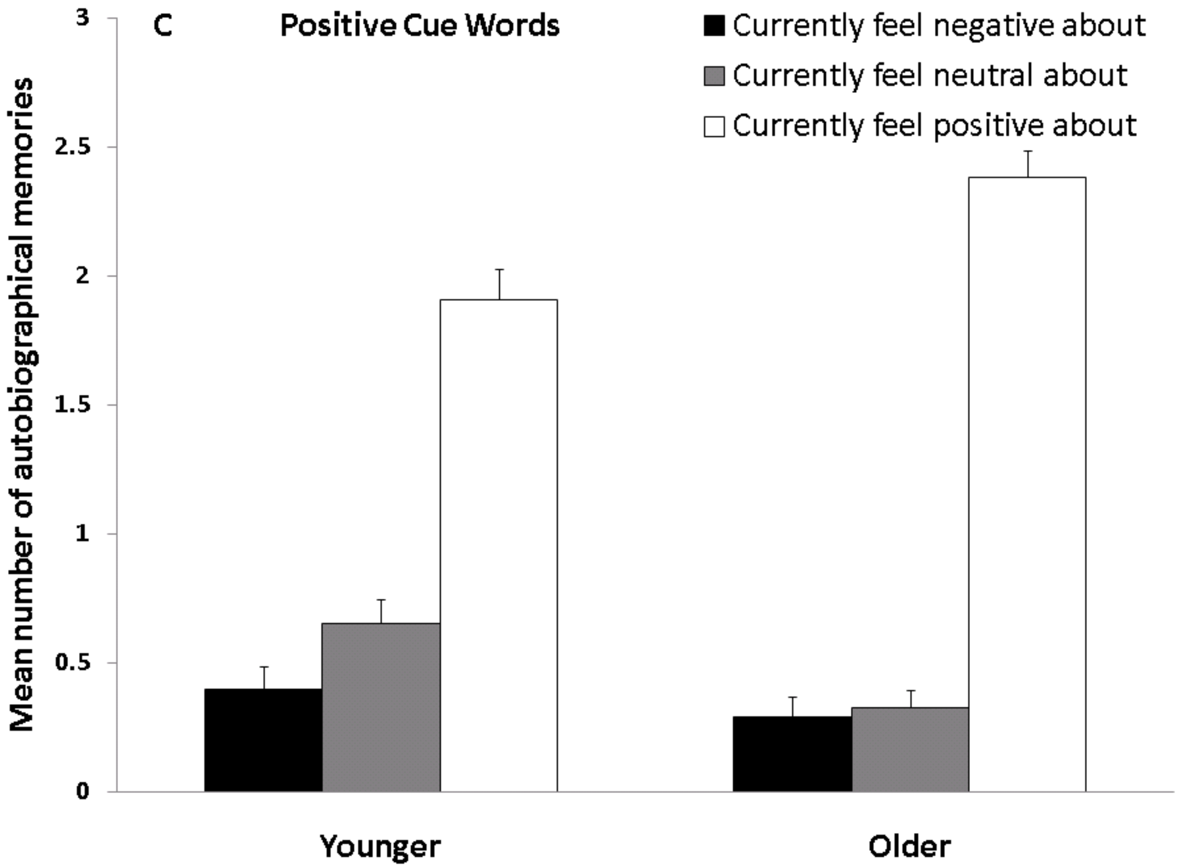

Figure 3. Experiment 2, mean number of autobiographical memories about which participants currently felt negative, neutral, or positive, by age group and for each cue word valence. Panel A: memories generated for negative cue words. Panel B: memories generated for neutral cue words. Panel C: memories generated for positive cue words. Error bars are standard errors of their respective means.

Relation between mood and years of education and "feel now" ratings of autobiographical memories. To examine whether my reported effects were influenced by Mood or Education variables, the above analyses were run with negative mood, positive mood, and number of years of education as covariates. With these variables included as covariates, the main effect of valence of "feel now" rating became non-significant ($p > .1$), and there were marginal interactions of valence of "feel now" rating with negative mood scores, F (2, 202) = 2.79, $p = .06$, $n_p^2 = .03$, and with positive mood scores, F (2, 202) = 2.81, $p = .06$, $n_p^2 = .03$. Importantly, the Valence of "feel now" Rating x Age Group interaction remained significant, F (2, 202) = 11.15, $p < .0005$, $n_p^2 = .1$, and the Valence of "feel now" Rating x Cue Valence interaction was also significant, F (4, 404) = 2.38, $p = .05$, $n_p^2 = .02$. Furthermore, the Valence of "feel now" Rating x Age Group x Cue Word Valence interaction remained significant, F (4, 404) = 3.82, $p < .01$, $n_p^2 = .04$. No other main effects or interactions reached significance.[7]

Discussion

In the current study, I compared retrieval of words on a phonemic fluency task, and of events on an autobiographical task, in younger and older adults. When asked to generate words that began with the letters F, A, and S, no positivity effect in output was found, though older adults output more neutral words. For my autobiographical task, older adults output more autobiographical memories classified as positive, and rated their memories more positively than did younger adults. I suggest that the positivity effect in older adults is primarily observed when the cognitive task allows for personal evaluation and/or engages a reflective style of processing, as on an autobiographical but not a fluency task.

[7] To examine whether performance on the neuropsychological tasks which asses executive function (Trails B and Digit Span backward) was related to retrieval of "feel now" autobiographical memories, scores on these tests were correlated with number of memories retrieved, for each valence type and age group. These analyses revealed only that for older adults, better (faster) performance on Trails B was related to retrieval of fewer neutral memories, $r = .27$, $p < .05$.

Phonemic Fluency Test (FAS)

To the best of my knowledge, only one study to date has examined the processing fluency account of aging-related differences in memory for emotional and neutral information. Although the study (Yang & Hasher, 2011) used an implicit and semantic memory task (speeded word fragment completion), my results are similar to theirs even though I used an explicit and phonemic-based fluency task, and performance on the FAS test likely relied on self-initiated retrieval of words to a greater extent. Both in Yang and Hasher's (2011) study and in mine, older adults generated more neutral than negative, or positive, information. These convergent findings provide support for Yang and Hasher's (2011) assertion that neutral information may be more accessible to older adults relative to information with emotional content (possibly for the reasons discussed above). Also similar to the current study, Yang and Hasher (2011) found that younger adults generated more neutral than positive words. Thus, information of a neutral valence appears to be more accessible for both older and younger adults relative to emotional information, but this pattern of results may simply reflect the numbers of neutral and emotional words in the English lexicon.

One might argue that older adults in this sample scored higher on the NART-R (reading test), and that this difference in vocabulary may have affected number, or valence type, of words output in the FAS test. However, consistent with previous studies (e.g., Bolla, Lindgren, Bonaccorsy, & Bleecker, 1990; Troyer, Moscovitch, & Winocur, 1997), number of words output did not differ between age groups; also, both age groups output greater numbers of neutral compared to negative, or positive, words. Furthermore, as fewer errors on the NART-R was related to greater output of negative words and greater total word output in both age groups, it is unclear how vocabulary size *per se* might have affected the Age x Valence interaction.

Autobiographical Memory Task

I turn next to the results for the autobiographical memory task. Older adults classified greater numbers of their autobiographical memories as positive, than negative or neutral, and classified greater numbers of memories as negative, than neutral. Younger adults, on the other hand, classified greater numbers of their autobiographical memories as positive or negative compared to neutral, with no significant differences between numbers of positive and negative memories generated. Thus, when older adults are asked to retrieve autobiographical memories, they preferentially recall events that they classify as positive, whereas younger adults retrieve memories that they classify as being positively and negatively valenced, relative to neutral.

Participant ratings of how they currently felt about their autobiographical memories replicated the pattern found for classifications of memories. Again, older adults showed a positivity effect; they generated greater numbers of autobiographical memories about which they currently felt positive, than negative or neutral. Younger adults generated greater numbers of autobiographical memories about which they currently felt positive and negative, than neutral. Thus, older adults appear to preferentially recall events that they not only evaluate as being positive in nature, but also which they currently feel positively about, whereas younger adults recall events about which they currently feel positive and negative.

What is especially interesting is the Valence of “feel now” Rating x Age Group x Cue Word Valence interaction. Here I find evidence of both a positivity enhancement and a negativity reduction for older adults. Given negative cue words, older adults generated greater numbers of autobiographical memories about which they currently felt positive, and fewer autobiographical memories about which they currently felt negative, relative to younger adults. Also, given either neutral or positive cues, older adults again generated greater numbers of memories about which they currently felt positive, relative to younger adults. These findings suggest that older adults not only may preferentially recall life events about which they currently feel positive, but may also be inclined to avoid recalling life events about which they currently feel negative, even when prompted with negative cues.

It is important to note that the cue word valence interactions, with memory valence and with valence of “feel now” rating, indicate that participants did indeed generate memories with valence concordant with that of the cue word. That is, participants generated greater numbers of positive and negative memories to positive and negative cue words, respectively. The only exception was for neutral cue words, for which participants generated greater numbers of positive, compared to negative and neutral memories. This is in line with experience sampling studies that show that both younger and older adults report a higher frequency of positive, than negative, affect in their day-to-day lives (e.g., Carstensen, Pasupathi, Mayr, & Nesselroade, 2000).

My autobiographical memory results are also largely in line with previous literature. A number of studies have investigated aging-related changes in autobiographical memory for emotional and neutral events. For instance, Kennedy et al. (2004) asked a sample of middle-aged and older nuns to recall aspects of their past physical and emotional health on which they had previously given reports fourteen years earlier. They found that older nuns recalled their past in a more positive light than was originally reported, compared with middle-aged nuns. In line with this, Comblain, D'Argembeau, and Van der Linden (2005) asked younger and older adults to generate negative, neutral, and positive autobiographical memories from the past two years and found that older adults rated their negative memories as having been more positive, compared to younger adults. These results suggest that older adults may have reappraised their negative memories to be more positive, as reported in my study. Fernandes, Ross, Wiegand, and Schryer (2008) also found a positivity effect in number of reports of positive autobiographical events. Interestingly, later recall of those initially retrieved events did not show a positivity effect, perhaps because the task instructions focused on accuracy of recall of events reported in the previous session. Notably, they did find a positivity effect in older adults' false memories about recent events, in line with my report of a biased output of positive events on autobiographical tests. Moreover, one recent study that also used the cue-word method to probe autobiographical memory found that older adults, especially older men, retrieved fewer negative memories in response to negative cue words compared with younger adults (Ros & Latorre, 2010).

Despite using a very similar methodology to the current study, however, Schlagman, Kliegel, Schulz, and Kvavilashvili (2009) did not find a positivity effect in older adults' voluntary autobiographical memories. Schlagman et al. (2009), examined 'involuntary' (spontaneous) and ‘voluntary’ (generated in response to word or phrase cues) autobiographical memories of younger and older adults. While they did not find a positivity effect in older adults’ voluntary memories, they did find that older adults rated their involuntary memories more positively compared to younger adults. One difference between Schlagman et al.’s (2009) procedure and mine is that they used phrases which described specific situations, as well as single words, as retrieval cues for voluntary autobiographical memories, whereas I exclusively used single words as cues. To illustrate, Schlagman et al.’s (2009) phrase cues “having a row” (negative phrase), “first date” (positive phrase), and “giving directions” (neutral phrase) might be perceived as stronger cues to generate autobiographical memories with a negative, positive, and neutral valence, respectively, compared to my word cues, which afforded more scope for emotional regulation goals to become evident. Moreover, Schlagman et al. did not analyze the number of memories that participants rated as being negative, neutral, and positive in valence, for each word cue valence as I did. Rather, mean valence ratings were analyzed by word cue type (negative, neutral, positive). It is perhaps not surprising, then, that both younger and older adults rated the memories that they generated in response to negative, neutral, and positive phrase cues as negative, neutral, and positive, respectively. This pattern is very similar to the pattern found in my Memory Valence x Cue Word Valence interaction for classifications of autobiographical memories, which suggests that participants generated memories for which valence was concordant with cue word valence.

In line with the cognitive control account, and with the predictions of SST more generally, I suggest that it is primarily when tasks engage participants in a reflective processing style, or when the cognitive task in question allows emotional goals to be more salient, that positivity effects are most likely to be found. I propose that tasks which engage participants in strategic and reflective processing allow greater focus on one’s emotional state, and may be more likely to show a positivity effect in aging.

I note that the cognitive control and processing fluency accounts are not necessarily mutually exclusive and it is likely that many of the cognitive tasks that have been used in the literature to assess aging-related positivity effects can be carried out through reliance on processing fluency of study materials and/or through use of strategic processes. Moreover, it is entirely possible that there may be individual differences in the extent to which these cognitive processes are used to carry out a given task. In light of these considerations, I acknowledge that both my fluency and "reflective" tasks likely tap into processing fluency and cognitive control mechanisms. I argue, however, that the autobiographical memory task lends itself much more readily to a reflective processing style as participants must contemplate events from their lives and in doing so may become focused on their emotional state, which would allow for cognitive control to be used in service of emotion regulation goals. This view is in accordance with recent research which shows that retrieval of specific autobiographical memories (as in my task) depends, in part, upon executive control processes (e.g., Dalgleish et al., 2007; Neshat-Doost, Dalgleish, & Golden, 2008; Piolino et al., 2010). This is in contrast to my fluency task, which discourages a reflective processing style by requiring participants to output as many words as possible in a short time period, with an emphasis on task accuracy (first letter of output, and generating words within specific test restrictions).

As mentioned in the Introduction, recent studies have shown that positivity effects in cognitive tasks can be influenced by instructions to focus on task accuracy or emotional state; when both younger and older participants focus on their emotional state, positivity effects tend to emerge, whereas positivity effects disappear when participants focus on task accuracy (e.g., Kennedy et al., 2004; Löckenhoff & Carstensen, 2007). This effect may even occur more strongly on intentional memory tasks that require controlled processing (Yang & Ornstein, 2011), as on my autobiographical task.

There is also evidence from neuroimaging studies that the brain basis for the positivity effect lies in control processes mediated by the prefrontal cortex. A number of studies have shown that when participants engage in emotion regulation strategies, such as reappraisal of emotion-eliciting events, activation increases in the dorsolateral prefrontal cortex, lateral prefrontal cortex, and medial prefrontal cortex, whereas activation in limbic structures such as the amygdalae decreases (for reviews see Green & Malhi, 2006, and Ochsner & Gross, 2005). In the context of the positivity effect literature, it is assumed that older adults' chronically activated goal to regulate their affective state motivates them to use cognitive control processes to engage in emotion regulation. Indeed, there is mounting evidence of the role of the prefrontal cortex in the involvement of positivity effects in a variety of cognitive tasks (e.g., Addis, Leclerc, Muscatell, & Kensinger, 2010; Kensinger & Schacter, 2008; Leclerc & Kensinger, 2008; Leclerc & Kensinger, 2010; St. Jacques, Dolcos, & Cabeza, 2010). My results and interpretation fall in line with this literature.

Finally, my results are in line with neuroimaging studies which show that when processing positive stimuli during tasks which induce a deep level of processing, older adults recruit the prefrontal cortex to a greater extent than younger adults, perhaps as a result of attempting to regulate emotional response to those stimuli (for a review see Nashiro, Sakaki, & Mather, 2011). Specifically, this effect appears in tasks in which participants make semantic (Ritchey, Bessette-Symons, Hayes, & Cabeza, 2011) and self-referential (Gutchess, Kensinger, & Schacter, 2007) judgments. Because my autobiographical memory task required participants to reflect upon how cue words could be related to events from their own lives, this task likely tapped into memories that were more deeply processed relative to the phonemic fluency task, and so may have been more likely to make emotion regulation goals more salient to older adults.

Limitations

It is possible that differences between my phonemic fluency and autobiographical tasks other than the extent to which participants engaged in a reflective processing style and use of cognitive control mechanisms could have contributed to the observed differences. First, words generated in the FAS test were coded for valence by independent coders and through use of the ANEW, whereas valence of memories in the autobiographical task was rated by participants themselves. If participants had coded valence of words generated in the FAS test themselves, it is possible that they would have classified words differently. It seems unlikely, however, that the majority of participants' classifications would differ greatly from those of independent coders. Furthermore, the emotional tone of a participant's autobiographical memory may not be as obvious to an objective observer as it would be to the participant, and so I felt that participants' classifications of the valence of their autobiographical memories would be more valid than those of objective coders. Moreover, Fernandes et al. (2008) had both younger and older adult external coders rate the autobiographical memories generated by younger and older adult participants, and found the same results regardless of coder age.

Nevertheless, to address the limitation that my tasks may have differed on variables other than a reflective processing style, future work can manipulate instructions given for the FAS test to focus either on accuracy (adherence to test restrictions) or emotional state, and to examine valence of words output. These two instruction conditions could also be used to compare the valence of memories generated in the autobiographical memory task.

Summary and Conclusions

Experiments 1 and 2 showed an aging-related positivity effect and a negativity reduction on an autobiographical memory task, but no evidence of such effects on a phonemic fluency task in the same sample of younger and older participants. In keeping with Mather and Carstensen's (2005) idea that aging-related positivity effects may be most likely to arise on memory tasks in which the to-be-remembered material is personally relevant, the most obvious difference between my fluency and autobiographical tasks is the degree to which the tasks engage participants in a self-reflective processing style. This likely includes aspects of cognitive control (e.g., Mather & Knight, 2005). Although the FAS test is traditionally used to measure verbal fluency (executive function), this task by its nature does not clearly lend itself to a reflective processing style—participants may not have sufficient motivation to preferentially retrieve positive information when the goal is to quickly generate words that begin with a certain letter, and is unlikely to activate goals to maintain positive well-being. Such a result is in line with Kennedy et al.'s (2004) claim that motivation to maintain positive well-being influences whether a positivity effect is obtained.

My results also speak to the current debate regarding another theoretical account of aging-related positivity effects, which postulates that these effects arise from age-related decline in the amygdala's ability to process negative information (Cacioppo, Berntson, Bechara, & Tranel, 2011). It is argued that if positivity effects stem from biological decline of the amygdala in particular, then they should be more consistent across tasks and less susceptible to experimental manipulations of motivational state (e.g., Charles & Carstensen, 2009; Scheibe & Carstensen, 2010). The fact that my study did not find consistent positivity effects across two tasks, in the same sample of participants, and that my phonemic fluency task did not provide evidence of a selective decrement in the processing of negative information in older adults, relative to positive information, goes against this theoretical account.

To conclude, I found no evidence of a positivity effect or negativity reduction in the valence of words output on a phonemic retrieval fluency task. I did, however, find evidence of a negativity reduction and a positivity effect on my episodic autobiographical memory task, and in appraisal of those memories, in older relative to younger adults. The results of my study are not readily accommodated by a processing fluency account. By this account, the fluency task should have revealed a bias in output, but it did not. Whether a positivity effect in older adults is observed seems to depend, at least in part, on whether the task is one which engages a self-reflective style of processing and, in so doing, primes emotion regulation goals.

3.3 Experiment 3: A Positivity Effect in Older Adults' Memorability Judgments of Pictures

Introduction

Experiment 3 examined whether there is evidence of positivity effects in strategic selection of items that older adults consider memorable. To this end, I developed a novel method of presentation of information in which older adults were asked to deliberately choose a subset of information, of different emotional valence, which they considered to be memorable among a set of possible items. Selection biases and later memory performance were then compared in younger and older adults.

Specifically, in Experiment 3 I sought to determine whether older adults actually deemed positive items to be more memorable than negative or neutral ones. The purpose of the current experiment was thus two-fold. The first was to employ a novel methodology to examine whether older and younger adults preferentially select information that they thought would be memorable, based on emotional valence. The second was to determine whether this leads to biases in their subsequent memory. In my study, younger and older adults were shown a 5 x 6 array of negative, neutral, and positive pictures and were asked to select a subset of the pictures that they feel they would be most likely to remember, after which they were asked to recall all of the pictures in the array. Unlike the methods employed in previous studies of metamemory, in which participants judge the memorability of individual items presented sequentially, this novel methodology encourages participants to make cross-item comparisons of characteristics, and to make preferential selections of relative memorability. I assume that my methodology, in which a subset of pictures is to be selected from an array, would require participants to employ a strategy to guide selection; participants must compare the characteristics of multiple items with the goal of selecting only those pictures that they deem most memorable. Importantly for the current thesis, this task also encourages participants to engage in reflective processing to make their picture selections, as they must consider which pictures that they will be most likely to remember later. This may allow older adults to select pictures in accordance with goals to regulate emotional state both during picture selection and at retrieval.

Based both on previous studies that implicated strategic control processes in mediating aging-related positivity effects, and the predictions of SST that older adults are more motivated to regulate their emotions, I expected that older adults would select more positive pictures as being memorable than negative or neutral ones, and would also be more likely to recall positive pictures. Moreover, as some (e.g., Charles, Mather, & Carstensen, 2003, Experiment 2; Denburg, Buchanan, Tranel, & Adolphs, 2003), but not all (e.g., Charles, Mather, & Carstensen, 2003, Experiment 1; Fernandes et al., 2008; Kensinger, Growdon, Brierley, Medford, & Corkin , 2002), studies have shown a negativity bias in younger adults' memory for pictures, I expected younger adults to select more negative pictures as being memorable, and that they would show enhanced recall for these pictures.

Method

Participants

Thirty healthy community-dwelling older adults (63-88 years of age; 18 female) recruited through the University of Waterloo's Research in Aging Participant pool, and 30 younger adults (18-25 years of age; 16 female) recruited from undergraduate psychology classes completed the study. Table 4 displays participant characteristics. Older adults received $10/hour remuneration, and younger adults received course credit for participating. For both age groups, inclusion criteria were: fluency in English, normal or corrected-to-normal vision and hearing, no history of neuropsychological impairment, no previous head injury, and not currently being treated for depression or anxiety. For older adults, an additional exclusion criterion was a score of less than 26 (out of 30) on the Mini-Mental State Exam, which may indicate cognitive impairment (MMSE, Folstein, Folstein, & McHugh, 1975). Consistent with literature indicating greater vocabulary with aging (e.g., Verhaeghen, 2003), the older adult group had a higher full scale IQ (FSIQ), $F(1, 58) = 35.58$, $p < .0005$, as estimated by the National Adult Reading Test – Revised (NART-R, Nelson, 1992) than the younger adult group, but the age groups did not differ on years of education ($p > .1$).

During the course of the study, participants of both age groups completed a battery of neuropsychological tasks (Trail Making Tests A and B, and Digit Span forward and backward). Scores on the Trail Making Tests and the Digit Span tasks were used to confirm that older adult participants were within normal range for cognitive functioning according to published norms (Spreen & Strauss, 1998; Wechsler, 1997). See Table 4 for mean demographic values and scores on neuropsychological tests. One older adult was replaced due to scoring less than 26 on the MMSE and the first younger adult run was replaced as it was noticed that some pictures on the poster were oriented upside down. This was corrected for subsequent participants.

Table 4 *Experiment 3, Participant Characteristics. Mean Values with Standard Deviations in Parentheses*

	Age Group			
	Younger		Older	
Age in years	20.80	(1.85)	74.57	(6.89)
MMSE score	-	-	29.43	(0.73)
Years of education	15.10	(1.52)	15.30	(4.28)
FSIQ (NART-R)	106.53	(5.49)	115.32	(5.91)
PANAS-X (percent positive)	58.10	(14.19)	69.23	(11.06)
PANAS-X (percent negative)	34.11	(11.59)	30.51	(9.22)
Trails A (time in seconds)	17.98	(5.63)	32.80	(14.91)
Trails B (time in seconds)	40.38	(13.08)	62.62	(24.71)
Digit Span Forward	9.27	(1.82)	8.20	(2.30)
Digit Span Backward	7.40	(2.03)	7.00	(1.70)

Mood measure. To compare mood at time of test, across age groups, raw scores on the Positive and Negative Affective Schedule – Expanded (PANAS-X; Watson & Clark, 1994) were converted to percentages (see Table 4 for means) and were analyzed with a mixed ANOVA with the between-subjects variable of age group (younger, older) and within-subjects variable of mood (positive, negative). There was a main effect of mood, F (1, 58) = 217.24, $p < .0005$, $\eta_p^2 = .79$: Both age groups reported more positive than negative mood. There was also a Mood x Age Group interaction, F (1, 58) = 11.99, $p < .005$, $\eta_p^2 = .17$, in which older adults reported greater positive mood than young, t (58) = 3.39, $p < .005$, but there were no age differences in negative mood ($p > .1$).

Materials and Procedure

Materials. Pictures were taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2001), a widely-used database of full-colour pictures with normative ratings on the dimensions of emotional valence and psychological arousal. Each dimension is rated on a scale of 1-9, with 1 being negative valence or low arousal, and 9 being positive valence or high arousal. Two picture lists were created to ensure that any effects would not be due to a specific picture set, both containing 10 pictures each of negative, neutral, and positive valence, for a total of 30 pictures per list. Valence ratings of pictures for the two lists were as follows: negative ($M_{\text{list 1}} = 3.00$, $SD_{\text{list 1}} = 0.48$; $M_{\text{list 2}} = 2.75$, $SD_{\text{list 2}} = 0.33$), neutral ($M_{\text{list 1}} = 4.82$, $SD_{\text{list 1}} = 0.71$; $M_{\text{list 2}} = 5.16$, $SD_{\text{list 2}} = 0.80$), and positive ($M_{\text{list 1}} = 7.50$, $SD_{\text{list 1}} = 0.36$; $M_{\text{list 2}} = 7.40$, $SD_{\text{list 2}} = 0.36$). For each valence category, half of the pictures were low in arousal ($M_{\text{list 1}} = 3.90$, $SD_{\text{list 1}} = 0.29$; $M_{\text{list 2}} = 4.03$, $SD_{\text{list 2}} = 0.25$) and half were high in arousal ($M_{\text{list 1}} = 6.38$, $SD_{\text{list 1}} = 0.29$; $M_{\text{list 2}} = 6.52$, $SD_{\text{list 2}} = 0.44$). Within each arousal category, about half of the pictures contained people and the other half contained animals, nature scenes, or inanimate objects. Picture content was matched as closely as possible across the two lists (e.g., pictures of attack dogs appeared in both lists). Average normative valence and arousal ratings did not differ between the two picture lists for any valence or arousal category (all ps > .1). Average normative valence differed between each valence category, and average normative arousal differed between low and high arousal pictures, for both picture lists (all ps < .0005). Moreover, normative arousal ratings did not differ across valence categories for low (negative $M = 4.10$, $SD = 0.28$; neutral $M = 3.88$, $SD = 0.24$; positive $M = 3.92$, $SD = 0.27$), and high (negative $M = 6.46$, $SD = 0.31$; neutral $M = 6.29$, $SD = 0.29$; positive $M = 6.60$, $SD = 0.48$), arousal pictures ($ps > .05$).

Procedure. Participants were given an information letter telling them that they would be viewing pictures that they were to remember for a later memory task. Participants were tested individually, and mood was assessed with the PANAS-X either before or after the picture viewing and memory tasks to examine the effect of mood on task performance.

Picture pre-exposure task. To equate as much as possible the encoding of study pictures, participants first viewed the 30 pictures from List 1 or 2 (counterbalanced across participants, for each age group) presented one at a time in a random order, and were asked to say out loud a word that described each picture in some way. Pictures were 312 pixels x 416 pixels in size and were presented for 4 seconds each on a white background in the centre of the screen. Participants had unlimited time to give their response, and pressed the space bar to advance to the next picture.

Picture selection task. Immediately after completing the pre-exposure task, participants were shown a white poster board with the 30 pictures displayed on it in a 5 x 6 array. The poster was mounted on a white wall of the testing room, 119 cm from the floor, and pictures were 11 cm x 14.5 cm (the same size as those in the pre-exposure task). Three versions of posters were created for each picture list to randomize the position of specific pictures (counterbalanced across participants, and picture list, for each age group). Participants were told that these were the same pictures that had been presented on the computer screen, and were asked to "select 15 of the pictures that you feel you will best be able to remember such that you could tell someone about the pictures or recognize them afterward." Participants were asked to indicate their selections by pointing, although some verbally described their selections, and were given an unlimited amount of time to make their selections. Afterward, the poster was removed.

Picture free recall task. After a delay of about 5-10 min. during which participants completed the NART-R and forward and backward digit span tasks (Wechsler, 1997), participants were given a sheet of paper with lines on it and were asked to “write down a short description of as many of the pictures that you saw as you can remember. This includes both the pictures that you selected as well as the pictures that you did not select”.

Participants’ written picture descriptions were later matched to study pictures from the poster by two independent coders. Matching discrepancies were resolved by a third coder and these final categorizations of pictures were linked with picture selection data to determine which of the selected pictures were later recalled. Coder discrepancies in matching written descriptions to study pictures occurred for 1.40 % and 5.10 % of younger and older adults’ picture descriptions, respectively. Descriptions that could not be matched to study pictures (intrusions), or were repeated, were not coded. Intrusions comprised 0 % and 0.76 % of younger and older adults’ picture descriptions, respectively.

Neuropsychological tasks. Next, participants completed the Trail Making Tests A and B (Reitan & Wolfson, 1985) to compare psychomotor function across age groups, and older adults completed the MMSE.

Post experimental picture rating. Last, to verify that participant ratings of pictures were concordant with the IAPS normative ratings, participants rated all of the study pictures on the dimensions of valence, arousal, and personal relevance using the Self-Assessment Manikin Scales (SAM, from IAPS, Lang, Bradley, & Cuthbert, 2001). These scales were the same as those used to gather normative ratings for IAPS, except that I adapted the scale used to measure perceived “dominance” of pictures to gather ratings of personal relevance. Pictures were shown one-at-a-time on a computer screen with SAM scales appearing below the pictures, and participants rated pictures by pressing number keys on the keyboard.

Results

Picture Selection

The number of pictures selected by participants was analyzed using a mixed ANOVA with the between-subjects factor of age group (younger, older), and the within-subjects factor of picture valence (negative, neutral, positive). There was a main effect of valence, F (2, 116)

= 6.61, $p < .005$, $\eta_p^2 = .10$; This was qualified by a Valence x Age Group interaction, F (2, 116) = 3.86, $p < .05$, $\eta_p^2 = .06$: Older adults selected greater numbers of positive than negative, t (29) = 4.88, $p < .0005$, or neutral, t (29) = 3.25, $p < .005$, pictures, but numbers of negative and neutral pictures selected did not differ ($p > .1$), whereas younger adults' picture selection did not differ at all by valence (all *p*s > .1; see Figure 4).[8] There was no effect of Age Group as younger and older adults both followed instructions and selected 15 pictures.[9]

[8] Comparisons between age groups indicated that older adults selected more positive pictures than younger adults, t (58) = 2.59, $p < .05$, and marginally fewer negative pictures, t (58) = 1.93, $p = .059$. Number of neutral pictures selected did not differ between age groups, $p > .1$.

[9] To examine whether performance on the neuropsychological tasks which assess executive function (Trails B and Digit Span backward) was related to picture selection, scores on these tests were correlated with number of pictures selected, for each valence type and age group. These analyses revealed only that for younger adults better (faster) performance on Trails B was related to selection of more neutral pictures, $r = -.39$, $p < .05$.

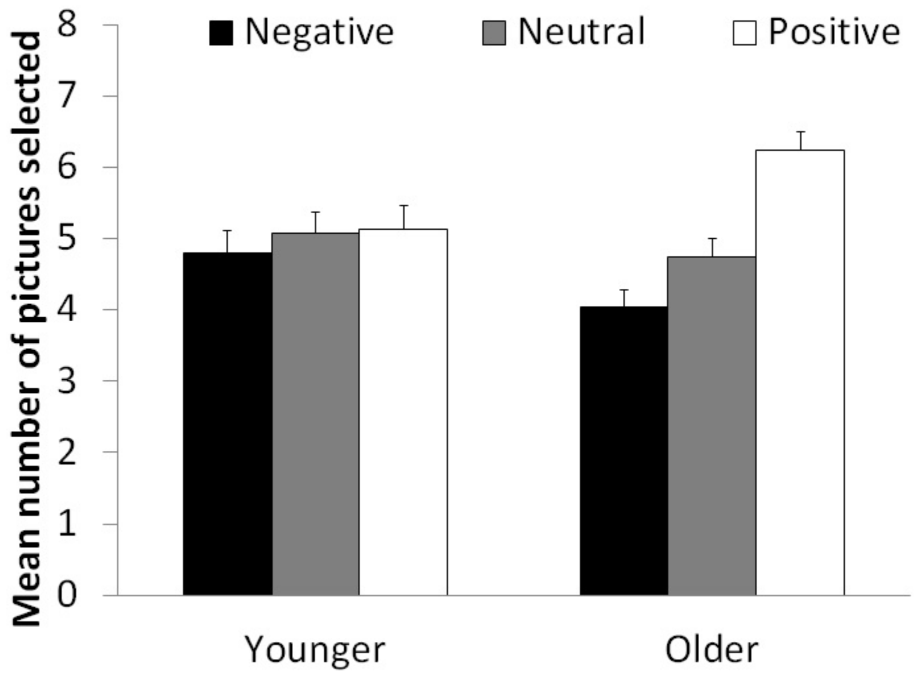

Figure 4. Experiment 3, mean number of pictures selected by participants, by valence and age group. Error bars are standard errors of their respective means.

To examine whether participants' picture selection was modulated by arousal, number of pictures selected was analyzed with a mixed ANOVA with the between-subjects factor of age group (younger, older), and the within-subjects factor of picture arousal category (low, high). There was no main effect of arousal ($p > .1$) but a significant Age Group x Arousal interaction, F (1, 58) = 7.66, $p < .01$, $\eta_p^2 = .12$: Older adults selected more low arousal pictures (M = 8.07, SD = 1.60) than did younger (M = 6.90, SD = 1.67), and fewer high arousal pictures (M = 6.93, SD = 1.60) than did younger (M = 8.10, SD = 1.67). There was no effect of Age Group as younger and older adults both followed instructions and selected 15 pictures.

Picture Recall

Total number of pictures recalled (both selected and non-selected pictures) was analyzed in the same way as selected pictures above. There was a main effect of valence[10], F (2, 116) = 6.88, $p < .005$, $\eta_p^2 = .11$; participants recalled greater numbers of positive (M = 6.63, SD = 1.65) than negative (M = 5.85, SD = 1.76), t (59) = 2.79, $p < .01$, or neutral (M = 5.75, SD = 1.58), t (59) = 3.61, $p < .005$, pictures, but recall of negative and neutral pictures did not differ ($p > .1$).[11] There was no effect of Age group ($p = .08$), and no Valence x Age Group interaction ($p > .1$).[12]

To examine whether participants' memory performance was modulated by arousal, number of pictures recalled was analyzed with a mixed ANOVA with the same factors as in

[10] To examine whether performance on the neuropsychological tasks which assess executive function (Trails B and Digit Span backward) was related to picture recall, scores on these tests were correlated with number of pictures recalled for each valence type and age group. No correlation reached significance (all ps > .1).

[11] Correlation analyses conducted to address the concern that mood may explain my significant findings did not reveal any systematic relation between participant mood and picture selection or recall performance, for either age group.

[12] Participants also completed a recognition task in which they were asked to make old/new judgments of study pictures. The 'new' pictures comprised the pictures from the other picture list. Only the main effect of Age Group was significant, F (1, 58) = 15.90, $p < .0005$: younger adults (M = 0.97, SD = .027) were more accurate at recognizing the pictures than older adults (M = 0.92, SD = .063).

the arousal analysis above. There was a main effect of arousal, F (1, 58) = 6.95, $p < .05$, η_p^2 = .11: participants recalled more high arousal, (M = 9.60, SD = 2.29) than low arousal (M = 8.63, SD = 2.26), pictures. Neither the interaction with age group ($p > .1$) nor the effect of age ($p > .05$) reached significance.

Accuracy of Memory for Selected Pictures

To examine the accuracy of participants' memorability predictions of pictures, I divided the number of selected pictures that were later recalled by the total number of pictures that participants selected as being memorable, for each valence type, to obtain proportion scores of selected pictures that were later recalled. Proportion scores were analyzed with a mixed ANOVA with a between-subjects factor of age group (younger, older), and a within-subjects factor of picture valence (negative, neutral, positive). Because proportion scores could not be computed for one younger and one older adult due to a lack of selection of pictures from at least one valence category, the analysis included 29 younger and 29 older adults.

There was a main effect of Valence[13], F (2, 112) = 4.97, $p < .01$, η_p^2 = .08; greater proportions of the positive (M = 0.79, SD = 0.20) than neutral (M = 0.67, SD = 0.22) pictures were later recalled, t (57) = 2.90, $p < .01$, and greater proportions of negative (M = 0.77, SD = 0.23) than neutral pictures were recalled, t (58) = 2.51, $p < .05$. Proportion of positive and negative pictures did not differ ($p > .1$). There was no effect of Age ($p > .1$) and the Valence x Age Group interaction was not significant ($p > .1$).[14]

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[13] To examine whether performance on the neuropsychological tasks which assess executive function (Trails B and Digit Span backward) was related to judgment accuracy, scores on these tests were correlated with proportion of selected pictures recalled, for each valence type and age group. No correlation reached significance (all ps > .1).

[14] Participant ratings of picture valence, arousal, and personal relevance were analyzed using mixed ANOVAs with the between-subjects factor of age group (younger, older), and the within-subjects factors of picture valence category (negative, neutral, positive) and picture arousal category (low, high). Analyses confirmed that participants rated pictures of each valence type, and arousal type, consistently with the normative IAPS ratings given above. In terms of personal relevance ratings, an Age Group x Valence x Arousal interaction, F (2, 116) =

To examine whether the accuracy of participants' memorability predictions was modulated by arousal, proportion of selected pictures that were later recalled was analyzed with a mixed ANOVA with the same factors as in the arousal analysis above. There were no significant effects (all *p*s > .1).

Accuracy of Memory for Non-Selected Pictures

I also investigated the effect of valence on recall of non-selected pictures to address the possibility that positivity effects might manifest in information deemed relatively less memorable. To this end, proportion of non-selected pictures that were later recalled was analyzed with a mixed ANOVA with a between-subjects factor of age group (younger, older), and a within-subjects factor of picture valence (negative, neutral, positive). The only significant effect was that of Age Group, F (1, 58) = 5.98, $p < .05$, $\eta_p^2 = .09$, as younger adults (M = 0.52, SD = 0.15) recalled greater proportions of non-selected pictures than older adults (M = 0.42, SD = 0.15).

Finally I examined the effect of arousal on recall of non-selected pictures by repeating the analysis above with the within-subjects factor of picture arousal category (low, high) instead of valence, and found that for both age groups high arousal pictures (M = 0.51, SD = 0.23) were more likely to be recalled than low arousal pictures (M = 0.43, SD = 0.20), F (1, 58) = 4.67, $p < .05$, $\eta_p^2 = .07$, and that again younger adults recalled greater proportions of non-selected pictures than older adults, F (1, 58) = 7.22, $p < .01$, $\eta_p^2 = .11$. The interaction between age group and arousal was not significant ($p > .1$).

Discussion

When asked to select from an array a subset of items believed to be memorable, older adults showed a positivity effect in their selections, choosing greater numbers of positive,

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4.10, $p < .05$, $\eta_p^2 = .07$, indicated that older adults rated negative low arousal, neutral high arousal, neutral low arousal, and positive low arousal pictures as more personally relevant than younger adults (all *p*s < .05). However, correlations between rated personal relevance, number of pictures selected, and number of pictures recalled revealed only that, for younger adults, higher ratings of personal relevance of positive pictures was related to greater selection of positive pictures.

relative to negative and neutral pictures, whereas younger adults' selections did not differ by valence. In terms of later memory performance, both age groups showed a positivity effect in recall of all study pictures (regardless of selection status), recalling greater numbers of positive than negative or neutral pictures. Thus, older adults accurately predicted the valence of pictures that they would later recall, whereas younger adults did not accurately predict a boost in their later memory for positive pictures.

This experiment is the first to show that older adults preferentially select and encode positive material, and that this preferential selection leads to positivity effects in memory. This is in line with the postulated "situation selection" incorporated in Gross and colleagues' process model of emotion regulation (Gross, 1998; Urry & Gross, 2010): Older adults selectively place themselves in situations which will allow them to maintain a positive sense of well-being, such as selectively encoding positive over negative or neutral information. In agreement with this, older adults in Experiment 3 selected more positive material as being memorable. Given that participants in Experiment 3 were asked to evaluate pictures in terms of their memorability, in the context of the goal to select those which are more memorable, it seems reasonable to assume that participants employed cognitive control, defined here as deliberate, strategic or reflective (evaluative) processes, during picture selection. Thus, my results are consistent with those of others which demonstrate a role of cognitive control in the expression of positivity effects in tasks involving episodic memory (e.g., Mather & Knight, 2005), and selective attention (e.g., Isaacowitz, Toner, & Neupert, 2009). It is interesting to note that older adults selected as memorable pictures lower in arousal compared to younger adults, whereas both age groups recalled more high arousal pictures, suggesting that younger adults may be more accurate in their predictions regarding the effect of arousal on memory. Moreover, both age groups recalled greater proportions of those high arousal pictures deemed less memorable (non-selected pictures), whereas picture valence did not influence accuracy of memorability predictions for non-selected pictures.

What factors may underlie older adults' superior accuracy of memorability predictions for emotional pictures in the current experiment? First, older adults may have more experience with processing neutral and emotional information and so may be more aware that emotional, and more specifically, positive, material is memorable and thus use valence as a cue for processing fluency. It may also be that older adults are more attentive to factors that affect memory performance due to concerns about aging-related declines in memory. Finally, older adults may have deemed memorable information with the valence that they *wished* to remember, possibly in service of emotion regulation goals. This leads to the possibility that the mere act of selecting a picture as memorable might increase the degree to which the picture is encoded and the likelihood of its later being recalled, which could account for my recall results. However, as younger adults showed a positivity effect in their overall picture recall but not in their memorability predictions, this explanation seems unlikely. Regardless, the end result is that older, relative to younger, adults were wiser to the influence of emotion, specifically positive emotion, on subsequent memory.

Previous studies of aging-related changes in metamemory which have employed verbal, non-emotional, stimuli report that older adults are just as accurate as their younger counterparts at predicting which items that they will later remember (Connor, Hertzog, & Dunlosky, 1997; Dunlosky, Baker, Rawson, & Hertzog, 2006; Hertzog, Sinclair, & Dunlosky, 2010; Serra, Dunlosky, & Hertzog, 2008, but see Daniels, Toth, & Hertzog, 2009). In typical metamemory studies, participants are shown items sequentially and are asked to judge the likelihood of recalling each item. Although this method is appropriate for identifying the stimulus characteristics on which participants may base metamemory judgments of items in isolation, my method has several features that render it a more naturalistic exploration of metamemory predictions for pictorial information.

Outside of the laboratory, participants would likely be presented with multiple items simultaneously, such as images or text in a magazine, advertisement flyer, or newspaper, and would need to determine which items they will process more extensively, and exert their limited cognitive resources. During encoding of study pictures, on a poster board with all pictures available at once, participants can base their selections on direct comparisons of all items. This allows participants to assess the characteristics of each picture and decide whether these would make each item more or less memorable, relative to the other items available. Indeed, participants of both age groups indicated in follow-up questions that they considered various picture characteristics when judging the relative memorability of items such as: perceptual (e.g., presence of a central object in a given scene), semantic (e.g., how easily they could put a word to a picture), personal relevance, emotional valence and arousal. These responses suggest that participants indeed were employing deliberate, strategic processes while evaluating pictures. However, responses also bring up the possibility that older adults may have based their picture selections on some characteristic that is more likely to be associated with positive stimuli than negative or neutral stimuli, but not positivity *per se*. Nevertheless, although participants vary in their beliefs about the characteristics that make pictorial information memorable, older adults as a group select positive pictures over negative and neutral ones.

My results suggest that when presented with an array of neutral, positive and negative items, older adults are more accurate at predicting the influence of positive emotion on subsequent memory. On the other hand, younger adults are less accurate at predicting the effect of emotion on their later recall—they underestimate the enhancement of positive material on subsequent memory. Only one study to date has examined metamemory for emotional material (Zimmerman & Kelley, 2010). In their study, younger adults were asked to judge the likelihood of recalling negative, neutral, and positive nouns presented one-at-a-time, and then completed a free recall test for the words. Unlike the current study, Zimmerman and Kelley (2010) found that participants were more likely to judge both positive and negative words as being more memorable than neutral words, and this was reflected in their free recall of the words. A possible reason for this discrepancy is that participant ratings in my study indicated that perceived arousal did not differ between pictures of different valences, whereas Zimmerman and Kelley's (2010) neutral words were less arousing than the emotional words, and so their younger adults may have judged the emotional words as more memorable because they were more arousing (Zimmerman & Kelley, 2010). It is also possible that given rich pictorial stimuli, younger adults use another characteristic on which to base their memorability predictions, whereas emotion is a more obvious cue to memorability with word stimuli. Indeed, younger adults have been shown to base metamemory judgments on such details as font size of studied words (Rhodes & Castel, 2008).

Moreover, my results are consistent with a recent study of aging-related changes in affective forecasting. Nielsen, Knutson, and Carstensen (2008) showed that older adults are better at predicting their affective reactions to wins and losses in the context of a computer game in which participants had to press a key quickly to either gain money or prevent loss of money. Although (perhaps unsurprisingly) both younger and older adults were relatively accurate at predicting the valence of their reactions in response to losses and gains, older adults were more accurate at predicting the intensity of arousal of those experiences, which is in line with my results showing that older adults are more accurate at predicting the effects of emotional stimuli on later memory.

The finding that older adults preferentially select positive information has implications for selection of strategies to compensate for aging-relating declines in memory. For example, older adults can apply a "positive reappraisal" strategy (Shiota & Levenson, 2009), to reinterpret information in a positive manner, thereby giving it a memorial advantage. There are also implications for everyday decision-making including selection of health care plans. For instance, Löckenhoff and Carstensen (2007) have shown that when considering different health care plans, older adults examine more positive than negative features of the plans, affecting their later decision of which to choose.

In summary, my results suggest that older adults may have an enhanced awareness of the way in which positive emotion can enhance their memory performance compared with younger adults, as evidenced by the greater accuracy of older adults' memorability predictions for positive stimuli. Future research should examine how this superior insight may be affected by the saliency of motivational goals to regulate emotions or to enhance accuracy (as in Kennedy, Mather, & Carstensen, 2004), and whether older adults are also aware of the circumstances under which emotional information may impair memory, as in the case of emotional distractors (e.g., Dolcos & McCarthy, 2006).

Importantly for the current thesis, results of Experiment 3 are in line with the cognitive control hypothesis, as older adults selected as most memorable pictures of a positive valence in a task which emphasizes deliberate reflection on participants' own memory processes. The selection of positive information is consistent with the idea that older adults may apply cognitive control to regulate emotion while completing cognitive tasks.

Chapter 4
Experiments on Attention

4.1 Introduction to Attention Experiments

Results of Experiments 1-3 suggest that within the domain of memory, aging-related positivity effects are most likely to emerge on tasks which emphasize self-reflection and allow for the application of cognitive control in the service of emotion regulation goals. Experiments 4-5 were conducted to examine whether tasks within other cognitive domains, such as attention, would also show evidence of positivity effects which differs depending on task demands.

A number of studies have found positivity effects, or negativity reductions, on tasks that assess attention bias, such as gaze preferences using eye tracking (Allard & Isaacowitz, 2008; Isaacowitz, Allard, Murphy, & Schlangel, 2009; Isaacowitz, Toner, Goren, & Wilson, 2008; Isaacowitz, Toner, & Neupert, 2009; Isaacowitz, Wadlinger, Goren, & Wilson, 2006a; Knight, Seymour, Gaunt, Baker, Nesmith, & Mather, 2007), and with a standard measure of selective attention, the dot probe paradigm (Lee & Knight, 2009; Mather & Carstensen, 2003; Orgeta, 2011). To evaluate the cognitive control and processing fluency hypotheses in the context of attention tasks, the following four experiments examined evidence for aging-related positivity effects in two classic attention paradigms. The first is the Rapid Serial Visual Presentation (RSVP) paradigm, for which performance is dependent on the ability to quickly process information. The second is the dot probe paradigm, which I have adapted in a manner that allows participants to use cognitive control to preferentially allocate their attention to stimuli of positive, negative, or neutral valence.

4.2 Experiments 4a and 4b: RSVP Paradigm

Introduction to Experiments 4a and 4b

In Experiments 4a and 4b, I use an RSVP paradigm to examine age differences in the ability of different valence stimuli to quickly capture attention. In this way, the task provides a measure of differences in processing fluency across age groups.

In a typical RSVP paradigm, participants are shown a series of rapidly presented stimuli such as words, letters, or digits. Within the stream of stimuli are embedded either two targets (T1 and T2), or just the T2, amongst distractors. Following presentation of the stream, participants must state the identities of the targets detected in the stream. Usually, participants are less accurate at detecting the second target (T2) when it is preceded by a first target (T1) compared to when it is presented alone, particularly when T1 and T2 are presented in close temporal proximity (SOAs of 200-500msec). The RSVP paradigm is known to tax attentional resources (for a recent review, see Martens & Wyble, 2010), and so detection of targets is more likely if the target captures attention in a relatively "automatic" manner (bottom-up processing). Importantly for the current thesis, because attentional resources are taxed by the RSVP paradigm (due to the fast speed of processing required), it makes it unlikely that (older) participants would be able to use cognitive control to preferentially allocate attention to improve detection of (positive) items in service of emotion regulation goals.

Past studies using RSVP

A number of studies have examined the influence of emotion on ability to detect targets in the RSVP paradigm and have found that emotional T2s are more likely to be detected than neutral T2s, but that an emotional T1 impair subsequent detection of a neutral T2, indicating that emotional targets capture attention (e.g., Anderson, 2005; Keil & Ihssen, 2004; Ogawa & Suzuki, 2004; Smith, Most, Newsome, & Zald, 2006; Trippe, Hewig, Heydel, Hecht, & Miltner, 2007). These findings are consistent with findings from visual search tasks that emotional (negative in particular) stimuli are detected more quickly than neutral stimuli (e.g., Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001).

Recently, researchers have begun to investigate aging-related changes in attention capture of emotional stimuli. In attention paradigms in which quick responding is emphasized, such as in visual search (Mather & Knight, 2006) and the RSVP paradigm (Langley, Rokke, Stark, Saville, Allen, & Bagne, 2008; Mickley Steinmetz, Muscatell, & Kensinger, 2010; Wieser, Muhlberger, Kenntner-Mabiala, & Pauli, 2006), the general pattern that emerges is that attention is captured by emotional stimuli similarly in older and younger adults.

The novel contribution of Experiments 4a and 4b is that, unlike previous studies, the emotional valence of both the T1 and T2 targets is manipulated across experiments. This allows for an examination of both the degree to which attentional capture of emotional stimuli impairs the detection of subsequently presented non-emotional stimuli, and the degree to which those same emotional stimuli can delay the suppression of attention induced by attention capture of a preceding non-emotional target. Also, previous studies in the positivity effect literature have used words as stimuli, whereas Experiments 4a and 4b use IAPS pictures to examine whether previously reported effects generalize to stimuli that are more visually complex than words and may generate stronger emotional reactions in the viewer.

To investigate aging-related changes in attentional capture of emotional information, Experiment 4a used an RSVP paradigm in which T1 was always neutral, and emotional valence of T2 was manipulated (positive, negative, or neutral). In Experiment 4b, the identities of the targets were switched, such that T1 valence was manipulated, and T2s were always neutral. If positive information captures the attention of older adults, then I expected positive T2s to be detected more accurately than negative or neutral T2s in Experiment 4a. Using similar logic, in Experiment 4b, I expected neutral T2s to be detected with less accuracy when preceded by positive T1s relative to negative, or neutral, T1s, as the positive picture would have captured attention, leaving fewer resources available to process subsequent stimuli.

Experiment 4a

Method

Participants

Thirty healthy community-dwelling older adults (60-78 years of age; 22 female) recruited through the University of Waterloo's Research in Aging Participant pool, and 30 younger adults (18-23 years of age; 20 female) recruited from undergraduate psychology classes, completed the study. Table 5 displays participant characteristics. Older adults received $10/hour remuneration, and younger adults received course credit for participating. For both age groups, inclusion criteria were self-reported: fluency in English, normal or corrected-to-normal vision and hearing, no history of neuropsychological impairment, no previous head injury, and not currently being treated for depression or anxiety. For older adults, an additional exclusion criterion was a score of less than 26 on the Mini-Mental State Exam, which may indicate cognitive impairment (MMSE, Folstein, Folstein, & McHugh, 1975). Consistent with literature indicating greater vocabulary with aging (e.g., Verhaeghen, 2003), the older adult group had a higher full scale IQ (FSIQ), $t(58) = 5.88$, $p < .0005$, as estimated by the National Adult Reading Test – Revised (NART-R, Nelson, 1992) than the younger adult group, but age groups did not differ in years of education ($p > .1$). Years of education data were missing for one younger adult participant. During the course of the study, participants of both age groups completed a battery of neuropsychological tasks (Trail Making Tests A and B, and Digit Span forward and backward). Scores on the Trail Making Tests and the Digit Span tasks were used to confirm that older adult participants were within normal range for cognitive functioning according to published norms (Spreen & Strauss, 1998; Wechsler, 1997). See Table 5 for mean demographic values and scores on neuropsychological tests.

Table 5 *Experiment 4a Participant Characteristics. Mean Values with Standard Deviations in Parentheses*

	Age Group			
	Younger		Older	
Age in years	19.50	(1.38)	69.27	(5.32)
MMSE score	-	-	28.77	(1.10)
Years of education	14.24	(1.09)	14.67	(1.92)
FSIQ (NART-R)	101.83	(8.62)	113.45	(6.54)
PANAS-X (percent positive)	55.52	(12.51)	64.37	(14.28)
PANAS-X (percent negative)	38.96	(13.15)	27.59	(7.57)
Trails A (time in seconds)	18.67	(7.81)	25.97	(7.04)
Trails B (time in seconds)	39.60	(16.19)	65.57	(22.62)
Digit Span Forward	8.27	(2.18)	7.97	(2.09)
Digit Span Backward	7.20	(1.88)	6.70	(2.14)

Materials and Procedure

Picture stimuli. Forty-five pictures were obtained from the IAPS database, a widely used database of full-colour photos with normative ratings of emotional valence and arousal (Lang, Bradley, & Cuthbert, 2001). There were five each of negative (Valence *M* = 2.59, *SD* = 0.71; Arousal *M* = 4.57, *SD* = 0.61) and positive (Valence *M* = 7.36, *SD* = 0.72; Arousal *M* = 4.45, *SD* = 0.60) pictures, and 10 neutral (T1 Valence *M* = 5.07, *SD* = 0.79; Arousal *M* = 4.45, *SD* = 0.87; T2 Valence *M* = 5.61, *SD* = 0.48; Arousal *M* = 4.42, *SD* = 0.63) pictures, used as targets in the RSVP paradigm. Twenty-five other neutral pictures were selected as distractor items (Valence *M* = 5.18, *SD* = 0.54; Arousal *M* = 4.48, *SD* = 1.27). IAPS normative ratings were used to categorize pictures according to valence, and all pictures were selected to be of medium arousal. For targets, three of the pictures of each valence featured animals, nature scenes, or inanimate objects, and two featured people. For distractors, 15 of the pictures featured animals, nature scenes, or inanimate objects, and 10 featured people. Pictures were resized to be 14cm in height and 11cm in width, when displayed on the computer monitor. Photo editing software was used to add a border 1cm in diameter to all pictures, with red borders for targets and white borders for distractors, so that participants could more easily distinguish targets from distractors in the RSVP trials.

RSVP task. Because pilot testing indicated that participants were close to floor and had trouble identifying individual pictures in the RSVP task, participants were first shown each of the target pictures presented one at a time on a computer screen, and were asked to provide a verbal label for each picture, which the experimenter wrote down; they were also told that they would use these labels to identify pictures during the RSVP task.

Participants were instructed that each trial would begin with presentation of a fixation cross, and afterward a stream of rapidly presented pictures would be shown, in which would appear either one or two target pictures with a red border (see Figure 5 for a graphical depiction of trial sequence), and that after the picture stream ended they were to say out loud the identity of the targets, using the verbal labels used at the beginning of the experiment, and to guess if they were not sure of the target's identity.

For each trial, a white fixation cross appeared in the centre of the screen, on a black background, until participants pressed the space bar. Next a stream of pictures was presented, in which either one target ("T2") or two targets ("T1" followed by a "T2") appeared embedded amongst the distractors. These are referred to as "T1 absent trials" and "T1 present trials", respectively. T1s were neutral in valence, and T2s were positive, negative, or neutral (different pictures than neutral T1s) in valence, manipulated between-subjects. For younger adults, pictures were presented for 100msec each with an ISI of 20msec, whereas for older adults pictures were presented for 200msec with the same ISI as younger adults. The stimulus duration for older adults was double that of younger adults as pilot testing indicated that older adults could not reliably detect target pictures at the 100mec duration and so performance was close to floor. Pictures were presented in the centre of the screen, on a black background. Additionally, the number of intervening items between the T1 and T2 on T1 present trials was varied such that 0, 2, 3, 5, or 8 pictures were presented between the targets. Furthermore, each category of T1 picture (people, animal/object/nature scene) was presented with each category of T2 picture, for a total of 250 experimental trials (125 T1 absent trials and 125 T1 present trials). Trial presentation was randomized for each participant. At the end of each trial, the participant was prompted to state the identity of the target pictures, and the experimenter recorded the response on an audio tape. These responses were later transcribed.

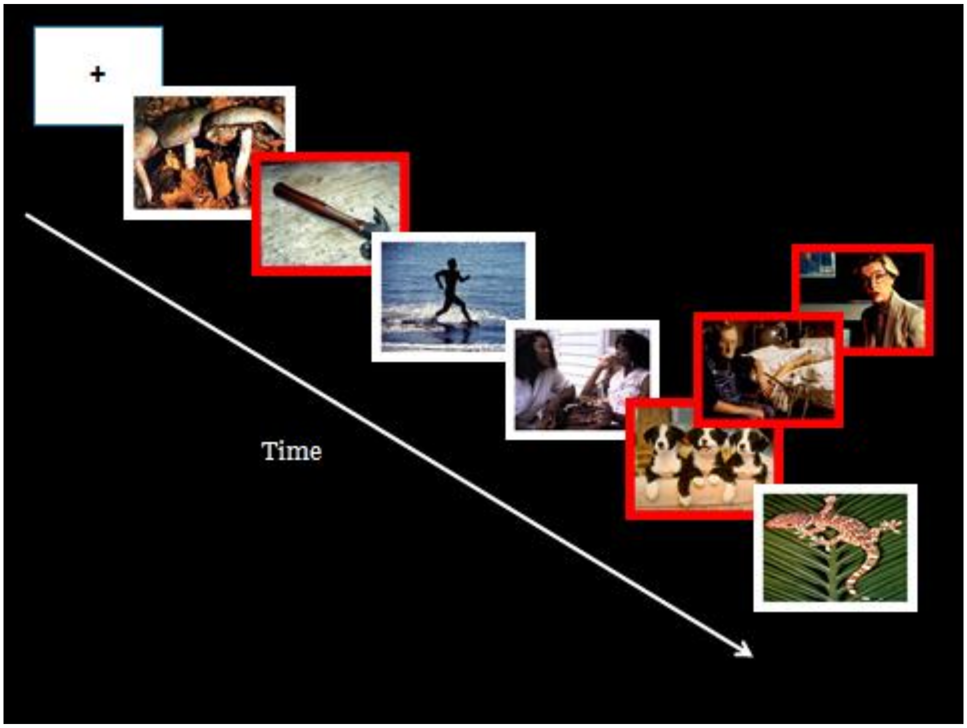


Figure 5. Experiment 4a, sequence of events in an RSVP trial. Both the T1 (always a neutral picture) and T2 (a positive, negative, or neutral, picture, manipulated between-subjects) contain red borders, in a stream of neutral distractors with white borders.

Participants also completed three blocks of ten practice RSVP trials which had the same trial characteristics as experimental trials, except that the picture presentation and ISI durations were initially longer than experimental trials and became progressively shorter over the blocks (block one, stimulus duration: 500msec, ISI: 200msec, block two, stimulus duration: 250, ISI: 100, block three, stimulus $duration_{young}$ 100msec, ISI_{young}: 20msec, stimulus $duration_{old}$: 200msec, ISI_{old}: 20msec).

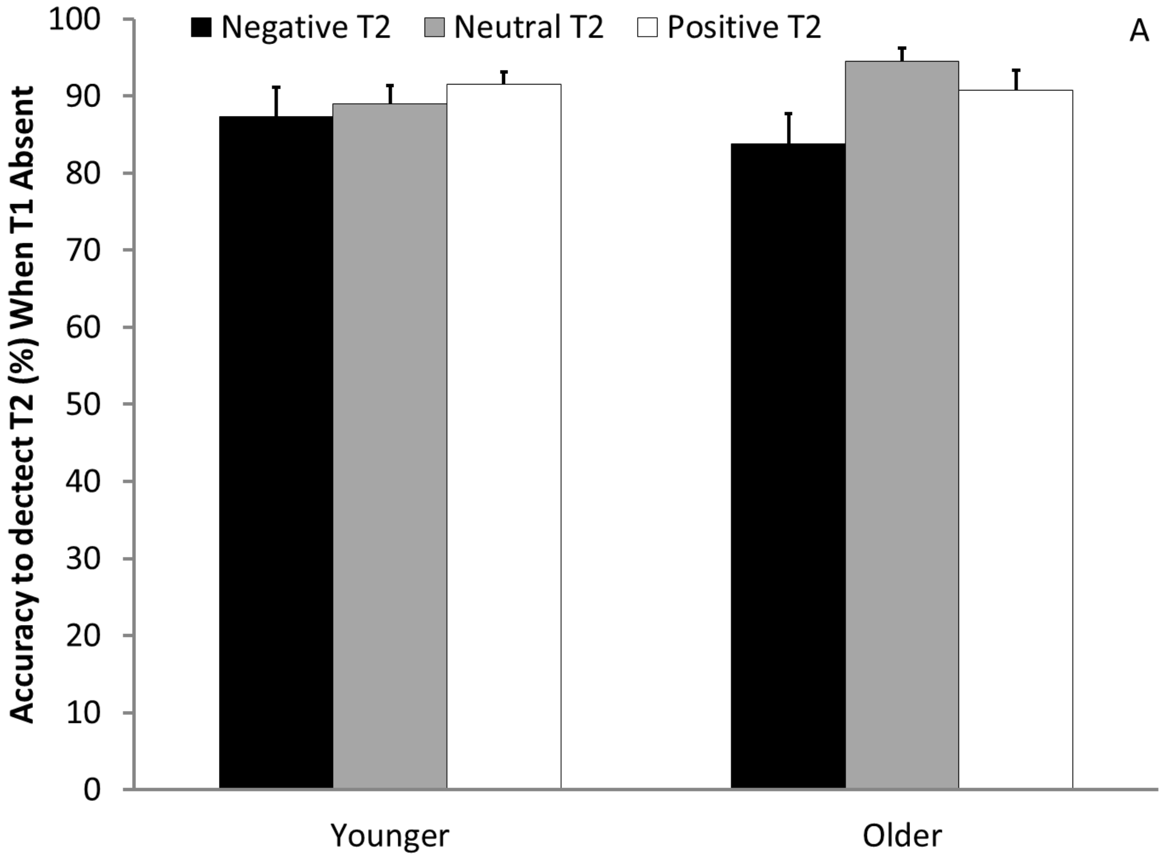
Participant picture rating. To examine whether participants rated pictures similarly to the IAPS normative ratings, participants rated each study picture on the dimensions of valence (very negative-very positive), arousal (not at all arousing-highly arousing), and personal relevance (using the dominance scale; very personally relevant-not at all personally relevant) with the IAPS Self-Assessment Manikin (SAM) scales. During picture rating, pictures were presented one at a time on the computer screen and participants were given a booklet with the SAM scales to make their ratings for each picture.

Procedure. Participants completed the RSVP task, followed by a battery of neuropsychological tasks (NART-R, Trail Making Tests A and B, digit span forward and backward and older adults completed the MMSE. Participant mood was assessed with the PANAS-X mood scale either before or after the RSVP task. Finally, participants rated the study pictures.

Results

Effect of T2 valence on accuracy to detect T2. The following analysis addressed two hypotheses: 1) whether older adults were overall more accurate at detecting a positively valenced T2 relative to negative or neutral ones, when compared with younger adults (in T1 Absent trials), and 2) whether older adults' accuracy to detect the T2 when the T1 was present was greater when the T2 was positive, relative to negative or neutral, when compared with younger adults (T1 Present trials; only trials on which the T1 was correctly identified were analyzed). Data were analyzed with a mixed ANOVA with the between-subjects factors of Age Group (younger/older) and T2 Valence (negative/neutral/positive), and the within-subjects factor of T1 Status (present/absent).

The main effects of T1 Status ($p < .0005$) and Age Group ($p < .05$) were qualified by a significant Age Group x T1 Status interaction, F (1, 54) = 17.58, $p < .0005$, $n_{p2} = .25$. Post hoc tests indicated that although both age groups, $t_{younger}$ (29) = 11.70, $p < .0005$, t_{older} (29) = 10.45, p < .0005, were more accurate at detecting the T2 when the T1 was absent (M_{younger} = 89.31, SD_{younger} = 8.42; M_{older} = 89.68, SD_{older} = 9.86), compared to when it was present (M_{younger} = 61.09, SD_{younger} = 15.10; M_{older} = 73.60, SD_{older} = 9.95), older adults were more accurate at detecting the T2 when T1 was present than younger adults, t (58) = 3.79, $p <$ .0005, but there were no age differences when T1 was absent ($p > .1$). No other interactions reached significance (ps > .1), and there was no main effect of T2 Valence ($p > .1$). See Figure 6.



Negative T2
Neutral T2
Positive T2
A
100
90
80
70
60
50
40
30
20
10
0
Accuracy to dectect T2 (%) When T1 Absent
Younger
Older

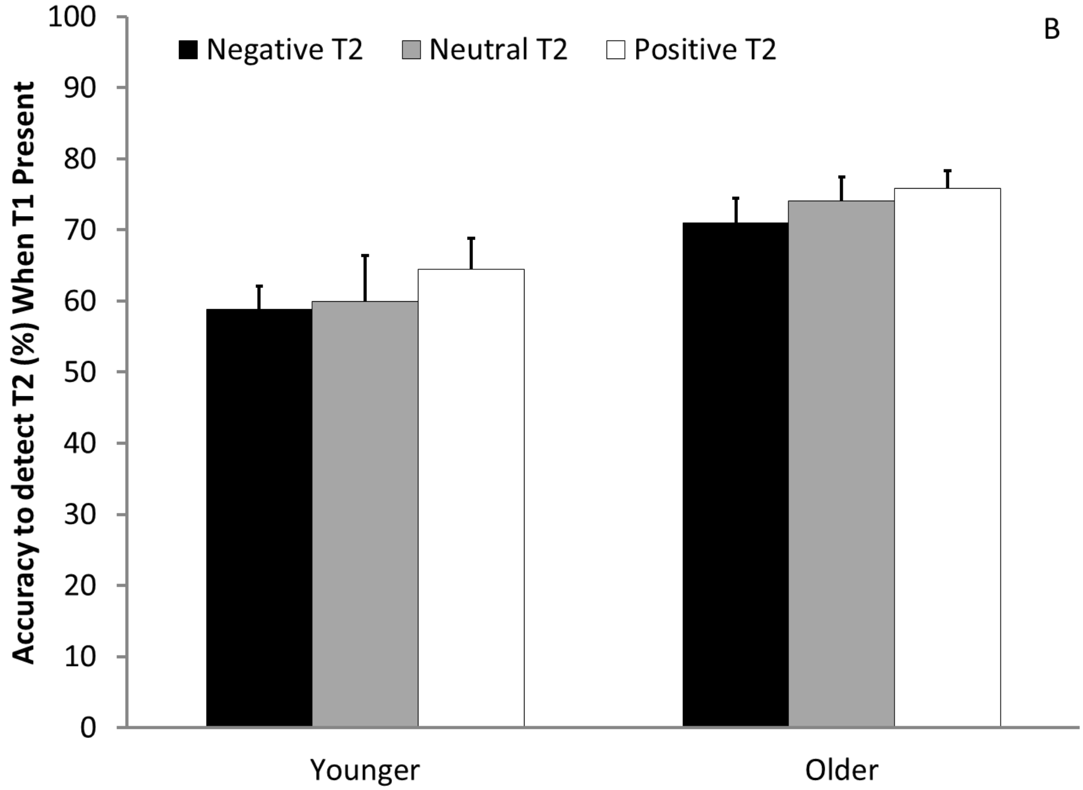


Figure 6. Experiment 4a, Panel A: Mean T2 detection accuracy for T1 Absent trials, by T2 valence condition and age group. Panel B: Mean T2 detection accuracy for T1 Present trials, by T2 valence condition and age group. Error bars represent standard errors of respective means.

To more directly assess whether older adults' attention is more likely to be captured by positive T2s relative to negative and neutral T2s, compared with younger adults, difference scores were calculated to assess the degree of impairment in detecting the T2 when T1 was present compared to when T1 was absent. Difference scores were calculated as follows: percent accuracy to detect T2 when T1 absent minus percent accuracy to detect T2 when T1 was present and correctly identified. Larger values on this measure indicate greater impairment in T2 detection. These difference scores also serve to control for baseline ability to detect T2 in T1 absent trials between the age groups and valence conditions. Difference scores were analyzed with a univariate ANOVA with the between-subjects factors of Age

Group (younger/older) and T2 Valence (negative/neutral/positive). There was a main effect of Age Group, F (1, 54) = 17.58, p < .0005, n_{p2} = .25: Detection of T2 was impaired to a greater degree, by the T1, in younger adults than in older adults. The effect of Valence and interaction of Valence and Age Group were not significant (ps >.1). See Figure 7.

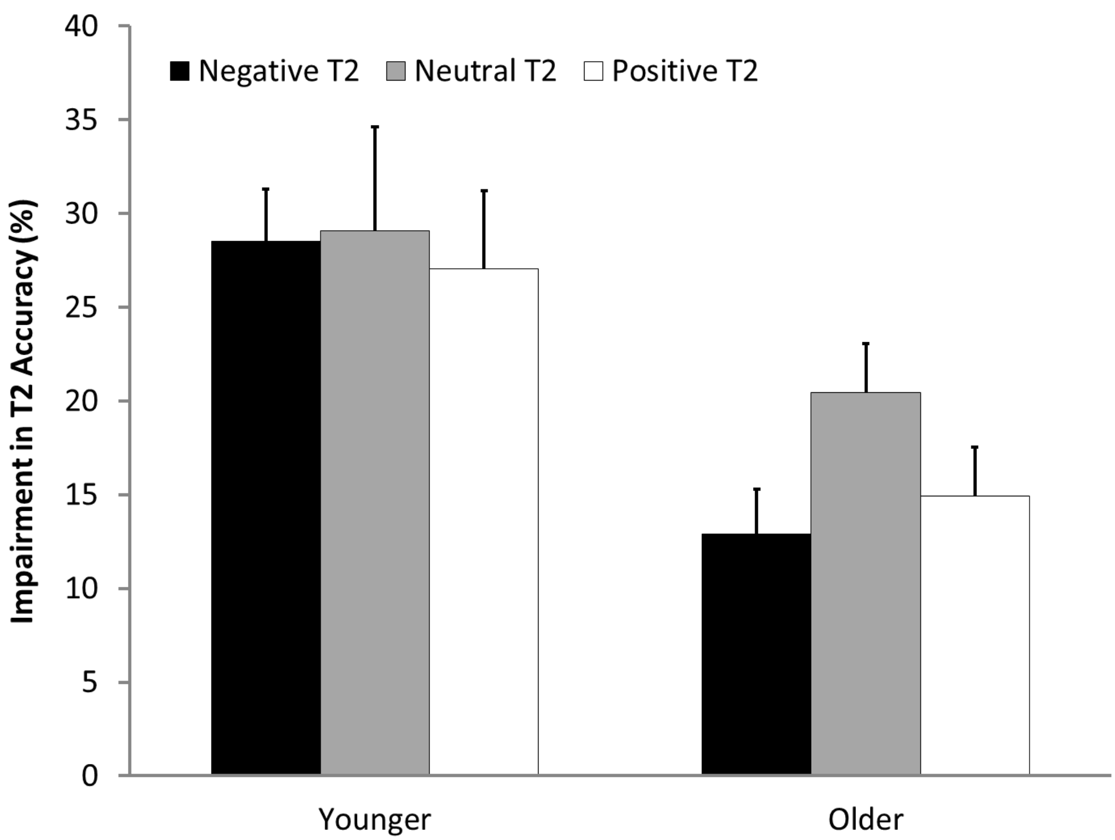


Figure 7. Experiment 4a, mean impairment in T2 detection accuracy when T1 was present, for each T2 valence condition, in younger and older adults. Error bars represent standard error of respective means.

Mood measure. Raw scores for basic negative and basic positive affect from the PANAS-X were converted to percent of maximum possible score (see Table 5). Both younger and older adults reported greater positive, than negative, mood ($t_{younger}$ (29) = 4.27, p < .0005; t_{older} (28) = 13.16, p < .0005). Older adults reported greater positive mood than young, t (58) = -2.55, p < .05, and less negative mood than young, t (58) = 4.10, p < .0005.

Effect of mood on performance in RSVP task. To examine whether mood was related to accuracy to detect T2 in each valence condition, partial correlations were conducted, controlling for age group. Neither positive nor negative mood scores were significantly associated with accuracy to detect T1 or T2 (T1 absent or present trials), or with the difference scores, for any of the T2 valence conditions (all *p*s > .05).

Participant Ratings of Pictures. To verify whether participant ratings of T2 and T1 pictures were comparable to the normative picture ratings, three multivariate ANOVAs were performed, with the between-subjects factors of Age Group (younger/older) and Valence Condition (negative/neutral/positive), to analyze the T1 and T2 SAM ratings for valence, arousal, and personal relevance, respectively.

Valence. For T2 pictures, there was a main effect of Picture Valence, F (2, 54) = 128.84, $p < .0005$, $n_{p2} = 0.83$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction ($p > .1$). Post hoc tests indicated that participants rated the valence of pictures consistently with the normative ratings. For T1 pictures, none of the main effects or interactions reached significance (all *p*s > .05), indicating that the neutral T1s were perceived similarly in valence across the three valence conditions.

Arousal. For T2 pictures, there was a main effect of Picture Valence, F (2, 54) = 3.70, $p < .05$, $n_{p2} = 0.12$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction ($p > .1$). Post hoc tests indicated that participants rated positive T2s as more arousing than negative T2s, t (38) = 2.43, $p < .05$, but neither positive nor negative T2s differed in arousal from neutral T2s (*p*s > .1). For T1 pictures, none of the main effects or interactions reached significance (all *p*s > .1), indicating that the arousal of the neutral T1s was perceived similarly in valence across the three valence conditions. As participant arousal ratings for T2s differed from the normative ratings (differences in arousal level across valence types) correlations between SAM Arousal ratings and accuracy to detect T2 in each valence condition were conducted. The only correlation that reached significant found that in the T2 Negative condition, higher SAM arousal ratings were associated with greater accuracy to detect negative T2 when T1 was present, $r = .53$, $p < .05$. No other correlations reached significance (all *p*s > .1).

Personal relevance. For T2 pictures, there was a main effect of Picture Valence, F (2, 54) = 4.42, $p < .05$, $n_{p2} = 0.14$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction ($p > .1$). Post hoc tests indicated that participants rated positive pictures as more personally relevant than negative, t (38) = 2.95, $p < .01$, but neither positive nor negative T2s differed in personal relevance from neutral T2s (*p*s > .05). For T1 pictures, no effects were significant (*p*s > .1). To examine whether personal relevance was related to accuracy to detect T2 for each valence condition, correlations were conducted. The only significant correlation was that in the T2 Neutral condition, higher SAM personal relevance ratings were associated with greater accuracy impairment in detecting neutral T2 when T1 was present, $r = .45$, $p < .05$. No other correlations reached significance (all *p*s > .05).

In summary, both age groups were more accurate at detecting the T2 when presented alone, compared to when it was preceded by a first target (main effect of T1 status). However, an Age Group x T1 Status interaction indicated that older adults were less impaired at T2 detection relative to younger adults when T1 was present, but not when T2 was presented alone. There were no significant effects of T2 Valence on detection performance.

Experiment 4b

Experiment 4a examined whether positive stimuli capture older adults' attention by examining the accuracy with which an emotional T2 is detected following an attention capturing T1. Conversely, the purpose of Experiment 4b was to examine the influence of an emotional T1 on subsequent detection of a neutral T2. Thus, in Experiment 4b, the emotionality of the T1 was manipulated between-subjects and the T2 was always neutral.

Method

Participants

Thirty healthy community-dwelling older adults (61-78 years of age; 22 female) recruited through the University of Waterloo's Research in Aging Participant pool, and 30 younger adults (18-25 years of age; 21 female) recruited from undergraduate psychology classes completed the study. Table 7 displays participant characteristics. Older adults received $10/hour remuneration, and younger adults received course credit for participating. For both age groups, inclusion criteria were self-reported: fluency in English, normal or corrected-to-normal vision and hearing, no history of neuropsychological impairment, no previous head injury, and not currently being treated for depression or anxiety. For older adults, an additional exclusion criterion was a score of less than 26 (out of 30) on the Mini-Mental State Exam, which may indicate cognitive impairment (MMSE, Folstein, Folstein, & McHugh, 1975). Consistent with literature indicating greater vocabulary with aging (e.g., Verhaeghen, 2003), the older adult group had a higher full scale IQ (FSIQ), t (58) = 4.37, $p < .0005$, as estimated by the National Adult Reading Test – Revised (NART-R, Nelson, 1992) than the younger adult group, but age groups did not differ on years of education ($p > .1$). During the course of the study, participants of both age groups completed a battery of neuropsychological tasks (Trail Making Tests A and B, and Digit Span forward and backward). Scores on the Trail Making Tests and the Digit Span tasks were used to confirm that older adult participants were within normal range for cognitive functioning according to published norms (Spreen & Strauss, 1998; Wechsler, 1997). See Table 7 for mean demographic values and scores on neuropsychological tests.

Table 6 *Experiment 4b Participant Characteristics. Mean Values with Standard Deviations in Parentheses*

	Age Group			
	Younger		Older	
Age in years	20.97	(1.81)	69.13	(5.31)
MMSE score	-	-	29.07	(0.78)
Years of education	15.70	(1.18)	14.90	(3.90)
FSIQ (NART-R)	107.21	(8.08)	115.58	(6.68)
PANAS-X (percent positive)	56.74	(14.33)	63.16	(14.51)
PANAS-X (percent negative)	37.45	(9.81)	30.34	(10.24)
Trails A (time in seconds)	21.20	(7.28)	31.02	(9.71)
Trails B (time in seconds)	43.61	(13.77)	70.89	(31.74)
Digit Span Forward	9.67	(2.00)	8.30	(1.93)
Digit Span Backward	7.10	(1.71)	7.30	(2.09)

Materials and Procedure

Stimuli, tasks, and procedures in Experiment 4b were identical to those in Experiment 4a except that in the Experiment 4b RSVP task, T1s were positive, negative, or neutral in valence, manipulated between-subjects, and T2s were always neutral (different pictures than neutral T1s). See Figure 8 for the sequence of events in the RSVP trials.

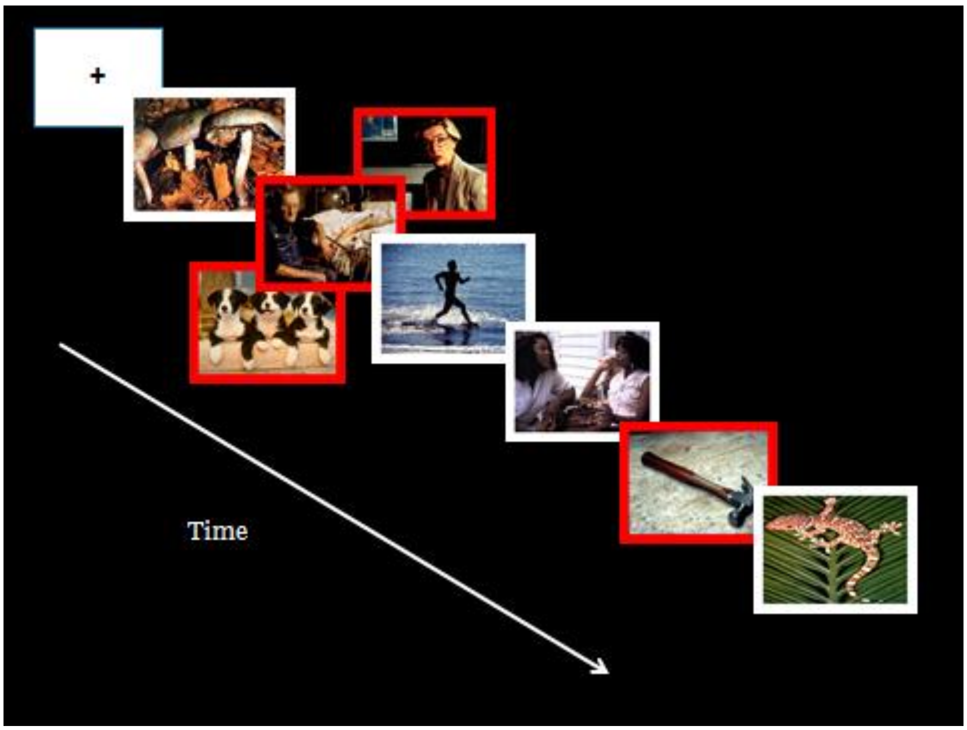


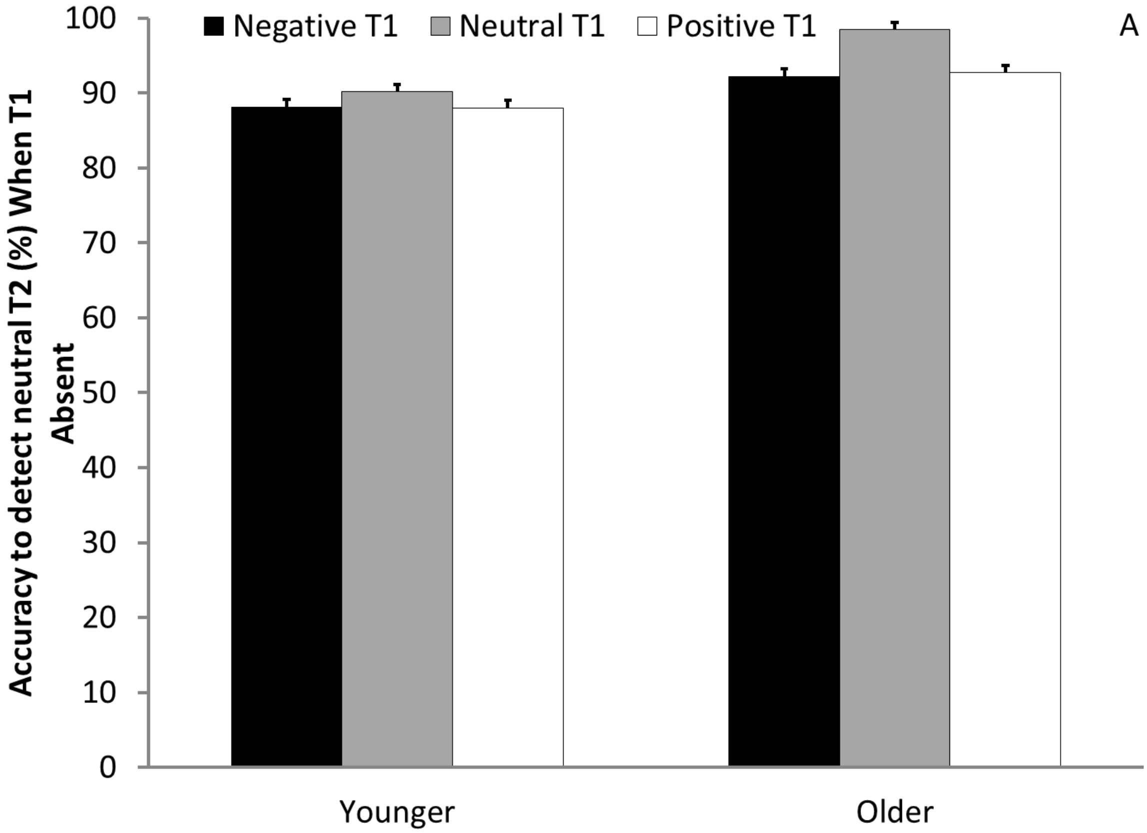
Figure 8. Experiment 4b, sequence of events in an RSVP trial. Both T1 (a positive, negative, or neutral, picture, manipulated between-subjects) and T2 (always a neutral picture) contain red borders, in a stream of neutral distractors with white borders.

Also, for the participant picture rating, some participants used the paper-and-pencil version of the SAM scales described in Experiment 4a, and the rest of the participants completed a computerized version of the rating task as described in Experiment 3 (memory section).

Results

Effect of T1 valence on accuracy to detect T2. I examined whether a positive (relative to neutral or negative) T1 differentially captured attention in older adults, impairing subsequent accuracy in detecting a neutral T2. Percent accuracy to detect a neutral T2, when preceded by T1, was analyzed with a mixed ANOVA with the between-subjects factors of Age Group (younger/older) and T1 Valence (negative/neutral/positive), and the within-subjects factor of T1 Status (present/absent; only trials on which the T1 was correctly identified were analyzed).

The main effects of T1 Status, F (1, 54) = 265.78, $p < .0005$, $n_{p2} = .83$, and Age Group, F (1, 54) = 37.02, $p < .0005$, $n_{p2} = .41$, were qualified by a significant Age Group x T1 Status interaction, F (1, 54) = 11.70, p < .005, $n_{p2} = .18$. Post hoc tests indicated that although both age groups were more accurate at detecting the T2 when the T1 was absent ($M_{\text{younger}} = 88.77$, $SD_{\text{younger}} = 8.92$; $M_{\text{older}} = 94.48$, $SD_{\text{older}} = 5.42$), compared to when it was present ($M_{\text{younger}} = 59.27$, $SD_{\text{younger}} = 12.24$; $M_{\text{older}} = 75.21$, $SD_{\text{older}} = 8.53$), $t_{\text{younger}}(29) = 11.69$, $p < .0005$, $t_{\text{older}}(29) = 12.35$, $p < .0005$, older adults were more accurate at detecting the T2 when the T1 was present relative to younger adults, t (58) = -5.85, $p < .0005$, and when the T1 was absent, t (58) = -3.00, $p < .005$. No other interactions reached significance (ps > .1). There was a main effect of T1 Valence, F (2, 54) = 3.36, $p < .05$, $n_{p2} = .11$. Post hoc tests indicated higher accuracy to detect the neutral T2 when T1 was neutral (M = 82.62, SD = 8.10) than negative (M = 76.48, SD = 9.22), t (38) = 2.24, $p < .05$. There was no difference in detection of T2 when T1 was neutral relative to positive (M = 79.64, SD = 8.87), $p > .1$, and when T1 was positive relative to negative ($p > .1$). See Figure 9.


Negative T1
Neutral T1
Positive T1
A
Accuracy to detect neutral T2 (%) When T1 Absent
100
90
80
70
60
50
40
30
20
10
0
Younger
Older

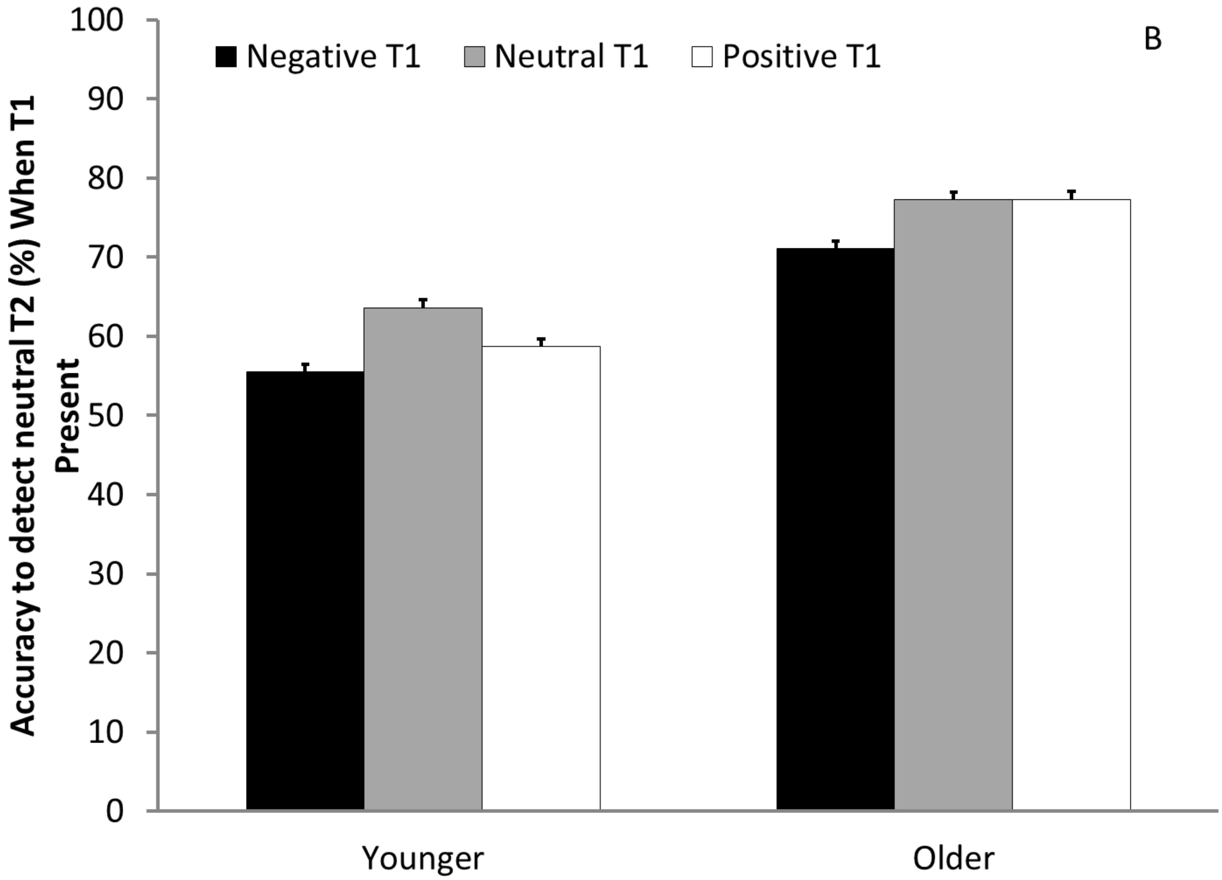


Figure 9. Experiment 4b, Panel A: Mean T2 detection accuracy for T1 Absent trials, by T1 valence condition and age group. Panel B: Mean T2 detection accuracy for T1 Present trials, by T1 valence and age group. Error bars represent standard errors of respective means.

To more directly assess whether older adults' attention is more likely to be captured by positive T1s relative to negative and neutral T1s, compared with younger adults, difference scores were calculated to assess the degree of impairment in detecting the neutral T2 when T1 was present compared with when T1 was absent. Difference scores were calculated as follows: percent accuracy to detect the neutral T2 when T1 was absent minus percent accuracy to detect the neutral T2 when T1 was present and correctly identified. Larger values on this measure indicate greater impairment in T2 detection. These difference scores also serve to control for baseline ability to detect the neutral T2 in T1 absent trials between the age groups and valence conditions. Difference scores were analyzed with a univariate ANOVA with the between-subjects factors of Age Group (younger/older) and T1 Valence condition (negative/neutral/positive). There was a main effect of Age Group, F (1, 54) = 11.70, $p < .005$, $n_{p2} = .18$: Detection of T2 was more impaired in younger adults than older adults. The effect of Valence and interaction of Valence and Age Group were not significant (*p*s >.1). See Figure 10.

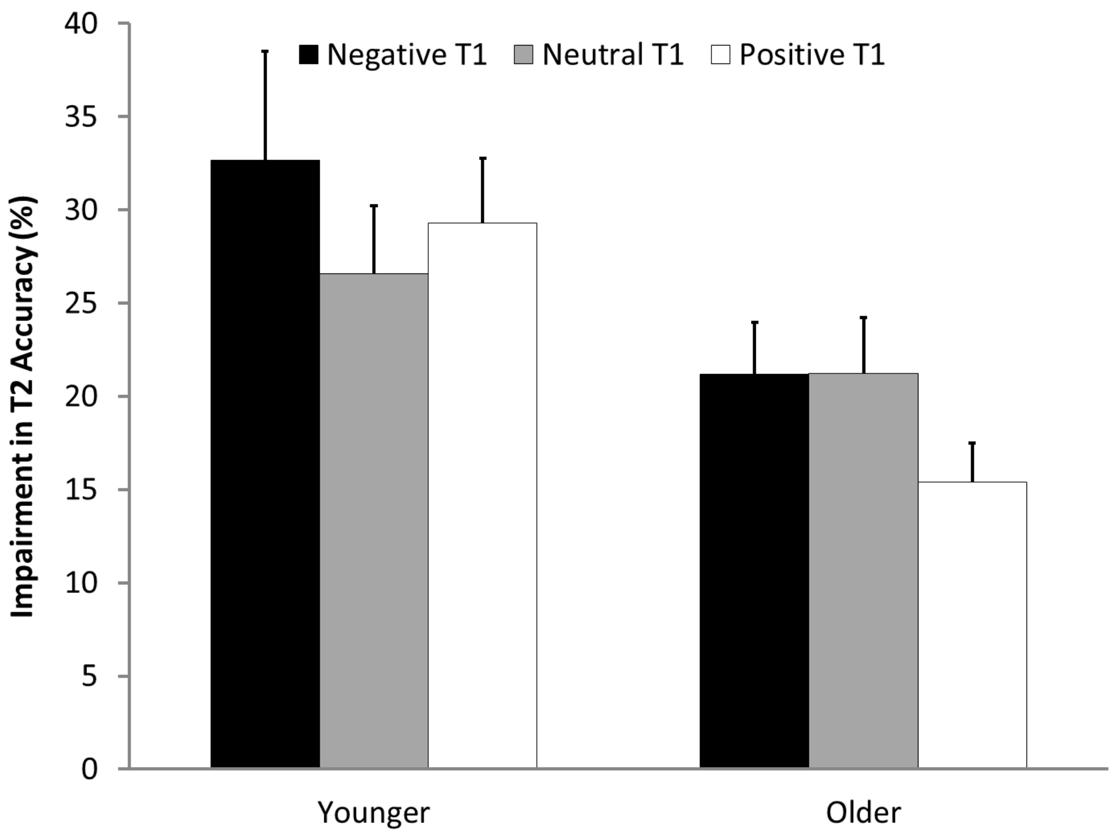


Figure 10. Experiment 4b, mean impairment in T2 detection accuracy due to T1 presence, by T1 valence condition and age group. Error bars represent standard error of respective means.

Mood measure. Raw scores for basic negative and basic positive affect from the PANAS-X were converted to percent of maximum possible score (see Table 6). Both younger and older adults reported greater positive, than negative, mood ($t_{younger}$ (29) = 5.74, $p < .0005$; t_{older} (29) = 8.54, $p < .0005$). Younger adults reported greater negative mood than older adults, *t* (58) = 2.75, $p < .01$, but the age groups did not differ on positive mood (p = .09).

Effect of mood on performance in RSVP task. To examine whether mood was related to accuracy to detect the T2 in each valence condition, partial correlations were conducted, controlling for age group. Neither positive nor negative mood scores were significantly associated with accuracy to detect T1 or T2 (T1 absent or present trials), or the difference scores, for any of the T2 valence conditions (all *p*s > .1).

Participant picture ratings. To verify whether participant ratings of T2 and T1 pictures were comparable to the normative picture ratings, three multivariate ANOVAs were performed, with the between-subjects factors of Age Group (younger/older) and Valence Condition (negative/neutral/positive), to analyze the T1 and T2 SAM ratings for valence, arousal, and personal relevance, respectively.

Valence. For T1 pictures there was a main effect of Picture Valence, F (2, 54) = 105.94, $p < .0005$, $n_{p2} = 0.8$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction ($p > .1$). Post hoc tests indicated that participants rated the valence of pictures consistently with the normative ratings. For T2 pictures, none of the main effects or interactions reached significance (all *p*s > .05), indicating that the neutral T2s were perceived similarly in valence across the three valence conditions.

Arousal. For T1 pictures there was a main effect of Picture Valence, F (2, 54) = 3.11, $p = .053$, $n_{p2} = 0.10$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction ($p > .1$). Post hoc tests indicated that participants rated positive T1s as more arousing than neutral T1s, t (38) = 2.39, $p < .05$, but neither positive nor neutral T1s differed in arousal from negative T1s (*p*s > .1). For T2 pictures, none of the effects of interaction reached significance (all *p*s > .1), indicating that the arousal of the neutral T2s was perceived similarly in valence across the three valence conditions. As participant arousal ratings for T1s differed from the normative ratings (differences in arousal level across valence types) correlations between SAM Arousal ratings and accuracy to detect T1 in each valence condition were conducted. The only correlation that reached significance found that in the T1 Neutral condition, lower SAM arousal was associated with greater accuracy to detect T2, $r = -.48$, $p < .05$. No other correlations reached significance (all *p*s > .05).

Personal relevance. For T1 pictures, there was a main effect of Picture Valence, F (2, 54) = 3.18, $p = .05$, $n_{p2} = 0.10$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction ($p > .1$). Post hoc tests indicated that participants rated positive pictures as more personally relevant than neutral, t (38) = 2.49, $p < .05$, but neither positive nor neutral T1s differed in personal relevance from negative T1s (*p*s > .1). For T2 pictures, no effects were significant (*p*s > .1). To examine whether personal relevance was related to accuracy to detect T1 for each valence condition, correlations were conducted. The only significant correlations were that in the T1 Neutral condition, lower personal relevance was associated with greater accuracy to detect the T2 in the T1 present and absent conditions (ps < .05), and lower personal relevance was related to greater impairment in detecting neutral T2 (difference scores), $p < .05$. No other correlations reached significance (all *p*s > .05).

Discussion: Experiments 4a and 4b

In Experiments 4a and 4b, I used an RSVP paradigm to examine age differences in processing fluency for images of different valence. Given the speed at which information must be processed in an RSVP task (Martens & Wyble, 2010), use of cognitive control to strategically direct attention toward pictures of a specific valence is limited. Although the Age x Valence interactions in these experiments did not reach significance, the pattern of results for difference scores (indicating degree to which T2 detection accuracy declines when T1 present) in Experiment 4a suggests that older, but not younger, adults are less impaired at detection of emotional (negative and positive) pictures relative to neutral pictures (although this greater attentional capture of emotional stimuli did not hold in Experiment 4b). Such a result indicates greater attentional capture by emotional stimuli for older adults, but not younger adults. In Experiment 4b, the pattern suggests greater attentional capture by negative pictures than positive pictures, in both age groups. Hence, there was no evidence for aging-related positivity effects (or negativity reductions) in attentional capture of information.

A previous study which examined aging-related changes in attentional capture of emotional words in the RSVP paradigm also found evidence that older adults' attention is captured by both positive and negative information (Langley, Rokke, Stark, Saville, Allen, & Bagne, 2008). This study, as well as one other (Mickley Steinmetz, Muscatell, & Kensinger, 2010), also did not find consistent evidence of attentional capture by positive and negative words by younger adults. For instance, Langley et al. (2008) found that attentional capture was enhanced for positive words, but reduced for negative words. These results, as well as results from Experiments 4a and 4b, stand in contrast to those obtained in other studies which have used the RSVP paradigm to examine attentional capture of emotional stimuli. More typically, studies of younger adults indicate enhanced attentional capture of emotional information (e.g., Anderson, 2005; Keil & Ihssen, 2004; Ogawa & Suzuki, 2004; Smith, Most, Newsome, & Zald, 2006; Trippe, Hewig, Heydel, Hecht, & Miltner, 2007). However, these studies used stimuli which were often more emotionally arousing (e.g., words such as kill and "fall in love" (a word in German), and images of mutilated bodies, babies, and erotic couples) than stimuli used in the positivity effect literature (e.g., words such as misery and joy), and so the enhanced attentional capture of these target stimuli may be due to the increased emotional arousal.

Moreover, the main effects of Age Group and Age Group x T1 Status interactions in Experiments 4a and 4b suggest superior ability of older adults to detect the second target in the RSVP stream, relative to young. This is in contrast to other studies which have demonstrated decrements in T2 detection for older adults (e.g., Georgiou-Karistianis, Tang, Vardy, Sheppard, Evans, Wilson, et al., 2007; Lahar, Isaak, & McArthur, 2001; Maciokas & Crognale, 2003). As the current experiments doubled the stimulus durations for older, compared to younger adults, this can likely account for the obtained age differences. Hence, extending the stimulus presentation duration appears to be an effective way to improve older adults' performance in the RSVP paradigm, a finding which is consistent with the theory that aging-related decrements in performance on cognitive tasks are related to reduced speed of processing in older adults (e.g., Salthouse, 1996).

Limitations and future directions

One possible limitation of Experiments 4a and 4b, which may have contributed to the null result with respect to interactions with Valence, is that highly complex pictures were used as stimuli, rather than words. As participants could only reliably identify target pictures after being given a great deal of exposure to the pictures prior to the main RSVP task, it is possible that attentional resources were allocated to discerning the contents of target pictures and so the influence of emotion was lessened. Also, as all study pictures were of medium high arousal (to more clearly determine effects of valence as opposed to arousal), and previous studies have indicated greater attentional capture of higher arousing stimuli (e.g., Anderson, 2005, Keil & Ihssen, 2004), this may also have attenuated effects of emotion. In future, it would be interesting to include highly emotionally arousing stimuli as targets (e.g., taboo words, erotic images, etc.) to examine interactions of valence and arousal in this paradigm, for older adults participants.

In summary, the pattern of results in Experiments 4a and 4b does not provide evidence for positivity effects in attentional capture by positive valence images, but rather suggests that both positive and negative stimuli capture the attention of older adults in a bottom-up manner, when the task limits the use of cognitive control in service of emotion regulation goals.

4.3 Experiments 5a and 5b: Dot Probe

Introduction to Experiments 5a and 5b

Experiments 4a and 4b examined whether there were age differences on a task that relied primarily on fluency of processing (and ease of attentional capture) of emotional stimuli, which would provide indirect support for a bottom-up account of aging-related positivity effects. No such support was found. The goal of Experiments 5a and 5b was to examine whether there were age differences, on a task which allowed for more top-down cognitive control in the allocation of attention to emotional stimuli.

Many previous studies that have examined selective attention to emotional and neutral stimuli have used a standard attentional paradigm called the dot probe paradigm (MacLeod, Mathews, & Tata, 1986). In this paradigm, participants are shown pairs of stimuli (e.g., faces, words) and after stimuli offset a dot appears in the former location of one of the stimuli. Participants are typically instructed to press a button to indicate the location of the dot on the screen, and the dependent measure is response time to detect the dot. The logic behind this task is that participants should be faster to detect the dot when it appears in a location to which they had just been attending relative to when the dot appears in an unattended location. By varying the characteristics of each stimulus of the pair, biases in attention for a particular type of stimulus can be determined. For example, if participants are presented with a pair of faces, one of which has an angry, and the other a neutral, expression, it has been demonstrated that clinically anxious participants (sensitive to threatening information) are faster to detect the dot when it replaces the angry face relative to when it replaces the neutral face, indicating a bias to direct attention toward the location of the angry (threatening) face (for a meta-analysis, see Bar-Haim, Lamy, Perfamin, Bakermans-Kranenburg, & van IJzendoorn, 2007).

One factor identified in the aging literature as crucial to the manifestation of such attentional biases is stimulus presentation duration; it has been shown that aging-related positivity effects (particularly in the form of negativity reductions) in attentional bias are more likely to occur at longer presentation times (e.g., 1000 msec or longer; Mather & Carstensen, 2003) than at short presentation times (e.g., 500 msec or less; Lee & Knight, 2009; Orgeta, 2011). It has been postulated that these differences reflect active use of cognitive control to direct attention at the longer relative to shorter presentation durations, which are instead mediated by relatively automatic re-orienting of attention (e.g., Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Orgeta, 2011; Williams, Watts, MacLeod, & Mathews, 1997).

A few recent studies have used the dot probe paradigm to examine aging-related changes in attentional biases to positive, negative, and neutral information. The first such study (Mather & Carstensen, 2003) found evidence that older adults are biased to direct their attention away from negatively valenced information (faces), relative to neutral information at stimulus duration of 1000 msec, consistent with the idea that older adults may use cognitive control to reduce attention to negative stimuli in service of emotion regulation goals. This effect was replicated in more recent studies which showed that at stimulus durations of 1000 msec, but not shorter, older adults showed a bias to direct attention away from negative information (Lee & Knight, 2009; Orgeta, 2011). One problem with these studies, however, is that they examined attentional biases to emotional (positive and negative) relative to only neutral information. That is they included only pairs of stimuli in which one stimulus was negative or positive in valence, and the other neutral; they never directly compared attention to negative and positive information. In addition, these studies included twice the number of trials with negative stimuli (angry and sad faces) as positive stimuli.

Experiments 5a and 5b of the current thesis extend these previous findings by presenting negative-positive stimulus pairs in a dot probe paradigm for 1000 msec. Such a design allows a direct comparison, with equal numbers of positive and negative stimuli, of whether older adults do indeed use strategic, top-down control to direct attention selectively toward positive and away from negative stimuli. Additionally, the current experiments compare attentional biases for two types of stimuli: faces (Experiment 5a), and IAPS pictures (Experiment 5b) to determine whether effects will generalize across stimulus types. If these effects do not generalize to stimuli other than faces, then it is possible that the previously reported effects in the literature may not actually reflect attention directed to stimuli of a certain emotional valence *per se*, but perhaps to certain characteristics of facial stimuli (eyes, mouths). Moreover, as eye gaze of faces used in dot probe paradigms is typically directed straight at the viewer, face stimuli may engage the viewer to a greater extent than scenes, for which the viewer takes the role of a passive observer. For instance, eye gaze is known to elicit reflexive shifts in attention (for a review, see Langton, Watt, & Bruce, 2000). It is important to demonstrate that positivity effects in orienting attention are not contingent on these factors.

Based on previous work, I expected older adults to show biases away from negative relative to neutral information. Moreover, as older adults have been shown to preferentially direct attention to positive relative to neutral information (e.g., Mather & Carstensen, 2003, Experiment 1; Allard & Isaacowitz, 2008; Isaacowitz, Allard, Murphy, & Schlangel, 2009; Isaacowitz, Toner, Goren, & Wilson, 2008; Isaacowitz, Toner, & Neupert, 2009; Isaacowitz, Wadlinger, Goren, & Wilson, 2006a; Isaacowitz, Wadlinger, Goren, & Wilson, 2006b), I predicted that the attentional bias away from negative information would be stronger in the context of negative-positive pairs than negative-neutral pairs.

Experiment 5a

Method

Participants

Thirty healthy community-dwelling older adults (62-88 years of age; 22 female) recruited through the University of Waterloo's Research in Aging Participant pool, and 30 younger adults (18-23 years of age; 19 female) recruited from undergraduate psychology classes completed the study. Table 7 displays participant characteristics. Older adults received $10/hour remuneration, and younger adults received course credit for participating. For both age groups inclusion criteria were self-reported: fluency in English, normal or corrected-to-normal vision and hearing, no history of neuropsychological impairment, no previous head injury, and not currently being treated for depression or anxiety. For older adults, an additional exclusion criterion was a score of less than 26 (out of 30) on the Mini-Mental State Exam, which may indicate cognitive impairment (MMSE, Folstein, Folstein, & McHugh, 1975). Consistent with literature indicating greater vocabulary with aging (e.g., Verhaeghen, 2003), the older adult group had a higher full scale IQ (FSIQ), $t(58) = 4.16$, $p < .0005$, as estimated by the National Adult Reading Test – Revised (NART-R, Nelson, 1992) than the younger adult group, but age groups did not differ in years of education ($p > .1$). During the course of the study, participants of both age groups completed a battery of neuropsychological tasks (Trail Making Tests A and B, and Digit Span forward and backward). Scores on the Trail Making Tests and the Digit Span tasks were used to confirm that older adult participants were within normal range for cognitive functioning according to published norms (Spreen & Strauss, 1998; Wechsler, 1997). See Table 7 for mean demographic values and scores on neuropsychological tests. Eight older adults were replaced due to scoring less than 26 on the MMSE, or having health conditions that could adversely impact vision (e.g., macular degeneration).

Table 7 *Experiment 5a Participant Characteristics. Mean Values with Standard Deviations in Parentheses*

	Age Group			
	Younger		Older	
Age in years	19.10	(1.30)	73.87	(8.11)
MMSE score	-	-	29.23	(0.97)
Years of education	14.77	(1.36)	15.57	(3.64)
FSIQ (NART-R)	108.43	(6.30)	115.74	(7.25)
PANAS-X (percent positive)	56.00	(12.80)	63.20	(10.10)
PANAS-X (percent negative)	33.38	(10.75)	31.17	(9.98)
Trails A (time in seconds)	20.61	(7.06)	29.56	(7.96)
Trails B (time in seconds)	44.23	(18.87)	65.62	(29.99)
Digit Span Forward	8.73	(2.32)	8.43	(2.18)
Digit Span Backward	7.30	(1.82)	6.97	(1.96)

Materials and Procedure

Face Stimuli. Seventy-two photos of faces were obtained from the NimStim Set of Facial Expressions (http://www.macbrain.org/resources.htm) database, a widely used database of full-colour photos of faces which have been empirically validated and found reliable in terms of ratings of emotionality (Tottenham, Tanaka, Leon, McCarry, Nurse, Hare, et al., 2009). There were 24 faces displaying each of three expressions: angry[15], neutral, and happy, used to form 36 unique face pairs. There were 12 pairs for which one face had an angry expression and the other a neutral expression (angry-neutral pairs), 12 pairs for which one face had a happy expression and the other a neutral expression (happy-neutral pairs), and 12 pairs for which one face had an angry expression and the other a happy expression (angry-happy pairs). Each pair consisted of the same person expressing two different emotions. For each pair type, half of the pairs featured a female, and half a male, face. For each gender, half of the faces were White, and half were East Asian or Black.

For practice purposes, faces of eight other individuals with a neutral expression were chosen to form eight neutral-neutral pairs in which both faces were of the same individual. Practice trials included only neutral-neutral pairs so as to replicate the methods of Mather & Carstensen (2003) as closely as possible. Face photos were resized to be 16.5cm in height, with some variation in width (approximately 12cm), when displayed on the computer monitor.

Dot probe task. Participants were instructed that they would see a fixation cross followed by pairs of faces presented on the computer screen, and after the faces disappeared a dot would appear in the former location of one of the faces. Participants were asked to indicate the location of the dot (left side of screen or right side of screen) by pressing the “B” key (labeled L) or the “N” key (labeled R), and to use their dominant hand to make the response as quickly and as accurately as possible (participants typically used the index finger

[15] Angry faces were used instead of faces depicting fear, sadness, or disgust, in line with the majority of studies examining the effect of negative emotion on attention using various tasks (e.g., visual search, dot probe).

of the dominant hand). Each experimental trial began with the presentation of a black fixation cross for 500 msec in the centre of the screen, with a white background. Upon fixation cross offset, a pair of faces was displayed for 1000 msec, one on the left side of the screen and the other on the right side of the screen. Upon face pair offset, a black dot 0.5cm in diameter was displayed in the centre of the former location of one of the faces and remained onscreen until the participant responded. Face pairs were presented in a randomized order and each unique fair pair was presented four times to counterbalance side of screen on which a given face of the pair appeared (L/R) and dot location (L/R), for a total of 144 trials. These trials were presented twice to increase number of trials included in each mean. See Figure 11 for sample face stimuli and overview of the dot probe task procedure.

There were 16 practice trials which followed the same procedure as in experimental trials.

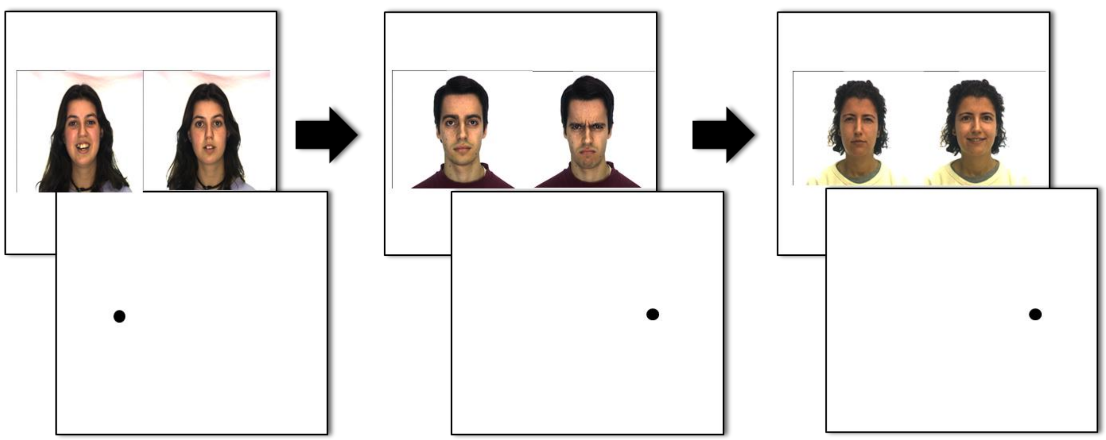


Figure 11. Experiment 5a, trials from the dot probe paradigm, with face stimuli.[16]

Procedure. Participants completed the practice trials of the dot probe task followed by the experimental trials. Afterward, participants completed a battery of neuropsychological tasks which included the NART-R, Trail Making Tests A and B, digit span forward and backward, and older adults also completed the MMSE. Additionally, participants completed

[16] Faces taken from the AR face database (Martinez &Benavente, 1998), as NimStim faces cannot be published in documents other than scientific journals.

the PANAS-X mood scale either after the neuropsychological tasks or before the dot probe task.

Results

Dot probe data cleaning. All participants' overall accuracy was equal to or greater than 95%. Data from two additional older adults were discarded due to low accuracy, and long response times relative to median response times of other participants in that age group. As in Mather and Carstensen (2003), to remove fast response time outliers, data from individual trials were discarded if the response time was 200 msec or less, as this may reflect reflexive responding. To remove slow response time outliers, separate cutoff scores were calculated for younger (545 msec) and older (799 msec) adult groups to exclude 10% of the slowest responses. Only correct responses were analyzed.

Performance on dot probe task.

Bias scores. As in Mather and Carstensen (2003) (as well as other studies, e.g., Cooper & Langton, 2006; Fox & Knight, 2005; Isaacowitz, Wadlinger, Goren, & Wilson, 2006b; Lee & Knight, 2009; Orgeta, 2011), difference scores were used to compute an attentional bias score for each face pair type (see Figure 12). These bias scores represent the degree to which attention was directed toward a face of a given valence within each face pair type (e.g., bias to detect an angry face in angry-happy pairs). To calculate bias scores for angry-neutral and happy-neutral face pairs, mean RTs to detect the dot when it replaced a neutral face were subtracted from mean RTs to detect the dot when it replaced the emotional face. For these bias scores, a positive value indicates greater bias to attend to the emotional face of the pair, whereas negative values indicate greater bias to attend to the neutral face of the pair. To calculate bias scores for angry-happy face pairs, mean RTs to detect the dot when it replaced a happy face were subtracted from mean RTs to detect the dot when it replaced an angry face. For these bias scores, a positive value indicates greater bias to attend to the happy face of the pair, whereas negative values indicate greater bias to attend to the angry face of the pair. For a table of raw RTs and associated analyses, see Appendix A.

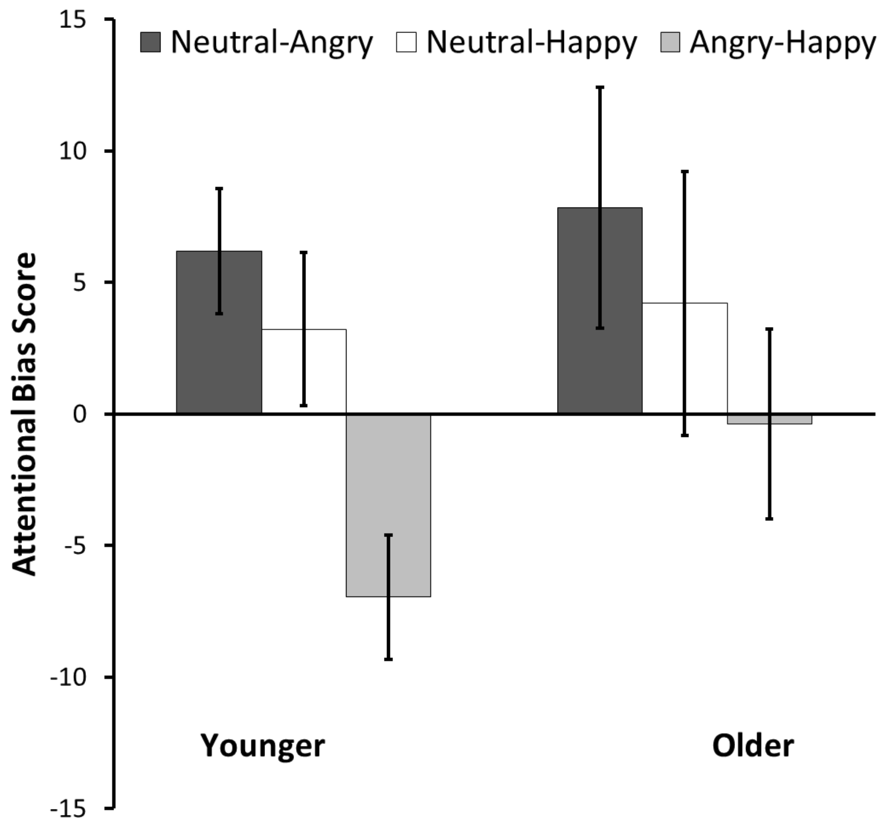


Figure 12. Experiment 5a, mean attentional bias scores (RT difference scores) showing the magnitude of bias to attend to angry, neutral, and happy faces in neutral-angry, neutral-happy, and angry-happy face pairs, by age group. Error bars represent standard error of respective means.

As in Mather and Carstensen (2003) and in the previous studies mentioned above, bias scores were analyzed with one-sample t tests to determine whether bias scores for each face-pair type in each age group were different than zero (score of zero indicates no bias in attention for either face in a pair). For younger adults, bias scores differed from zero for the angry-neutral pairs, t (29) = 2.60, $p < .05$, indicating greater bias to attend to the angry faces, and for the angry-happy pairs, t (29) = 2.94, $p < .01$, indicating greater bias to attend to the angry faces, but not for the happy-neutral pairs ($p > .1$). For older adults, none of the bias scores differed from zero (all *p*s > .09), although for the bias score for the angry-neutral pairs there was a trend for biased attention to the angry face ($p = .098$).[17]

T-tests were also conducted to compare age groups in terms of magnitude of bias scores. No significant differences were found between age groups for any of these bias scores (all *p*s > .1).

Mood measure. Raw scores for basic negative and basic positive affect from the PANAS-X were converted to percent of maximum possible score (see Table 7). Both younger and older adults reported greater positive, than negative, mood ($t_{younger}$ (29) = 8.30, $p < .0005$; t_{older} (28) = 10.66, $p < .0005$). There was no age group difference in negative mood ($p > .1$), but older adults reported greater positive mood than young, t (57) = 2.39, $p < .05$. Mood data were missing for one older adult participant.

Effect of mood on performance in dot probe task. To examine whether mood was related to magnitude of bias scores and RTs, partial correlations were conducted, controlling for age group. The relation between negative mood and bias scores for angry-happy, angry-neutral, and happy-neutral face pairs, respectively, were not significant, *p*s > .1. Greater positive mood was significantly related to a smaller bias score for angry-happy face pairs, indicating that positive mood was related to greater attention to the angry face of the pair, $r = -0.31$, $p < .05$. None of the correlations between positive mood, negative mood, and RTs to detect the dot when it replaced an angry, neutral, or happy face reached significance.

Experiment 5b

The purpose of Experiment 5b was to determine whether the effects in attentional bias scores reported in Experiment 5a could be replicated with a different type of stimulus, namely pictures of emotional and neutral scenes. As mentioned in the introduction, if these

[17] To examine whether performance on the neuropsychological tasks which assess executive function (Trails B and Digit Span backward) was related to attentional bias for angry, neutral, and happy faces, scores on these tests were correlated with bias scores for each face pair type and age group. These analyses only revealed that for younger adults better (faster) performance on Trials B was related to greater attentional bias for happy faces, $r = -.51$, $p < .005$.

effects do not generalize to stimuli other than faces, then it is possible that the previously reported effects in the literature may not actually reflect attention directed to stimuli of a certain emotional valence *per se*, but perhaps to certain characteristics of facial stimuli (eyes, mouths). Moreover, as eye gaze of faces used in dot probe paradigms is typically directed straight at the viewer, face stimuli may engage the viewer to a greater extent than scenes, for which the viewer takes the role of a passive observer. It is important to demonstrate that positivity effects in orienting attention are not completely contingent on these factors but rather generalize across stimulus types, consistent with the aging-related motivation to regulate affective response as postulated by SST.

Method

Participants

Thirty healthy community-dwelling older adults (62-87 years of age; 24 female) recruited through the University of Waterloo's Research in Aging Participant pool, and 30 younger adults (17-23 years of age; 20 female) recruited from undergraduate psychology classes completed the study. Table 8 displays participant characteristics. Older adults received $10/hour remuneration, and younger adults received course credit for participating. For both age groups inclusion criteria were: fluency in English, normal or corrected-to-normal vision and hearing, no history of neuropsychological impairment, no previous head injury, and not currently being treated for depression or anxiety. For older adults, an additional exclusion criterion was a score of less than 26 (out of 30) on the Mini-Mental State Exam, which may indicate cognitive impairment (MMSE, Folstein, Folstein, & McHugh, 1975). Consistent with literature indicating greater vocabulary with aging (e.g., Verhaeghen, 2003), the older adult group had a higher full scale IQ (FSIQ), $t(58) = 4.90$, $p < .0005$, as estimated by the National Adult Reading Test – Revised (NART-R, Nelson, 1992) than the younger adult group, but age groups did not differ in years of education ($p > .1$). During the course of the study, participants of both age groups completed a battery of neuropsychological tasks (Trail Making Tests A and B, and Digit Span forward and backward). Scores on the Trail Making Tests and the Digit Span tasks were used to confirm that older adult participants were within normal range for cognitive functioning according to published norms (Spreen & Strauss, 1998; Wechsler, 1997). See Table 8 for mean demographic values and scores on neuropsychological tests. One older adult was replaced due to scoring less than 26 on the MMSE.

Table 8 *Experiment 5b Participant Characteristics. Mean Values with Standard Deviations in Parentheses*

	Age Group			
	Younger		Older	
Age in years	19.57	(1.55)	72.07	(6.51)
MMSE score	-	-	28.9	(0.88)
Years of education	14.67	(1.52)	15.47	(3.51)
FSIQ (NART-R)	106.45	(8.27)	115.94	(6.63)
PANAS-X (percent positive)	56.21	(9.98)	67.56	(11.33)
PANAS-X (percent negative)	31.65	(10.37)	28.83	(8.11)
Trails A (time in seconds)	18.41	(5.55)	29.97	(7.16)
Trails B (time in seconds)	36.88	(12.40)	82.46	(36.15)
Digit Span Forward	9.30	(2.25)	8.57	(1.92)
Digit Span Backward	7.67	(1.92)	6.97	(2.11)

Materials and Procedure

Picture Stimuli. Seventy-two pictures were selected from the IAPS database, a widely used database of full-colour photos with normative ratings of emotional valence and arousal (Lang, Bradley, & Cuthbert, 2001). There were 24 each of negative, neutral, and positive pictures, used to form 36 unique picture pairs. IAPS normative ratings were used to categorize pictures according to valence, and all pictures were selected to be of medium arousal. Follow-up t-tests confirmed that negative (Valence $M = 2.71$, $SD = 0.33$; Arousal $M = 5.02$, $SD = 0.37$), neutral (Valence $M = 5.20$, $SD = 0.58$; Arousal $M = 4.87$, $SD = 0.58$), and positive (Valence $M = 7.29$, $SD = 0.38$; Arousal $M = 4.88$, $SD = 0.43$), pictures differed on normative valence ($ps < .0005$), but not normative arousal ($ps > .1$). There were 12 pairs for which one picture was negative and the other neutral (negative-neutral pairs), 12 pairs for which one picture was positive and the other neutral (positive-neutral pairs), and 12 pairs for which one picture was negative and the other positive (negative-positive pairs). For each pair type, half of the pictures of each valence featured a scene with people, and half contained animals, nature scenes, or inanimate objects. For practice purposes, eight other pictures with a neutral valence were chosen to form eight neutral-neutral pairs. Pictures were resized to be 17cm in height and 16cm in width, when displayed on the computer monitor. Pictures were selected to be of medium arousal level across all valence types.

All tasks and procedures in Experiment 5b were identical to those used in Experiment 5a, except pictures were used as stimuli instead of faces. As such, participants rated study pictures after all other study tasks. See Figure 13 for sample stimuli and overview of the dot probe paradigm.

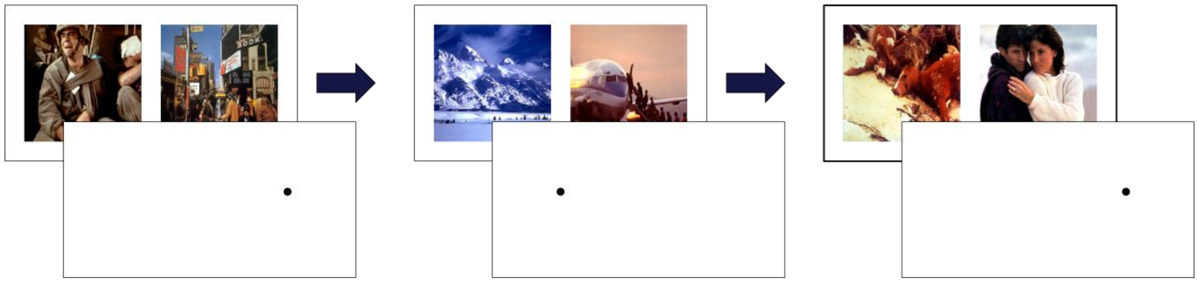


Figure 13. Experiment 5b, trials from the dot probe paradigm with picture stimuli.

Picture Rating Task. To compare normative ratings with participant ratings of pictures, participants rated each picture in the experiment on the dimensions of valence, arousal, and personal relevance, using a computerized version of the SAM scales (the order of the figures in the dominance scale was reversed to form the personal relevant scale, such that a value of 1 indicated that the picture was very personally relevant, and a value of 9 indicated that the picture was not at all personally relevant). After the presentation of a fixation cross in the centre of the screen for 500 msec, a picture was displayed in the centre of the computer screen with a SAM scale below. Participants rated each picture three times, (once for each scale) using the keys 1-9 on the keyboard. Pictures advanced automatically after they were rated with a key press. A practice version of the picture rating task was included in which participants rated the pictures from the dot probe practice trials. For analyses regarding participant picture ratings, see Appendix B.

Results

Dot probe data cleaning. All participants' overall accuracy was equal to or greater than 95%. Data from two additional older adults were discarded due to long response times relative to median response times of other participants in that age group. As in Mather and Carstensen (2003), to remove fast response time outliers, data from individual trials were discarded if the response time was 200 msec or less, as this may reflect reflexive responding. To remove slow response time outliers, separate cutoff scores were calculated for younger (522 msec) and older (803 msec) adult groups to exclude 10% of the slowest responses. Only correct responses were analyzed. For raw RT data and associated results, see Appendix C.

Performance on dot probe task.

Bias scores. None of the bias scores differed significantly from zero for either age group, indicating that participants were not biased to either picture of a pair (all *p*s > .1). See Figure 14.

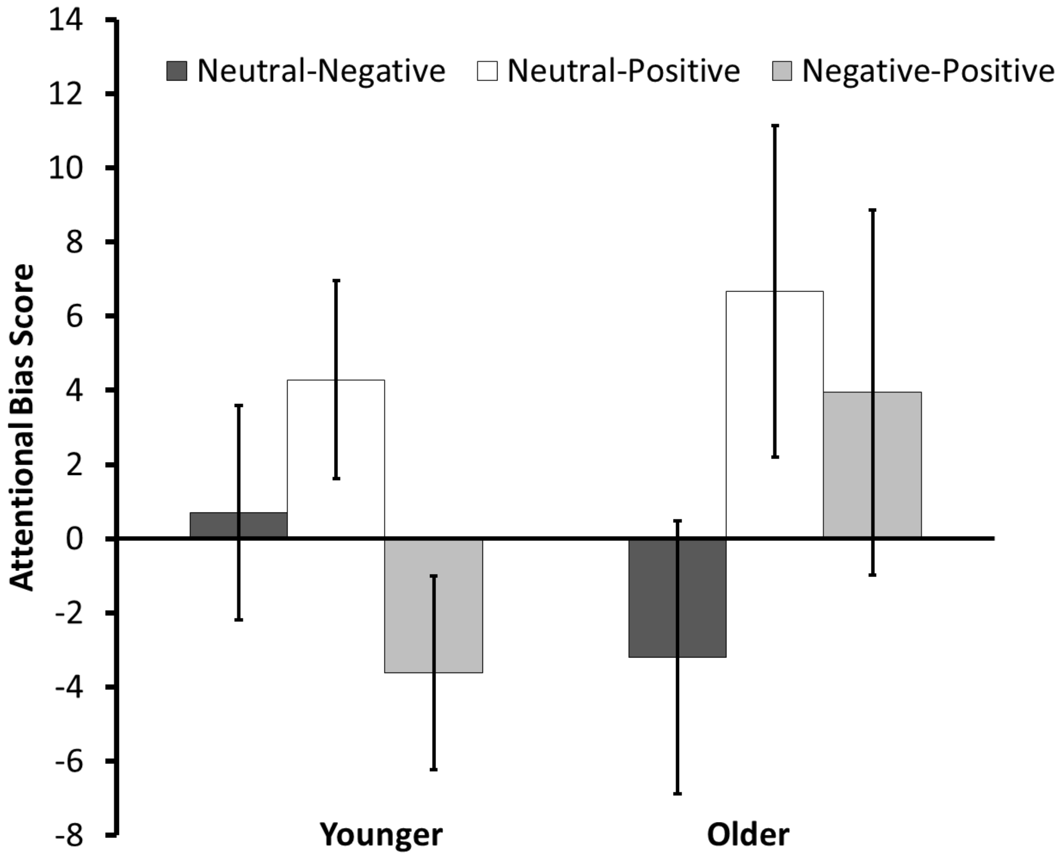


Figure 14. Experiment 5b, mean attentional bias scores (RT difference scores) showing the magnitude of bias to attend to negative, neutral, and positive pictures in neutral-negative, neutral-positive, and negative-positive picture pairs, by age group. Error bars represent standard errors of respective means.

Mood measure. Raw scores for basic negative and basic positive affect from the PANAS-X were converted to percent of maximum possible score (see Table 8). Both younger and older adults reported greater positive, than negative, mood ($t_{younger}$ (29) = 9.98, *p*

< .0005; t_{older} (29) = 13.70, p < .0005). There was no age group difference in negative mood (p > .1), but older adults reported greater positive mood than young, t (58) = 4.23, p < .0005.

Effect of mood on performance in dot probe task. To examine whether mood was related to magnitude of bias scores and RTs, partial correlations were conducted, controlling for age group. Greater negative mood was associated with a greater bias to attend to neutral pictures in negative-neutral pairs, r (57) = -.28, p < .05, but was not associated with magnitude of bias scores for positive-neutral or negative-positive pairs, ps > .1 The relation between positive mood and bias score magnitude was not significant for any picture pair type, ps > .1. Moreover, none of the correlations between positive mood, negative mood, and RTs to detect the dot when it replaced a negative, neutral, or positive picture reached significance.

Discussion: Experiments 5a and 5b

Experiments 5a and 5b examined whether older adults are biased to direct attention toward positive stimuli, or away from negative stimuli, relative to younger adults, in the context of an attention task which allowed sufficient time for participants to use cognitive control to direct their attention to preferred stimuli (dot probe task). Results of Experiment 5a suggest a negativity bias in younger adults' attention: Younger adults were biased to direct attention toward negative (angry) faces relative to neutral or positive (happy) faces. In contrast, older adults showed an attenuation of this negativity bias in attention to faces, which may suggest an aging-related reduction in attention to faces expressing negative emotions (negativity reduction as opposed to positivity enhancement). In Experiment 5b, none of the comparisons reached statistical significance, so it is unclear whether the effects seen with faces in Experiment 5a can generalize to other types of stimuli such as pictures. However, the pattern of results in Experiment 5a suggests that older adults direct attention away from negative stimuli and toward positive stimuli. These findings indicate that older adults may use top-down cognitive control processes to reduce attention to negative stimuli.

Results of Experiments 5a and 5b suggest that older adults may regulate attention to emotional stimuli by directing attention not toward positive stimuli but away from negative stimuli. One novel contribution of these experiments is that they examine attention to positive and negative stimuli presented simultaneously, through inclusion of the angry-happy face pairs (Experiment 5a) and negative-positive picture pairs (Experiment 5b). If older adults are biased to direct attention toward positive stimuli and away from negative stimuli, then the attentional bias scores for these pairings would be expected to reflect this tendency. However, bias scores for these stimulus pairs are more consistent with a bias to direct attention away from the negative stimulus of the pair (Experiment 5a).

The findings of Experiment 5a are in line with results of recent studies which used the dot probe paradigm to compare attention to faces in younger and older adults. For example, Mather and Carstensen (2003) also presented face stimuli for 1000 msec, allowing enough time for cognitive control to be applied in service of emotion regulation goals, found that older adults were biased to direct attention away from negative faces, although their younger adults did not show attentional biases for emotional faces. As such, Experiment 5a did not completely replicate these findings as was expected, as the younger adult group in Experiment 5a showed stronger evidence of attentional biases than did older adults. It is possible that none of the bias scores reached statistical significance in the older adult group because of the greater variance associated with both the bias scores and RTs (see also Lee & Knight, 2009).

The results of Experiment 5a are also consistent with those of Orgeta (2011), which showed evidence that older adults direct attention away from negative faces, although only at the longest face presentation duration of 1000 msec and not with shorter presentation times (17 msec and 500 msec), consistent with the idea that this aging-related bias to direct attention away from negative stimuli is the result of application of cognitive control. Moreover, Lee and Knight (2009) used the dot probe task to examine attention to negative, positive, and neutral faces, words, and IAPS pictures. The strongest result occurred for the face stimuli, with older adults showing avoidance of negative faces at presentation times of 1500 msec, and vigilance toward negative faces at subliminal presentation times (50 msec for older adults). As in Mather and Carstensen (2003), younger adults did not show attentional biases for emotional faces relative to neutral faces. These results also support the notion that older adults may quickly detect threat information when there is little opportunity to use cognitive control, such as with subliminal and relatively short stimuli presentations, but may avoid negative information when the opportunity arises to use cognitive control to regulate emotion.

The findings of Lee and Knight (2009) additionally inform the null results of Experiment 5b, as they also did not find evidence of biases in attention to IAPS pictures in either younger or older adults. It is possible that the degree of visual complexity of IAPS pictures when compared with faces may contribute to this null effect. For example, within some negative scenes, there are areas of the scene that contain no threat/negative information, and older adults may direct attention to these areas rather than saccade to the neutral or positive picture of the pair to avoid the specific area containing negative information. This could allow for faster RTs to detect a dot that replaces the negative pictures than if participants directed attention away from the negative picture completely. Alternatively, it is possible that effects are stronger with faces because an angry face with gaze fixed on the viewer may be perceived as a greater threat than a scene with negative content that is not directed toward the viewer, and so older adults may be more motivated to avoid looking at the angry face compared with the negative picture.

It is interesting to note that studies of attention to faces in younger and older adults which use eye tracking apparatus to follow participants' gaze more consistently demonstrate that older adults preferentially attend to positive faces (as well as away from negative faces), particularly when they are in a bad mood (e.g., Allard & Isaacowitz, 2008; Isaacowitz, Allard, Murphy, & Schlangel, 2009; Isaacowitz, Toner, Goren, & Wilson, 2008; Isaacowitz, Toner, & Neupert, 2009; Isaacowitz, Wadlinger, Goren, & Wilson, 2006a; Isaacowitz, Wadlinger, Goren, & Wilson, 2006b), whereas the studies which have used the dot probe paradigm find avoidance of negative stimuli. As stimulus presentation times are much longer in eye tracking studies (e.g., 4000 msec) than in dot probe studies, it is conceivable that preferential attention to positive stimuli may occur only for these longer stimulus durations, when older adults have ample time to implement gaze patterns in accordance with goals to regulate emotions. Moreover, Isaacowitz et al. (2006b) suggest that eye tracking may be a more sensitive measure of aging-related positivity effects (and negativity reductions) than the dot probe paradigm.

Limitations and Future Directions

As with the memory experiments of the current thesis (1-3), one limitation of Experiments 5a and 5b is that cognitive control was not directly manipulated/disrupted during the dot probe task, and so I can only infer older adults' use of cognitive control in service of emotion regulation goals. As such, a future study could examine performance in the dot probe paradigm under conditions of divided attention to directly assess biases in attention when the ability to use cognitive control is disrupted in contrast to full attention conditions.

Another possible limitation of the study is that participants were given instructions to detect the dot as quickly and accurately as possible. As instructions to focus on accuracy may prevent older adults from implementing emotion regulation strategies (e.g., Kennedy, Mather, & Carstensen, 2003; Experiment 1 of the current thesis), the instructions in the current experiments may have attenuated any biases to preferentially direct attention to positive stimuli and away from negative stimuli, contributing to the null results of Experiment 5b and the absence of significant differences in bias scores for the older adult group in Experiment 5a. Nevertheless, the dot probe task is very easy for participants to carry out (nearly all participants have accuracy rates exceeding 95%) as all that is required of them is to press a key when the dot probe is detected. I would argue that instructions to maintain high accuracy and fast RTs would not fully prevent the use of cognitive control to direct their attention. This is in contrast to Experiment 1 (FAS test) in which task demands reduce the degree to which participants can apply cognitive control, as speed of output is emphasized. Moreover, it would be interesting to see if aging-related negativity reductions in attention would be stronger when faces of older adults were used as stimuli, as faces of younger adults may seem less relevant to older adults, resulting in less motivation to regulate emotions when presented with young adult faces.

In summary, Experiments 5a and 5b provided some evidence that older adults direct attention away from negative stimuli (negativity reduction) whereas younger adults direct attention toward negative stimuli (negativity bias), and suggest that these biases are the result of the application of top down cognitive control processes in service of emotion regulation goals.

Chapter 5
General Discussion

5.1 Summary of Major Results

My thesis sought to identify factors that underlie the inconsistent findings of positivity effects in studies of memory and attention. I examined the contribution of a factor that has recently been identified in the literature as a possible source of the inconsistent findings: inter-study differences in task demands. Specifically, my thesis addressed whether positivity effects are more likely to emerge on cognitive tasks that allow for the use of cognitive control, especially in a reflective manner, or on those which emphasize reliance on processing fluency for the successful completion of the task. In line with the assumption of SST that goals to regulate emotional state are more salient in older, relative to younger, adults, and may influence the way in which information is cognitively processed (e.g., Carstensen, 1995), I hypothesized that positivity effects are more likely to occur on tasks that allow cognitive control processes to be used in the service of emotion regulation goals, such as in tasks that are reflective in nature, compared with tasks that emphasize speed, accuracy, or otherwise de-emphasize awareness of affective state while completing the task. In this way, my thesis evaluated the extent to which these two cognitive mechanisms (cognitive control and processing fluency) underlie manifestations of positivity effects in tasks of memory and attention.

To address my hypothesis, I conducted a suite of memory and attention experiments. I used five different tasks (three different memory tasks, and two different attention tasks) which varied with respect to the degree to which the task allowed for the use of cognitive control, were reflective in nature, and emphasized the ability to process information more fluently (i.e., faster, or with greater accuracy). I then compared younger and older adults' performance on the tasks to examine under what circumstances positivity effects occurred.

Experiments 1 and 2 (Tomaszczyk & Fernandes, in press) compared performance on two different types of memory tasks that differed with respect to the degree to which participants must rely on cognitive control/reflective processing versus processing fluency to successfully complete the task. Clear positivity effects were found on the task that was reflective in nature (autobiographical memory task) but not on the task that relied more heavily on fluency (phonemic fluency task). Experiment 3 (Tomaszczyk & Fernandes, under revision) examined whether older adults may strategically select positive information to later remember (i.e., use cognitive control to regulate encoding of positive material), by asking participants to judge the likelihood of remembering positive, negative, and neutral pictures for a later memory test. Older, but not younger, adults showed a positivity effect in terms of the number of pictures selected as particularly memorable, whereas both age groups showed a positivity effect in picture recall.

In Experiments 4a and 4b, I used an RSVP paradigm to examine age differences in the ability of different valence stimuli to capture attention. In this way, the task provides a measure of differences in processing fluency across age groups. Little evidence for positivity effects was found in these experiments. Experiments 5a and 5b used a dot probe paradigm to examine whether older adults preferentially orient attention toward positive, or away from negative, pictures and faces relative to neutral pictures and faces. This paradigm allowed enough time for participants to use cognitive control to guide their attention to stimuli. Some evidence of positivity effects was found, as older adults were shown to be less biased to attend to negative (angry) faces compared to younger adults.

5.2 Theoretical Implications of Results

Across a suite of memory and attention studies, I found greater support for the cognitive control hypothesis of the aging-related positivity effect than the processing fluency hypothesis. This result is in line with a top-down account of the emergence of aging-related positivity effects in memory and attention tasks. As few studies in the positivity effect literature have entertained an alternate explanation to the "top-down" cognitive control account, that positivity effects may result from an aging-related enhancement in the "bottom-up" processing of positive items, the novel contribution of this thesis is that it compares these accounts and in so doing identifies the cognitive mechanism that underlies observations of a positivity effect in cognitive processing associated with normal aging. As such, this thesis contributes to the determination of boundary conditions under which aging-related enhancements in the cognitive processing of emotional information will most likely be observed. Results are consistent with the postulates of SST that enhanced affective experiences in older age are due to shifts in motivation to regulate emotional state which bias the cognitive processing of emotional information such that positive information receives preferential processing.

As mentioned in the Introduction, I do not view the cognitive control and processing fluency accounts as mutually exclusive by necessity. Given that Carstensen (e.g., Charles & Carstensen, 2009; Mather & Carstensen, 2005) maintains that goals to regulate emotion are "chronically active" in older adults, it is somewhat surprising that fluency does not appear to contribute to aging-related positivity effects in memory and attention. If, by the term *chronically active*, Carstensen is implying that older adults' goals to regulate emotional state are implicit, these goals could influence information processing of emotional stimuli in a way similar to how implicit attitudes can affect social-cognitive information processing in a relatively automatic manner (e.g., Bargh, Chaiken, Govender, & Pratto, 1992; Spielman, Pratto, & Bargh, 1988). Also, as performance on cognitive tasks is thought to depend upon both controlled and automatic processes (e.g., Shiffrin & Schneider, 1977), it seems likely that the preferential processing would depend at least in part on relatively automatic cognitive processes. The operation of these relatively automatic processes in service of emotion regulation goals while completing a cognitive task could result in more fluent processing of positive information (positivity effect) or less fluent processing of negative information (negativity reduction).

If older adults have implicit goals to increase positive affect, this raises the question of why older adults should require executive control to show positivity effects. One possible explanation is that, although older adults may hold a (perhaps implicit) goal to regulate emotion, the actual cognitive processes necessary to implement this goal are effortful. Indeed, prefrontal cortex activity has been implicated in the act of regulating emotion (for reviews see Green & Malhi, 2006, and Ochsner & Gross, 2005). This question touches on the apparent paradox of older adults being better able to regulate emotions by the preferential cognitive processing of positive material, despite their reduced ability to use executive functions for cognitive tasks, relative to younger adults (Scheibe, 2011). Indeed, a prominent, and currently favoured, hypothesis regarding the source of aging-related declines in cognitive functioning called the "frontal lobe" hypothesis, maintains that due to greater atrophy of the frontal lobes compared with other brain structures, aging disproportionately affects those cognitive processes governed by the brain's frontal lobes, namely the higher-level executive functions (West, 1996, 2000).

A few possible explanations to address the paradox have been described by Scheibe (2011). First, in keeping with the aging-brain hypothesis (Cacioppo et al., 2011), positivity effects/negativity reductions may simply be due to decreased amygdala activity in response to negative stimuli. Second, the goal to maintain a positive affective state when completing cognitive tasks may strongly motivate older adults to strategically direct a greater proportion of their cognitive resources toward emotion regulation. Related to this is the idea that older adults' propensity to direct their cognitive efforts toward emotion regulation is selective and compensatory in nature. Third, older adults may be more adept at emotion regulation compared with younger adults, and so proportionately fewer cognitive control resources are necessary to regulate emotion during cognitive tasks. Some evidence does exist to support this idea (Scheibe & Blanchard-Fields, 2009). Given the findings of the current thesis that cognitive control appears to underlie aging-related positivity effects, I suspect that motivational factors play a greater role in the manifestation of positivity effects in older adults than do aging-related changes in amygdala activation.

Moreover, that processing fluency does not appear to account for positivity effects and negativity reductions is at odds with the aging-brain hypothesis of aging-related changes in cognitive processing of emotional information (Cacioppo et al., 2011). If positivity effects/negativity reductions are due to the amygdala being less responsive to negative stimuli in older adults, then I would expect to see relatively reduced processing of negative information when compared with positive information in tasks that rely heavily on the ability to fluently process information for their successful completion, such as in the FAS test and

RSVP paradigm. Furthermore, some studies which have employed the visual search paradigm to compare younger and older adults' ability to detect discrepant angry, happy, and neutral faces in a display (e.g., Knight & Mather, 2006) have found that both age groups detect angry faces more quickly than happy and neutral faces, which suggests an age-invariant advantage for threat information in visual attention, which also speaks against the aging-brain hypothesis.

On the other hand, if Carstensen uses the term *chronically active* to mean that the goal to regulate emotional state is explicitly available to older adults on a continuous basis and that they use cognitive control to implement other cognitive processes to carry out this goal, there still remains the possibility that, in addition to the recruitment of cognitive control processes, positive information is easier to cognitively process or negative information requires more effortful to process. That the definition of the term chronically active is vague in terms of the implicit/explicit distinction limits certain avenues of potential study. For instance, if goals to regulate emotion are postulated to operate on an implicit level, then it may be fruitful and interesting to explore the degree to which positivity effects emerge on a range of tasks assessing the effects of implicit goals on behaviour. Regardless, results of the experiments presented in this thesis suggest that processing fluency does not account for aging-related positivity effects in memory and attentional paradigms, and that these effects are consistent with motivationally-driven employment of cognitive control processes.

SST is not the only major psychological theory that takes into account the effects of time perception on the processing of social and cognitive information. Another theory rooted in the tradition of social psychology, called terror-management theory (TMT; Solomon, Greenberg, & Pyszczynski, 1991), attempts to explain the effect of what is deemed *mortality salience* on social-cognitive functioning. TMT maintains that the awareness that one will eventually die, as well as the feeling of terror that accompanies this awareness, is a potent motivator for individuals to embrace values, views, and relationships (e.g., Cox & Arndt, 2011) that give them a sense of personal meaning (e.g., Cohen & Solomon, 2011).

The findings of my thesis experiments, which are consistent with the idea that older adults use cognitive control processes to bias their cognitive processing of information in such a way as to presumably increase levels of positive affect (e.g., Isaacowitz, Toner, & Neupert, 2009), also suggest the cognitive mechanism by which individuals reduce the anxiety associated with the threat of impending death and increase positive feelings. Also, as studies of the positivity effect have, by and large, operated on the assumption that older adults are more aware of impending death and that this awareness impacts their cognitive processing, it would be interesting to directly manipulate mortality salience as in studies of TMT and examine the extent to which positivity effects occur in both younger and older adults. Priming mortality salience would be a more direct way to test this assumption of the SST compared with the less direct ways that have been used in past SST-based studies, in which salient endings are primed such as the threat of political takeovers and imagining greater time constraints (e.g., Fung, Carstensen, & Lutz, 1999). For example, younger adults have been shown to pay less attention to fear-inducing stimuli (snakes and spiders) when primed with mortality (MacDonald & Lipp, 2008), and I suspect that this effect would be even stronger in older adults.

5.3 Limitations and Future Directions

A possible alternative explanation for aging-related positivity effects is that they are actually mood congruency effects. As older adults often report more positive, or less negative, mood relative to younger adults, the case could be made that older adults have better memory for, and pay greater attention to, positive information because they are in a more positive mood, and they are preferentially processing information that is congruent with their current mood state. However, studies of the positivity effect typically take pains to assess participant mood with questionnaires such as the PANAS or PANAS-X, and either statistically control for effects of mood or demonstrate through correlational analyses the lack of association between mood and the dependent variables of interest (e.g., Charles, Mather, & Carstensen, 2003; Tomaszczyk, Fernandes, & MacLeod, 2008). In the experiments of the current thesis, participant mood was assessed with a well-known and often used mood scale, the PANAS-X, and the aforementioned statistical tests were used to rule out mood effects to account for the pattern of results obtained.

As mentioned above, I would expect that bottom-up processing of information partly contributes to aging-related positivity effects in cognitive tasks, and so I would find it prudent to further examine evidence for the processing fluency account. For example, it would be interesting to examine age differences in performance on other types of fluency tasks, or tasks which rely heavily on the ability to access information quickly, to determine the extent to which the results of the fluency task used in the current thesis are generalizable.

One interesting avenue for future research is to extend the findings of Experiment 3, which gave evidence that older adults are more likely to select positive information as memorable, relative to younger adults. If older adults use cognitive control to deliberately select positive information to later remember, this may be based on: 1) a motivationally based preference for processing positive information, 2) metacognitive beliefs that positive information is more memorable, or 3) metacognitive monitoring during encoding, for example, the subjective feeling of fluently processing positive items, irrespective of whether positive information is actually encoded to a greater extent than negative items (see Kornell et al., 2011 for a striking example of a double dissociation between metacognitive monitoring judgments and actual memory). To disentangle these explanations, the picture stimuli from Experiment 3 could be used in a traditional judgment of learning paradigm, which would facilitate comparisons with results of previous research. Younger and older participants could view negative, neutral, and positive pictures (or words as well) one at a time and be asked to make a judgment of learning after the presentation of each item (estimate the likelihood of recalling that item on a later recall test) followed by a recall test for the studied items. This would be followed by questions regarding participants' beliefs about the effect of emotional valence and arousal on memory performance. This design would allow for the distinction between memory beliefs and memory judgments, and their impact on actual memory performance. Furthermore, motivation to regulate emotions could be manipulated through instructions to focus on emotional state or accuracy while completing this task, and the effect on metamemory judgments as well as actual memory performance could be assessed.

Another potentially fruitful line of inquiry would be to provide an empirical test of one of the central assumptions of the SST that older adults are more motivated to maintain positive well-being than younger adults, as this has yet to be validated by empirical evidence. Previous studies have inferred the role of motivation in aging-related positivity effects, but none have directly tested this idea. As such, I could directly test the hypothesis that older adults are more motivated to cognitively process positively valenced information than young, using a quantifiable measure of motivation. To test this hypothesis, younger and older adults could complete a computerized "key press" task that quantifies and provides a behavioural measure of the motivational incentive of stimuli (based on Ferrey, Frischen, & Fenske, in preparation). Participants would be given instructions to press numerical keys from 1 to 6 to view a 2-second presentation of one of six different image types assigned to a given key: positive, negative, or neutral (half of each valence category being of high or low psychological arousal). Keys would be on a progressive ratio schedule such that each time a given key is pressed, twice as many key presses will be required to view the next image from the category associated with that key. Thus, independent variables are valence and arousal category of the image, and age group; the dependent variable is the number of key presses that participants make to view each image type, which quantifies degree of motivation to view the images.

I predict that older adults would make more key presses to view positive than negative or neutral images when compared with younger adults. To provide evidence of the validity of my dependent variable, the experiment could be replicated with the addition of an eye tracking apparatus, which is an indicator of where attention is directed in a visual scene. Thus, gaze patterns could be linked with number of key presses in response to individual images and serve as a measure of motivation to attend to images. I predict that older adults who show positivity effects in number of key presses would also visually fixate more on positive images, relative to young.

The main limitation of the current thesis is that participants' ability to use cognitive control was not directly manipulated; rather, use of cognitive control is inferred based on the extent to which the specific cognitive task allows for cognitive control to be used in service of goals to regulate emotion. As such, future work could examine the effect of disrupting the ability of participants to use cognitive control on performance on the tasks presented here to further test the cognitive control hypothesis. Nevertheless, a strength of the current thesis is that a number of different memory and attention paradigms were used to investigate whether cognitive control or processing fluency plays a larger role in regulating the processing of emotional information. The use of a number of different tasks to evaluate the cognitive control and processing fluency accounts is a strength of this thesis, and allows for conclusions to be drawn regarding the generalizability of the findings to different types of cognitive tasks.

5.3.1 The Importance of Understanding Aging-Related Positivity Effects

The literature reviewed in this thesis strongly suggests that, despite declines in cognitive and physical functioning, older adults are able to regulate their affective state to maintain high levels of well-being. This finding is echoed in recent statistics from Canadian population surveys which show that Canadians of all ages are satisfied with their lives as a whole, with 92.1% of Canadians reporting that they are satisfied or very satisfied with life (Statistics Canada Canadian Community Health Survey, 2009). Although levels of life satisfaction (the cognitive appraisal of how one's life is going, rather than affective/emotional state) decline slightly with age (perhaps due to the development of aging-related health problems), 88.5% of older adult Canadians still report being satisfied with life (Statistics Canada Canadian Community Health Survey, 2009), and also report the lowest levels of daily stress of any age group (Statistics Canada Canadian Community Health Survey, 2009). Moreover, prevalence of mood disorders, such as depression and bipolar disorder, is lower in adults aged 65 years and older than in adults aged 35-64 (Statistics Canada Canadian Community Health Survey, 2009). Nevertheless, increases in the population of older adults means that in the coming decades there will be greater numbers of older adults who are living with mood disorders, and low levels of well-being brought on by declining health and other factors. That aging-related health problems may be responsible for declines in well-being is consistent with the finding that 51.5% of Canadians who were dissatisfied with life reported that their health was ‘fair’ or ‘poor’ (Statistics Canada Canadian Community Health Survey, 2009). As such, it is important to characterize the normal emotional experience of older adults, which includes the way in which they cognitively process affective information, as a first step in being able to accurately identify pathological mood states in this population, and in the development of strategies to prevent and manage the disruption of the positive well-being of older adults.

5.4 Conclusions

This thesis investigated the contribution of two cognitive mechanisms in the manifestation of aging-related positivity effects in memory and attention: cognitive control and processing fluency. A suite of memory tasks and attention tasks that differed in terms of task demands to employ cognitive control or to rely on processing fluency was used to evaluate the extent to which these two cognitive mechanisms could account for aging-related positivity effects. Results suggest that top-down cognitive control, rather than bottom-up differences in processing fluency, is the mechanism driving this effect. Differences in task demands, and the degree to which they allow top-down or bottom-up processing, can account for inconsistencies within the current literature in the emergence of a positivity effect in older relative to younger adults. The thesis results are consistent with the postulate of SST that older adults’ greater focus on regulating their emotional state is a motivationally driven, effortful process.

Appendix A

Experiment 5a (Dot Probe with Faces) RT Analyses

Raw RTs. Mean RTs to detect the dot when it replaced a face expressing a given emotional valence type (referred to as the "target"), as a function of the valence type of the other face of the pair (referred to as the "context"), were analyzed with a mixed ANOVA. The within-subjects factor was target face Valence for each respective context face valence (angry target with neutral context/angry target with happy context/neutral target with angry context/neutral target with happy context/happy target with neutral context/happy target with angry context), and the between-subjects factor was Age Group (see Table 9).

Table 9 *Experiment 5a, mean RTs to Detect Dot in the Dot Probe Paradigm when Dot Replaces Angry, Neutral, or Happy Target Faces in the Context of Angry, Neutral, and Happy faces, by Age Group. Error Bars Represent Standard Deviations of Respective Means.*

	Age Group			
Target Valence, Context Valence	Younger		Older	
Angry in Neutral	402	(34.88)	564	(76.01)
Angry in Happy	403	(34.89)	566	(76.12)
Neutral in Angry	409	(36.73)	572	(79.14)
Neutral in Happy	408	(39.41)	570	(80.05)
Happy in Angry	410	(36.50)	566	(73.97)
Happy in Neutral	404	(39.81)	566	(75.88)

Greenhouse-Geisser corrected values are reported. There was a significant effect of Age, *F* (1, 58) = 111.86, $p < .0005$, $n_{p2} = 0.66$; younger adults were faster (*M* = 406.82, *SD* = 35.66) to detect the dot than older adults (*M* = 568.27, *SD* = 75.80). There was an effect of Valence, *F* (5, 290) = 2.56, $p < .05$, $n_{p2} = .04$, but no Age x Valence interaction ($p > .1$). To examine the main effect of Valence, paired t-tests were used to compare the different face pair types. To control for multiple (16) comparisons, the Bonferroni correction was applied, but no comparison reached this adjusted criterion for significance ($p < .003$). However, two comparisons were significant with the $p = .05$ criterion: RTs were faster to detect the dot when it replaced an angry target in a neutral context than when the dot replaced a neutral target in a happy context, t (59) = 2.07, $p < .05$, and RTs were faster to detect the dot when it replaced an angry target in a happy context than when it replaced a neutral target in an angry context, t (59) = 2.56, $p < .05$.

When the analysis was repeated, collapsing across context valence for each target valence type (i.e., for angry, neutral, and happy targets), there was a main effect of Face Valence, F (2, 116) = 3.91, $p < .05$, $n_{p2} = 0.63$, but no Age Group x Face Valence interaction ($p > .1$), and a significant effect of Age Group, F (1, 58) = 111.86, $p < .0005$, $n_{p2} = 0.66$. The main effect of target Face Valence indicated that the dot was detected more quickly when it replaced an angry target (M = 483.81, SD = 100.35) than a neutral target (M = 489.50, SD = 102.48) faces, t (59) = 2.93, $p < .01$. There was no significant RT difference between angry and happy targets (M = 486.60, SD = 99.20), $p > .1$, and there was no RT difference between neutral and happy targets ($p > .1$).

Appendix B

Experiment 5b (Dot Probe with Pictures) Participant Picture Ratings Analyses

Participant Ratings of Pictures. Data were missing from 1 older adult participant. To verify whether participant ratings of pictures were concordant with normative ratings used to select pictures for the dot probe task participant ratings of pictures were analyzed. Three mixed ANOVAs were performed, with the between-subjects factor of Age Group, and the within subjects factor of Picture Valence, to analyze the participant ratings of valence, arousal, and personal relevance, respectively.

For picture valence, analyses confirmed that participants rated pictures in accordance with normative ratings (values are reported with the Greenhouse-Geisser correction). There was a main effect of Picture Valence, F (2, 114) = 383.50, $p < .0005$, $n_{p2} = 0.87$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction ($p > .1$). The main effect of valence indicated that participants rated negative pictures as more negative than neutral pictures, t (58) = 18.30, p < .0005, neutral pictures as less positive than positive pictures, t (58) = 15.70, $p < .0005$, and negative pictures as more negative than positive pictures, t (58) = 21.59, $p < .0005$.

For picture arousal, there was a main effect of Picture Valence, F (2, 114) = 6.30, $p < .01$, $n_{p2} = .10$, but no effect of Age Group ($p > .1$), and no Age Group x Picture Valence interaction, ($p > .1$). The main effect of Valence indicated that participants rated positive pictures as more arousing than negative, t (58) = 2.23, $p < .05$, or neutral, t (58) = 4.30, $p < .0005$, pictures but there was no difference in arousal between negative and neutral ($p > .1$) pictures.

For personal relevance, there were main effects of Picture Valence, F (2, 114), $p < .0005$, $n_{p2} = 0.52$, and Age Group, F (1, 57) = 6.55, $p < .05$, $n_{p2} = .10$, but no Age Group x Picture Valence interaction ($p > .1$). The main effect of Picture Valence indicated that negative pictures were rated as less personally relevant than neutral, t (58) = 2.01, $p < .05$, and positive, t (58) = 8.57, $p < .0005$, pictures, and that neutral pictures were rated as less personally relevant than positive pictures, t (58) = 9.72, $p < .0005$. The main effect of Age Group indicated that older adults rated the pictures as more personally relevant than younger adults, t (57) = 2.56, $p < .05$.

Appendix C

Experiment 5b (Dot Probe with Pictures) RT Analyses

Raw RTs. RTs to detect the dot when it replaced a picture of a given valence type (referred to as the "target"), as a function of the valence type of the other picture of the pair (referred to as the "context"), were analyzed with a mixed ANOVA. The within-subjects factor was target picture Valence for each respective context picture valence (negative target with neutral context/negative target with positive context/neutral target with negative context/neutral target with positive context/positive target with neutral context/positive target with negative context), and the between-subjects factor was Age Group (see **Table 10**).

Table 10 *Experiment 5b, Mean RTs to Detect the Dot in the Dot Probe Paradigm when Dot Replaces Negative, Neutral, or Positive Target Pictures in the Context of Negative, Neutral, and Positive Pictures, by Age Group. Error Bars Represent Standard Deviations of Respective Means.*

	Age Group			
Target Valence, Context Valence	Younger		Older	
Negative in Neutral	394	(35.05)	578	(65.53)
Negative in Positive	392	(33.08)	576	(65.34)
Neutral in Negative	395	(35.05)	574	(62.28)
Neutral in Positive	392	(33.68)	575	(59.84)
Positive in Negative	395	(35.83)	572	(64.38)
Positive in Neutral	388	(34.41)	569	(64.54)

Greenhouse-Geisser corrected values are reported. There was a significant effect of Age, F (1, 58) = 201.15, p < .0005, n_{p2} = 0.78; younger adults were faster (M = 392.68, SD = 33.14) to detect the dot than older adults (M = 574.12, SD = 61.74). There was a trend for an effect of Valence, F (5, 290) = 2.02, p = .09, n_{p2} = .03, but no Age x Valence interaction, p = .7.

When the analysis was repeated collapsed across context pair valence types (i.e., for negative, neutral, and positive targets), again there was a trend of an effect of Valence, F (2, 116) = 2.51, p = .09, n_{p2} = 0.41, but no Age x Valence interaction, p = 0.32, and a significant effect of Age, F (1, 58) = 201.15, p < .0005, n_{p2} = 0.78.

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