The source of the positivity bias in older adults' emotional memory

by

Jennifer C. Tomaszczyk

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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.

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Abstract

According to socioemotional selectivity theory (SST), old age is associated with a greater emphasis on self-regulation of emotional states, a focus that fosters a bias in processing positively valenced material in older adults. There is disagreement, however, about whether the "positivity bias" suggested by SST influences performance on memory tasks. Some studies suggest that older adults remember more positive than negative information, or simply less negative information, relative to younger adults, whereas other studies report no such differences. This thesis examined (1) whether variations across studies in encoding instructions or in personal relevance of study materials could account for these inconsistencies, and (2) whether differences in attention at encoding to positive, negative, and neutral stimuli could account for the positivity bias in older adults' later memory for the stimuli. In Experiment 1, younger and older adults were instructed either to passively view positive, negative, and neutral pictures or to actively categorize them by valence. On a subsequent incidental recall test, older adults recalled equal numbers of positive and negative pictures, whereas younger adults recalled negative pictures best. There was no effect of encoding instructions. Crucially, when pictures were grouped into high and low personal relevance according to participants' ratings, a positivity bias emerged only for low relevance pictures. In Experiment 2, attention to pictures at encoding was directly manipulated through use of a divided attention paradigm. Although divided attention lowered recall in both age groups, attention did not interact with age and valence. Taken together, the results suggest that variability in the personal relevance of study pictures may be the factor underlying cross-study differences in whether a positivity bias is observed in older adults' memory.

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Chapter 1
General Introduction

Older adults experience declines in many aspects of health, including decrements in perceptual and cognitive functions. Moreover, old age had traditionally been considered a time of suboptimal emotional functioning (see Carstensen, 1995). The awareness that death is not far off purportedly brought about increased introspection, withdrawal from social activities, and the dampening of emotional experiences (Cumming & Henry, 1961). The view that older adults are less concerned about their emotional experiences compared to younger adults has been vigorously challenged, however, and current research indicates that older adults place *more* emphasis on optimizing emotional functioning than do younger adults! Currently under debate is how this greater focus on emotional functioning affects older adults' cognitive processing. This thesis examines age-related changes in cognitive processing of emotional material, and in particular, how memory for emotional material differs in younger and older adults, to shed light on the contentious issue of whether older adults have better memory for positive information, relative to negative and neutral information.

The introduction will begin with a short discussion of the characteristics of emotions. Next, changes in emotional experiences during aging and the impact of these changes on cognitive functioning will be discussed, followed by a statement of the goals of the thesis.

1.1 Introduction to Emotion

Emotions have been conceptualized in psychology as possessing two separate dimensions: valence and arousal. Valence refers to the pleasantness (positive/negative) of a stimulus or episode, whereas arousal refers to its intensity (high intensity/low intensity) (Barrett & Wager, 2006), also conceptualized as the level of excitement that it generates (calming/exciting) (Lang, Bradley, & Cuthbert, 2001). For example, seeing a picture of a loved one may produce feelings with a positive valence and low arousal, whereas seeing a picture of an execution may produce feelings with a negative valence and high arousal. Neutral stimuli have been conceptualized as the absence of valence, or a valence in between positive and negative (LaBar & Cabeza, 2006).

Recent explanations suggest that emotions arise from subjective cognitive appraisals of the valence and arousal of events (Scherer, Dan, & Flykt, 2006), speaking to the fundamental link between emotions and cognitive processes (Lazarus, 1991). In the human brain, structures such as the anterior cingulate cortex, insula, hippocampus, and amygdala are known to play a role in the processing of emotional information (Davidson, Fox, & Kalin, 2007).

1.2 Emotion and Aging

Despite declines in many aspects of health and of perceptual and cognitive functions, there is increasing evidence that older adults are happier than younger adults. For instance, cross-sectional studies have shown that older adults experience fewer negative feelings and emotions (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Gross et al., 1997; Mroczek & Kolarz, 1998), and longitudinal studies have shown that negative affect generally decreases with increasing age (Charles, Reynolds, & Gatz, 2001). Older adults dissipate negative affect, and maintain positive affect, better than younger adults (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000), and also report greater control of their emotions (Gross et al., 1997;

Lawton, Kleban, Rajagopal, & Dean, 1992).

This pattern fits well with an influential recent theory - socioemotional selectivity theory (SST; Carstensen, 1995). Carstensen postulates that as people age and perceive their remaining life to be more limited, their goals shift from seeking new information, to ensuring emotion regulation. Emotion regulation, as defined by Carstensen, is the maintenance of a positive affective state, and engaging in emotionally meaningful activities and relationships (Carstensen, 1995). Carstensen implies that this is an active process such that older adults and people who view their time left in life as limited will actively seek out emotionally fulfilling, positive, experiences (e.g., interacting with emotionally close over novel partners). Consistent with this, recent research indicates that older adults engage in cognitive control to prevent negative information from impacting their cognition (e.g., Mather & Knight, 2005). This definition of emotion regulation differs from Gross' classic conceptualization of emotion regulation (see Gross & Thompson, 2007), which can result from processes that are "automatic or controlled, conscious or unconscious" (Gross & Thompson, 2007, p. 8). Also, Carstensen's conceptualization of emotion regulation centres on increasing positive affect or decreasing negative affect, whereas emotion regulation as defined by Gross does not serve such a specific purpose. For instance, according to Gross' definition an individual may engage in emotion regulation to increase negative affect by choosing to listen to sad songs when in a sad mood.

It is also important to keep in mind that both emotion regulation and information seeking are purported to be present throughout the lifespan. Rather, it is the salience of each of the goals that changes throughout life. In young adults the information seeking goal is said to be most salient, and emotion regulation goals would be less salient. For older adults, on the other hand, emotion regulation goals are more salient than information seeking goals. SST posits that perception of time is the primary factor that motivates people to switch from the goal of novel information seeking to the goal of emotion regulation. People who imagine their time left in life to be expansive, such as younger adults, will preferentially focus on acquiring new information and having novel experiences; people who view their time as being limited, such as older adults (and also younger adults with a terminal disease), prefer to maximize the maintenance of positive emotions and to engage in emotionally meaningful experiences. This focus on emotion regulation has been demonstrated in older adults' preference for interacting with emotionally close over novel partners (Fredrickson & Carstensen, 1990; Fung, Carstensen, & Lutz, 1999).

Thus, according to SST, it is the perception of limited time that is associated with aging, rather than the aging process *per se,* which accounts for the shift toward an emphasis on maintaining positive emotions. For example, when forced to choose between advertisements which emphasize either emotionally meaningful or knowledge-seeking goals, older adults prefer those that are emotionally meaningful, in contrast to younger adults who prefer advertisements that emphasize knowledge-seeking goals (Fung & Carstensen, 2003). In support of this account, when older adults make this choice after imagining a scenario in which their lives would be appreciably extended, they demonstrate a preference for the advertisements that emphasize knowledge-seeking to the same extent as do younger adults.

This focus on emotion regulation can also be experimentally induced by asking participants to focus on their current emotional state. For instance, Kennedy, Mather, and

Carstensen (2004) asked both older and middle-aged nuns to recall information about their level of well-being from the previous 14 years, while focusing on (a) their current emotional state, (b) the accuracy of their memories, or (c) without being given any instructions (control). Older control participants and participants that focused on current emotional state recalled their past as being more positive than they had reported 14 years before, whereas younger controls and older participants who focused on memory accuracy, recalled their past as being more negative than previously reported. Thus, the study also demonstrates how a focus on current emotional state can affect the characteristics of autobiographical memories. The idea that a focus on emotion regulation can affect cognitive processing has been explored more fully in a number of other studies.

1.3 Emotion, Aging, and Cognition

Recent work has sought to determine whether this shift in goal from information seeking to emotion regulation influences age-related changes in cognitive processing. Because older adults are purported to be more focused on emotion regulation (the maintenance of positive affect), it is hypothesized that, relative to younger adults, they also cognitively process positive stimuli to a greater extent than negative stimuli (see Mather & Carstensen, 2005). This phenomenon has been referred to as a “positivity bias” in older adults (or those nearing the end of life). It is important to note that the positivity bias can also be characterized as a decrease in cognitive processing for negative stimuli relative to younger adults, as at least one study has demonstrated this pattern of results (Charles et al., 2003, Experiment 2). This distinction highlights the importance of including a reasonable baseline (i.e. neutral stimuli) against which to measure changes. It is also important to note that the positivity bias is typically conceptualized as a within-groups difference, such that the pattern of the effect of valence is different in each age group. For instance, it could be shown that older adults have a better memory for positive items relative to negative items, whereas younger adults have equal memory for both positive and negative items. Or, it could be shown that older adults have equal memory for positive and negative items, whereas younger adults have a better memory for negative items. In the latter case, it can be said that younger adults display a negativity bias in memory, whereas older adults do not display a negativity bias.

To this end, a number of studies have examined the extent to which older adults' attention is directed to positive relative to negative or neutral stimuli. It has been demonstrated that older adults avoid negative information and prefer to focus their attention on positive stimuli. For example, in a dot-probe paradigm, older and younger participants were shown pairs of faces, one with a positive or negative facial expression and the other with a neutral expression (Mather & Carstensen, 2003). When the face pair disappeared, a dot was shown in the location of one of the faces. Participants were instructed to indicate the location of the dot. Older adults were slower to respond when the dot appeared in the location of the negative face, and faster when it appeared in the location of a positive face, relative to when the dot appeared in the location of a neutral face. Younger adults did not show a response speed bias for either emotional face. Another study used eye tracking to monitor the gaze patterns of older and younger adults while they viewed pairs of faces, one of which was neutral and the other of which expressed one of several negative emotions, or happiness (Issacowitz, Wadlinger, Goren, & Wilson, 2006). Older adults' gaze patterns were directed toward happy faces and away from (negative) angry faces, whereas younger adults' gaze patterns were directed toward (negative) fear faces. In another eye tracking study, participants viewed pairs of pictures, one of which was neutral and the other of which was either negative or positive (Rösler et al., 2005). Although there were no age differences in attention to positive pictures, compared to older adults, younger adults spent more time looking at the negative image of the pair.

In addition to these studies, others in the area of decision-making have shown that, relative to younger adults, older adults spend more time examining the positive options of an item, and less time examining negative options of the item (Mather, Knight, McCaffrey, 2005). Functional magnetic resonance imaging provides evidence of a neural basis for these age differences in processing of emotional material. For example, although both younger and older adults show greater activation in regions associated with emotional processing, such as the amygdala, in response to viewing emotional relative to neutral pictures, older adults show relatively more brain activity in response to positive than to negative pictures (Mather et al., 2004). These studies suggest that emotional content influences cognitive functioning, particularly in older adults.

Whereas studies of attention have supported the possibility of a positivity bias in older adults, evidence for a bias in memory for positive information is more variable and appears to depend on the type of memory test and the nature of the stimuli used. Aging is a variable certainly known to influence memory, and generally memory decreases with advancing age (see Nilsson, 2003, for a review). Interestingly, emotion can change the pattern of memory deficits in older adults. Studies have shown that emotion (both positive and negative) can "boost" memorability of items in younger (Cahill & McGaugh, 1995) and older (Denburg, Buchanan, Tranel, & Adolphs, 2003) adults. For example, in a study by Charles, Mather, and Carstensen (2003, Experiment 1) older and younger adults were shown positive, negative, and neutral images. On a later memory recall test, older adults recalled a greater number of positive compared to negative and neutral images, whereas younger adults showed better memory for both positive and negative relative to neutral images. Thus relative to younger adults, who show a similar emotionality boost in memory for both positive and negative stimuli, older adults displayed the boost more for positive stimuli.

Similar findings have been documented on tests of working memory for images (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005), and memory for choices (Mather & Johnson, 2000). In studies of autobiographical memory, older adults typically show a positivity bias (e.g., Field, 1981; Kennedy et al., 2004; Levine & Bluck, 1997). Particularly telling is a study in which participants recalled positive, negative, and neutral autobiographical memories and then rated each memory on a number of characteristics (Comblain, D'Argembeau, & Van der Linden, 2005). Interestingly, older adults rated their negative memories as eliciting more positive emotion compared to younger adults, suggesting that older adults re-evaluate their negative memories to highlight any positive aspects.

Other work, however, fails to show such a positivity bias in memory in older adults. Studies of episodic memory for words have not supported a positivity bias in older relative to younger adults. In studies in which participants were given incidental (Leigland, Schulz, & Janowsky, 2004) or intentional (Grühn, Smith, & Baltes, 2005) memory tests for positive, negative, and neutral words, both older and younger adults recalled a greater proportion of positive relative to negative and neutral words, and displayed a bias in recognition for both types of emotional words relative to neutral words (Leigland et al., 2004). No age group X valence interaction emerged to indicate a positivity bias in older adults. To account for these results, it has been suggested that "age differences in the positive-negative disparity of emotional memory are more likely [to be observed] under conditions in which the to-be-remembered material elicits strong emotional reactions. In such conditions, age differences in emotional reactivity and in the ability to self-regulate emotion could play important roles" (Grühn et al., 2005, p. 586). In essence, Grühn et al. (2005) suggest that words may not evoke emotional reactions that are strong enough to activate older adults' emotion regulation goals, whereas stimuli such as photographs of emotional scenes do evoke emotional reactions strong enough to motivate older adults to engage in emotion regulation.

Memory for emotional faces has also yielded mixed results. In one study, older adults recognized a smaller proportion of negative faces than did younger adults (Leigland et al., 2004). Another study found no age differences in recognition memory for emotional faces: Both younger and older adults recognized more neutral faces that had previously been presented as happy (positive) than neutral faces that had been presented as angry (negative) (D'Argembeau & Van der Linden, 2004).

Memory for emotional pictures (scenes) has also been mixed, with some studies showing the effect and others not. Support for a positivity bias in recall of emotional pictures for older adults was found by Charles et al. (2003, Experiment 1). Here, participants passively viewed positive, negative, and neutral pictures and then were given an incidental recall test for the pictures after a 15 min delay. Whereas younger adults recalled equal numbers of positive and negative pictures, older adults recalled positive pictures best. Both age groups recalled greater numbers of both positive and negative pictures than neutral pictures. Evidence for a positivity bias in older adults' recall was also found in a study by Mather and Knight (2005), in which participants also passively viewed study pictures. However, a number of studies have failed to find a positivity bias in older adults' recall for emotional pictures. In one study, older and younger adults were shown positive, negative, and neutral pictures and were asked to rate them during encoding according to emotional characteristics. In an incidental recognition test for the pictures two weeks later, the authors failed to find a positivity bias for older adult participants (Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004). Similarly, in another study that assessed memory for positive, negative, and neutral pictures in an incidental recall test 24 hrs after a study period in which participants closely attend to the emotion portrayed in each picture, both older and younger adults recalled a greater number of negative pictures, fewer positive pictures, and the fewest number of neutral pictures (Denburg et al., 2003). It is possible that the long delays between study and test may have affected the pattern of results of the studies above, however studies that used short delay periods have also failed to find evidence of a positivity bias in recall of emotional pictures for older adults (Kensinger, Brierly, Medford, Growdon, & Corkin, 2002; Charles et al., 2003, Experiment 2). This conflicting evidence regarding the existence of a positivity bias in older adults' memory will be the focus of this thesis.

1.4 Goals of the Current Thesis

The goal of this thesis is to identify factors that influence older adults' memory for emotional stimuli. More specifically, this thesis seeks to examine factors that determine whether older adults display a positivity bias in memory for realistic pictorial stimuli. In the first experiment, the influence of encoding instructions and personal relevance of study pictures on memory for positive, negative, and neutral pictures was examined. Because studies that instructed participants to simply view study pictures (a ‘passive’ encoding strategy) found a positivity bias in older adults’ memory (e.g., Charles et al. 2003), whereas studies that required participants to categorize or otherwise attend to the valence of study pictures (an ‘active’ encoding strategy) did not (e.g., Kensinger et al., 2002) the first experiment directly compared the two types of encoding instructions to determine whether this factor influences the positivity bias. Personal relevance of study pictures was also hypothesized to influence whether older adults display a positivity bias in memory, based on recent studies of memories high in self-relevance. The second experiment examined the effect of attention to pictures at study on later memory for the pictures, to determine whether a positivity bias in older adults’ memory may be due to greater attention paid to positive pictures at study. The motivations for examining each of the aforementioned factors in relation to a positivity bias in older adults’ memory will be fully explained in the introduction to each experiment.

Chapter 2
Experiment 1: Personal Relevance Modulates the Positivity Bias in Recall of Emotional Pictures in Older Adults (Tomaszczyk, Fernandes, & MacLeod, submitted)

2.1 Introduction

This experiment addresses possible reasons for the varying results of the effect of emotional valence on memory for pictures in older and younger adults. In Charles et al. (2003, Experiment 1), emotionality of pictures boosted later memory performance regardless of valence in young adults whereas the boost was restricted to positive stimuli in older adults (see also Mather & Knight, 2005). However, in other studies in which older and younger adults actively rated positive, negative, and neutral pictures on emotional characteristics during encoding (Denburg et al., 2003; Kensinger et al., 2002), no positivity bias was found.

The goal of Experiment 1 was to determine what could explain the discrepancy across studies in whether a positivity bias was observed in older adults. The first objective was to determine whether instructions during encoding influenced memory for positive, negative, and neutral pictures in younger and older adults. Studies that did find a positivity bias for older adults instructed participants to passively view pictures, whereas studies that failed to find a positivity bias instructed participants to actively rate pictures according to emotional characteristics. Consequently, instructions were manipulated between subjects by asking participants either (a) to passively view a series of pictures, or (b) to actively rate a series of pictures during encoding, prior to an incidental recall test for the pictures. If instructional differences are crucial, a positivity bias should emerge for older adults in the passive condition, as in the Charles et al. (2003) study, but there should be no positivity bias in older adults in an active condition, as in the Kensinger et al. (2003) study. Participants also completed a recognition test for the study pictures. A positivity bias was not expected to emerge in recognition performance, as previous work (e.g. Charles et al., 2003) has found evidence of a positivity bias only in older adults' recall, but not in their recognition.

It is also possible that the order in which pictures of different valences are recalled contributes to a positivity bias in older adults' recall. If older adults output positive pictures before negative and neutral pictures, whereas younger adults output negative pictures before positive and neutral pictures, there could be a differential output interference effect (e.g., Smith, D'Agostino, & Reid, 1970) in younger compared to older adults. That is, the rate and number of pictures recalled of a given emotionality may decrease with later output in both age groups. If older adults output positive valence items first, but younger adults do not, then younger adults will appear to have less of a positivity bias in recall. To examine this possibility, the order in which positive, negative, and neutral pictures were recalled was analyzed. This was the first time that such an analysis had been undertaken.

The second objective was to determine whether personal relevance of to-be-remembered emotional stimuli influences memory. For this reason, a scale was constructed to measure personal relevance, based on the Self-Assessment Manikin (SAM) form from the International Affective Picture System (IAPS, Lang et al., 2001). Analyses were then conducted to test the possibility that the emergence of a positivity bias for older adults depends upon whether study pictures are high or low in personal relevance. Other work suggests that age differences in memory for highly personally relevant emotional information are not always found. For example, flashbulb memories for the September 11th attack on their home country were preserved in both older and younger United States citizens (Davidson, Cook, & Glisky, 2006). Thus, memory for highly negative emotional information that is personally relevant may be preserved in older adults.

At least one study has failed to find differences in the emotional characteristics of older and younger adults' (personal) autobiographical memories (Alea, Bluck, & Semegon, 2004), suggesting that when material is highly relevant, older adults do not attend to positive information only. Anecdotally, older adults do not seem to have difficulty recalling significant personal negative events, such as the death of a close friend, or a car accident involving family members, which suggests that they can commit highly personally relevant information to memory, even when that information is negative. If this is correct, then recall of pictures that are relatively high in personal relevance should not differ across positive and negative valence conditions, and there is no reason to expect that age would interact with emotional valence. Recall of pictures that are low in personal relevance, however, should differ across both valence and age groups, and differences in motivation suggested by SST should then result in a positivity bias in older adults. That is, when pictures are lower in personal relevance, older adults may be motivated more than younger adults to encode and maintain the positive rather than negative pictures in memory, in an effort to maintain a more positive affect, as suggested by SST.

2.2 Method and Results

2.2.1 Method

Participants. One-hundred and twelve people took part in the study: Fifty-six healthy community-dwelling older adults (61-84 years of age; 35 female) were recruited through the University of Waterloo's Research in Aging Participant pool, and 56 younger adults (18-23 years of age; 38 female) were recruited from undergraduate psychology classes (see Table 1 for participant characteristics). For participating, older adults received $10 remuneration; younger adults received course credit. For both age groups, inclusion criteria were: fluency in English, normal or corrected-to-normal vision and hearing, no current or history of neuropsychological impairment, and no head injury resulting in unconsciousness for more than 1 minute. For older adults, an additional exclusion criterion was a score of less than 26 on the Mini-Mental State Exam (MMSE, Folstein, Folstein, & McHugh, 1975). The MMSE is a neuropsychological test that measures several aspects of cognition and provides an overall score of cognitive functioning. The MMSE is widely used to screen for preclinical dementia or cognitive impairment. The exclusion criterion based on MMSE score necessitated replacement of 2 older adults. The National Adult Reading Test – Revised (NART-R, Nelson, 1992) was used to compare the two age groups on level of intelligence. The NART-R provides a measure of full-scale IQ based upon the number of errors in pronunciation of low frequency English words. Older adults had a higher full scale IQ (FSIQ), $F(1, 110) = 64.22$, $p < .001$, as estimated by the NART - R, but did not differ from young with respect to years of education ($p > .05$).

Table 1

Participant characteristics in Experiment 1. Mean values with standard deviation in parentheses.

	Age Group			
Characteristic	Younger		Older	
Age in years	19.70	(1.51)	73.04	(6.02)
MMSE score	-	-	28.80	(1.26)
Education (years)	13.86	(1.66)	14.73	(3.01)
FSIQ	104.89	(7.10)	115.33	(6.69)
PANAS-X (percent positive)	55.29	(15.54)	62.50	(15.93)
PANAS-X (percent negative)	38.42	(14.59)	29.10	(9.49)

Apparatus. Visual stimuli were presented on a Viewsonic VE710b LCD monitor (screen resolution set at 1280 x 1024 pixels), with E-prime software (Version 1.1; Psychology Software Tools, Inc., Pittsburgh, USA), on a PC running Windows XP (Intel Pentium 4 CPU; 3GHz).

Stimuli. Ninety-six digitized pictures were selected from the International Affective Picture System (IAPS, Lang et al., 2001), a collection of 800 pictures with normative ratings of valence and arousal based on a sample of young adults enrolled in an introductory psychology course. Normative ratings of IAPS pictures used a scale from 1 (most negative or least arousing) to 9 (most positive or most arousing). Of the 96 pictures selected, 32 were positive, 32 negative, and 32 neutral. Figure 1 shows a sample of each type of picture. Within each valence category, half of the pictures were of medium-low arousal and half were of medium-high arousal, and half in each valence and arousal combination contained people with the other half containing animals, nature scenes, or inanimate objects (see Appendix for picture list characteristics).

Figure 1. Samples of (a) positive, (b) negative, and (c) neutral IAPS pictures used in the study.

(a)  (b)  (c) 

Across valence categories, average normative valence ratings differed (positive M = 7.22, SD = 0.47; negative M = 2.87, SD = 0.41; neutral M = 5.24, SD = 0.53), using Tukey's HSD (all ps < .001), and average normative arousal ratings did not differ (positive M = 4.90, SD = 0.86; negative M = 5.12, SD = 0.81; neutral M = 4.73, SD = 0.95; all ps > .10), all ps > .17. Medium-low (M = 4.12, SD = 0.33) and medium-high (M = 5.71, SD = 0.42) arousal pictures differed from each other with respect to average normative arousal rating, across valence categories (all ps < .001).

The 96 pictures were divided into two lists of 48 pictures each, both preserving the characteristics of the original list. Pictures were matched for content between the lists (e.g., both lists contained pictures of dogs) as much as possible. Average normative valence ratings were matched between lists for positive pictures (list 1: M = 7.14, SD = 0.43, list 2: M = 7.21, SD = 0.45), negative pictures (list 1: M = 2.90, SD = 0.38, list 2: M = 2.80, SD = 0.44), and neutral pictures (list 1: M = 5.20, SD = 0.50, list 2: M = 5.25, SD = 0.60). A two-way Analysis of Variance (ANOVA) with list number and valence type as factors and normative valence ratings as the dependent variable revealed no main effect of list number (p = .93), and no interaction between list number and valence type (p = .76). Average normative arousal ratings were also matched between lists for positive pictures (list 1: M = 4.90, SD = 0.90, list 2: M = 4.94, SD = 0.86), negative pictures (list 1: M = 5.00, SD = 0.86, list 2: M = 5.17, SD = 0.81), and neutral pictures (list 1: M = 4.71, SD = 0.95, list 2: M = 4.84, SD = 1.00). A two-way ANOVA with list number and valence type as factors and normative arousal ratings as the dependent variable revealed no main effect of list number (p = .54) and no interaction between list number and valence type (p = .96).

A list of six IAPS pictures was created for the practice phase, with two of medium arousal (one with and one without people) from each valence category. All pictures were 1010 x 752 pixels and covered almost the whole computer monitor; a black border filled the remainder.

Procedure. There were two between subjects factors, age (younger, older) and instruction (passive, active), and one within-subject factor, valence (positive, negative, neutral). Participants were randomly assigned to conditions and were tested individually. To assess affect/mood at time of test, participants completed the Positive and Negative Affective Schedule – Expanded Form (PANAS-X, Watson & Clark, 1994) either before or after completing the experimental tasks (counterbalanced across participants). The PANAS-X is a 60-item scale that assesses specific affect types, including negative and positive affect. Participants are instructed to rate the extent to which they felt each item during a specified time period on a Likert-type scale from 1 (very slightly or not at all) to 5 (extremely). For this study, participants were asked to rate the extent to which they felt each item "during the past few days, including today." Scores on the Basic Negative and Basic Positive subscales were examined to assess participants' positive and negative affect. There are 23 items that assess Basic Negative affect (e.g., afraid, angry, sad) and 18 items that assess Basic Positive affect (e.g., happy, proud, attentive). Therefore, the maximum possible scores for Basic Negative and Basic Positive affect are (23 items x 5 maximum score per item) 115 and (18 x 5) 90, respectively. A full consideration of age differences in PANAS-X scores and its relation to recall of pictures is presented in the Results section.

Picture viewing phase.

Participants were seated 65-78 cm from the computer screen. In the ‘passive’ instruction condition, they were told to view pictures as they would a television screen, as in Charles et al. (2003). In the ‘active’ instruction condition, they were told to categorize each picture as positive, negative, or neutral (as in Kensinger et al., 2003) using their dominant hand to press keys 1, 2, or 3 (labeled as P, N, U) on the numeric keypad on the keyboard.

Participants first viewed the series of practice pictures presented one at a time in random order at a rate of 4 s per picture. Each picture presentation began with a black fixation cross on a white background in the center of the screen for 500 ms, immediately followed by the picture. Participants then completed the study phase under the same instructions and presentation duration as in practice, and viewed pictures from either list 1 or list 2 (counterbalanced). Afterward, participants completed the NART-R, which took approximately 5 minutes; this introduced a delay between study and test.

Memory phase.

A surprise recall test followed in which participants were asked to write down descriptions of as many of the pictures as they could remember from the previously presented list, taking as much time as they wished. This was followed by a surprise recognition test for the study phase pictures, in which they saw all 48 study phase pictures and the 48 pictures from the other picture list which they had not seen before. Lists used for the study phase and recognition test were counterbalanced across experimental conditions for each age group.

For the recognition test, participants were told that they would be viewing a series of pictures, some of which they had seen in the study phase (Old pictures), and some of which they had not seen in the study phase (New pictures). To indicate that a picture was Old, participants used their dominant hand to press the ‘n’ key on the keyboard (labeled ‘O’ for Old), and pressed the ‘m’ key (labeled ‘N’ for New) to indicate that a picture was New. Picture presentation specifications for the recognition test were identical to those in the study phase, except that picture offset was determined by the participant, or after 30s.

Picture rating.

Following the memory tests, participants rated each picture using a modified SAM form in a paper-and-pencil booklet, on three different scales ranging from 0-8. They rated (1) level of pleasantness (valence), (2) arousal, and (3) the added dimension of personal relevance (ranging from completely personally irrelevant to very personally relevant) that they felt while viewing each picture. Data from participants’ SAM ratings were used to ascertain that participants’ ratings of study pictures were congruent with the normative valence and arousal ratings of Lang et al. (2001), and to determine whether any age differences in picture ratings existed. Participants first practiced using the rating scales by rating pictures from the practice phase. Picture presentation specifications were identical to those in the study phase. Pictures remained on the screen until the 3 ratings were complete, or for 15 s. Finally, older adult participants completed the MMSE.

2.2.2 Results

Memory for pictures

Recall. Two coders independently matched recall responses (written descriptions of each picture recalled) to the IAPS pictures from study, and agreed on 96% of picture descriptions. Discrepancies in coding were resolved by discussion, and consensus agreement. Only one picture description from a younger adult’s recall and six picture descriptions from older adults' recall could not be coded and so were excluded from the recall totals. Mean number of pictures recalled, shown in Table 2, was analyzed in a repeated-measures ANOVA with valence (positive, negative, and neutral) as the within-subject factor and age (younger, older) and instruction (passive, active) as the between subjects factors.

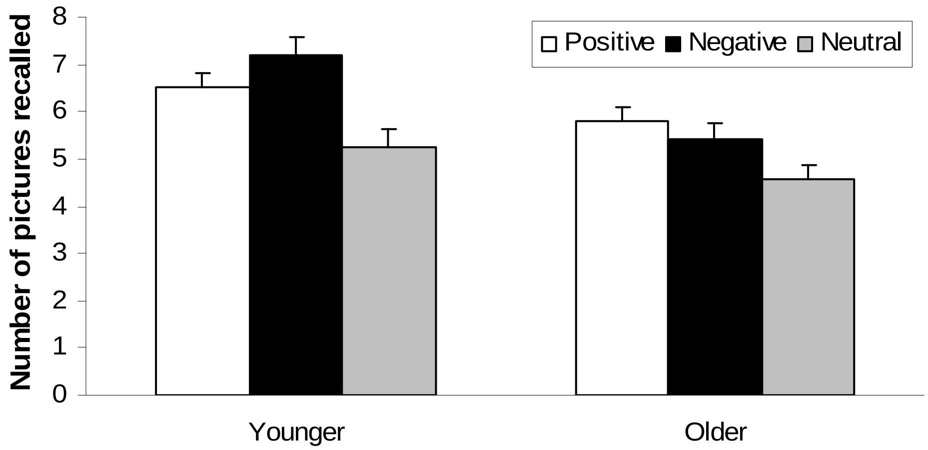
Table 2

Mean number of pictures recalled for each age group as a function of valence type and instruction condition in Experiment 1. Standard deviations are in parentheses.

	Age group and Valence type					
	Younger adults			Older adults		
Instruction Condition	Positive	Negative	Neutral	Positive	Negative	Neutral
Passive	5.93 (2.07)	6.96 (2.22)	4.78 (2.50)	5.89 (2.20)	5.50 (2.38)	4.25 (1.88)
Active	7.07 (2.39)	7.46 (2.89)	5.75 (2.74)	5.71 (2.45)	5.36 (2.82)	4.93 (2.48)

There was a main effect of age, $\underline{F}(1, 108) = 7.68$, $\underline{p} < .01$, $\eta^2 = .066$, with younger adults recalling more pictures than older adults. There was also a main effect of valence, $\underline{F}(2, 216) = 22.94$, $\underline{p} < .001$, $\eta^2 = .18$, with better recall of both negative and positive, relative to neutral, pictures. Most importantly, there was a significant valence X age interaction, $\underline{F}(2, 216) = 3.99$, $\underline{p} = .02$, $\eta^2 = .036$. As shown in Figure 2, younger adults recalled more negative than both positive ($\underline{t}(55) = 2.35$, $\underline{p} < .05$) and neutral ($\underline{t}(55) = 7.27$, $\underline{p} < .001$) pictures, and more positive than neutral pictures ($\underline{t}(55) = 3.85$, $\underline{p} < .001$). In contrast, older adults recalled equal numbers of negative and positive pictures ($\underline{t}(55) = 1.22$, $\underline{p} = .23$), and fewer neutral, compared to both positive ($\underline{t}(55) = 3.60$, $\underline{p} < .001$) and negative ($\underline{t}(55) = 2.35$, $\underline{p} < .05$) pictures. There was no main effect of instruction ($\underline{p} = .20$), and no other interaction reached significance (all $\underline{p}$s > .30).

Figure 2. Mean number of pictures (maximum of 16) of each valence type recalled as a function of age group in Experiment 1. Error bars are standard errors of their respective means.



Recognition. Accuracy of recognition performance was computed as false alarm rate subtracted from hit rate, for pictures of each valence type. Because there was no main effect of instructions (p = .83), and because instructions only interacted with age group (F(1, 108) = 4.40, p = .38) but did not affect the age x valence interaction (p = .49), results collapsed across instruction conditions are reported below. See Table 3 for means.

Other than the main effect of valence, F(2, 220) = 12.90, p < .0005, no other main effects or interactions reached significance (all ps > 0.20). Simple contrasts indicated that recognition accuracy was highest for positive (M = 0.84, SD = 0.15) and neutral (M = 0.86, SD = 0.16) pictures, which did not differ from each other, F(1, 110) = 1.19, p = .28. Recognition accuracy was lower for negative (M = 0.80, SD = 0.14) pictures than for both positive (F(1, 110) = 12.71, p = .001) and neutral (F(1, 110) = 24.87, p < .0005) pictures. There was no main effect of age (p = .22), and no age x valence interaction (p = .67).

Table 3

Mean recognition accuracy for each age group as a function of valence type in Experiment 1. Standard deviations are in parentheses.

Age Group and Valence type					
Younger adults			Older adults		
Positive	Negative	Neutral	Positive	Negative	Neutral
0.86 (0.15)	0.82 (0.16)	0.87 (0.19)	0.83 (0.14)	0.78 (0.10)	0.85 (0.12)

Recall output order. To determine mean output order for pictures of each valence type and for each age group, output percentiles were calculated for each participant. Output percentiles are “a measure of the… position of a recalled [picture] during output” (Bjork & Whitten, 1974, p. 176) relative to the last item recalled. As in Bjork and Whitten (1974), output percentiles were calculated as follows: “if a subject recalled a total of N [pictures] from a list, the ith [picture] recalled was assigned a percentile score of (i / N) X 100. For example, the first of 10 [pictures] recalled was given a score of 10%, and the eighth of 12 words recalled was given a score of 67%” (p. 177). Thus, lower output percentiles indicate pictures output earlier in recall, and higher output percentiles indicate pictures output later in recall (closer to the last item). Output percentiles were analyzed with a repeated measures ANOVA, with valence as the within subjects factor and age group as the between subjects factor. See Table 4 for means.

Table 4

Mean output percentiles for each age group as a function of valence type in Experiment 1. Standard deviations are in parentheses.

Age group and Valence type					
Younger			Older		
Positive	Negative	Neutral	Positive	Negative	Neutral
52.47 (10.95)	53.98 (10.24)	58.77 (11.75)	56.39 (12.48)	56.79 (17.51)	59.24 (14.65)

There was a main effect of valence, F(2, 214) = 3.03, $p = .05$. Positive pictures (M = 54.41, SD = 11.84) were output earlier than neutral pictures (M = 59.00, SD = 13.21) F (1, 107) = 6.13, $p = .015$, but output order of negative pictures (M = 55.37, SD = 14.32) did not differ from that of neutral pictures ($p = .078$), and output order of positive pictures did not differ from that of negative pictures ($p = .63$). There was also a main effect of age, $F(1, 107) = 4.76$, $p = .031$, with older adults recalling study pictures later (M = 57.48, SD = 10.98) than younger adults (M = 55.08, SD = 14.88). However, this may be artifactual due to older adults recalling fewer pictures compared to younger adults, which results in larger output percentiles for older adults. Thus, it is unclear whether true age differences emerged for output order of recalled pictures. Crucially, the age x valence interaction was not significant ($p = .67$). Clearly, output order differences do not underlie age differences in recall of emotional pictures.

Affect measure. Because the numbers of items contained in the Basic Negative and Positive affect subscales of the PANAS-X are different, raw PANAS-X scores for these subscales were converted to percents of the maximum possible score for each subscale to directly compare levels of positive and negative affect for each participant. Considered separately, each age group reported greater positive ($M_{Younger}$ = 55.29, $SD_{Younger}$ = 15.54; M_{Older} = 62.50, SD_{Older} = 15.93) than negative ($M_{Younger}$ = 38.42, $SD_{Younger}$ = 14.59; M_{Older} = 29.10, SD_{Older} = 9.49) affect, $t_{Younger}(55) = 5.14$, $p < .001$; $t_{Older}(55) = 11.93$, $p < .001$. However, comparing age groups, older adults reported greater positive affect, $F(1, 110) = 5.88$, $p < .05$ and less negative affect, $F(1, 110) = 16.05$, $p < .001$ than younger adults. Linear regression analyses found no relation between negative or positive affect and recall of pictures of any valence (all ps > .10). Further analyses verified that a number of other factors did not influence the pattern of results. Specifically, FSIQ was not related to recall for any valence, and there was no effect of order of PANAS-X administration, or of picture list (1 or 2), on recall (all ps > .05). Participants recalled more medium-high (M = 9.13, SD = 3.54), than medium-low (M = 8.28, SD = 3.33), arousal pictures, $F(1, 110) = 9.54$, $p < .01$. Arousal and age did not interact. There was no effect of gender on recall for any valence ($p = .58$), or on affect scores (ps > .39). However, there was an interaction between gender and valence, $F(2, 220) = 5.65$, $p = .004$: Women recalled a greater number of positive picture (M = 6.52, SD = 2.28) than men (M = 5.46, SD = 2.25).

Participant ratings of pictures

Valence. There was a main effect of valence, $F(2, 220) = 579.14$, $p < .001$. Consistent with the normative valence ratings (Lang et al., 2001), simple contrasts indicated that positive pictures were given higher valence ratings (M = 5.89, SD = 1.20) than neutral pictures (M = 3.48, SD = .73), $F(1, 110) = 398.26$, $p < .001$ and negative pictures (M = 1.30, SD = .90), $F(1, 110) = 693.43$, $p <.001$, and negative pictures were given lower ratings than neutral pictures $F(1, 110) = 492.37$, $p < .001$. Importantly, there was no interaction between age group and valence type ($p = .54$), and no main effect of age group ($p = .88$).

Arousal. For participant ratings of arousal, there was a main effect of valence type, $F(2, 220) = 14.32$, $p < .0005$. Consistent with the normative ratings, simple contrasts indicated that positive (M = 4.05, SD = 1.34) and negative (M = 4.12, SD = 1.47) pictures were not rated as significantly different in arousal, $F(1, 110) = .092$, $p = .76$. Inconsistent with the normative ratings, both negative ($F(1, 110) = 30.54$, $p < .001$) and positive (F(1,

110) = 28.90, $p < .001$) pictures were rated as more arousing than neutral ($M = 3.44$, $SD = .97$) pictures. There was no interaction between age group and valence type ($p = .49$), and no main effect of age group ($p = .056$).

Personal relevance. Mean rated personal relevance of pictures was analyzed with a repeated-measures ANOVA, with valence (positive, negative, and neutral) and memory status (recalled, not recalled) as a within–subject, and age (younger, older) as a between subjects manipulation. There was a main effect of valence, $F(2, 216) = 85.44$, $p < .001$, with positive pictures ($M = 4.08$, $SD = .39$) rated as more personally relevant than both negative ($M = 2.95$, $SD = .29$; $F(1, 108) = 65.42$, $p < .001$) and neutral ($M = 2.44$, $SD = .23$; $F(1, 108) = 183.72$, $p < .001$) pictures, and negative rated as more personally relevant than neutral pictures, $F(1, 108) = 17.23$, $p < .001$. There was no main effect of recall status on personal relevance ratings, and no other main effects or interactions were significant (all $ps > .08$).

Personal relevance: High/low split

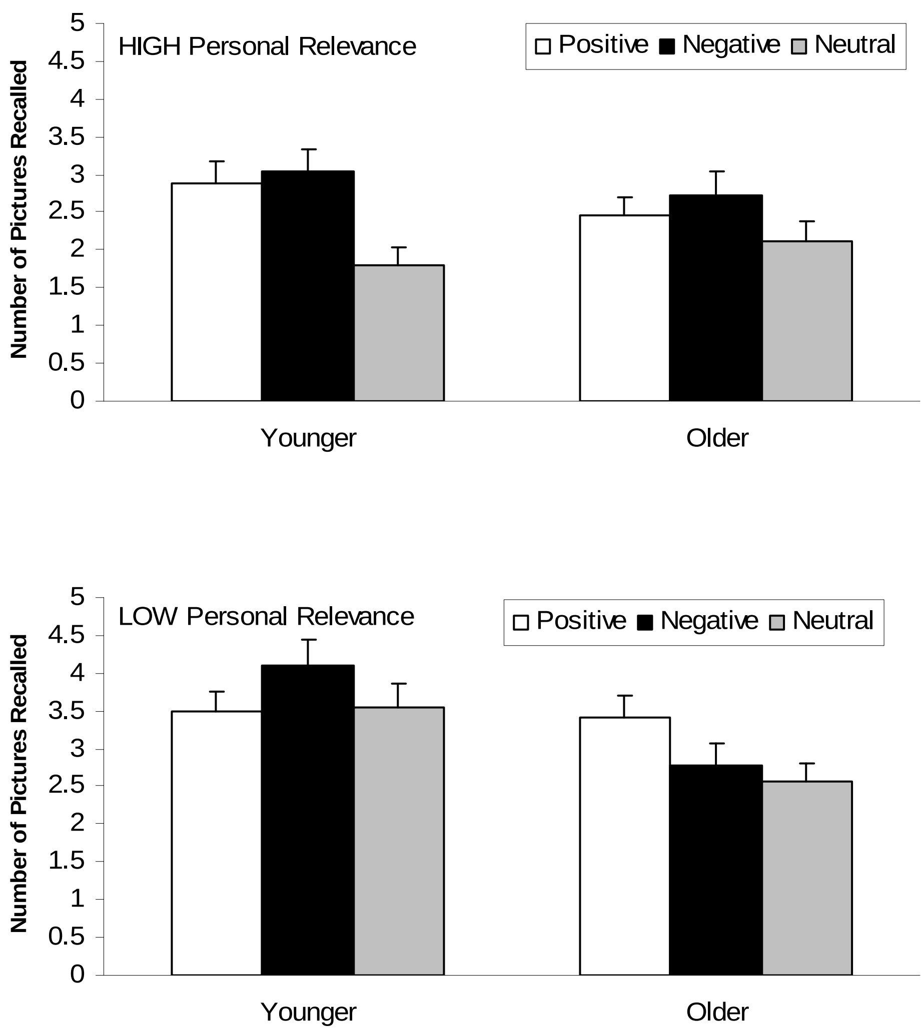
Having clearly shown that encoding instructions were not critical in whether previous studies observed a positivity bias, the second goal of Experiment 1 was to determine whether personal relevance of pictures affected recall. A mean split based on average ratings of personal relevance for older and for younger adults for positive ($M_{Younger} = 4.19$, $M_{Older} = 4.21$), negative ($M_{Younger} = 2.66$, $M_{Older} = 3.18$), and neutral ($M_{Younger} = 2.24$, $M_{Older} = 2.81$) pictures was used to classify recalled pictures as either high or low in personal relevance. These data were then analyzed in the same manner as the recall data.

For pictures high in personal relevance, there was a main effect of valence $F(2, 220)$

= 9.08, $p < .001$, $\eta^2 = .076$; whereas equivalent numbers of negative and positive pictures were recalled ($p = .39$), fewer neutral pictures were recalled compared to both positive, $F(1, 110) = 10.82$, $p < .001$ and negative, $F(1, 110) = 16.66$, $p < .001$, pictures. There was no main effect of age, and most importantly, no significant age X valence interaction (see Figure 3a).

Figure 3. The top panel shows mean recall of pictures rated as high in personal relevance, of each valence type in Experiment 1. The bottom panel shows mean recall of pictures rated as low in personal relevance, of each valence type. Error bars are standard errors of their respective means.

(a) (b)



For pictures low in personal relevance, there was a main effect of age, F(1, 110) = 5.33, $p < .05$, $\eta^2 = .046$, with younger adults recalling more pictures than older adults. Importantly, in contrast to the high relevance pictures, there was no main effect of valence, but a significant age X valence interaction, F(1, 110) = 4.13, $p < .05$, $\eta^2 = .036$. For younger adults, there were no differences in recall for the different valence types, but in older adults, a positivity bias emerged: Older adults recalled more positive than negative (t(55) = 2.09, $p < .05$) or neutral (t(55) = 2.88, $p < .01$) pictures; recall of the negative and neutral pictures did not differ (see Figure 3b).

It is possible that unequal numbers of pictures of each valence type were classified as low and as high in personal relevance due to the fact that they were based on participants' ratings of pictures, and that this could account for the patterns of the age x valence interactions observed. For example, if older participants rated more positive than negative pictures as low in personal relevance, this could increase the likelihood that older adults would recall a greater number of positive pictures low in personal relevance compared to negative pictures low in personal relevance. To address this, the number of pictures recalled for each valence type and personal relevance level (low, high) was expressed as a percent of the total number of pictures of each valence type classified as low or high in personal relevance. These scores thus represent the percent of the total numbers of study pictures for each valence and personal relevance level that were recalled by participants. These scores were analyzed in the same manner as in the high/low analyses already reported.

Concurring with the preceding findings, for pictures high in personal relevance there was main effect of valence, F(2, 208) = 4.11, $p = .018$. More of the positive (M = 41.69, SD

= 24.94; F(1, 104) = 7.14, p = .009) and marginally more of the negative (M = 39.26, SD = 24.05; F(1, 104) = 3.85, p = .052) pictures were recalled relative to neutral pictures (M = 32.90, SD = 24.00), but there was no difference in percent of positive and negative pictures recalled (p = .41). There was no main effect of age (p = .26), and no age x valence interaction (p = .48).

Again concurring with the preceding findings, for pictures low in personal relevance the main effects of age (F(1, 108) = 8.10, p < .01) and valence (F(2, 216) = 7.99, p < .001) were qualified by an age x valence interaction F(2, 216) = 3.22, p = .042. Younger adults recalled a higher percent of the negative pictures (M = 46.61, SD = 24.25) than of the positive pictures (M = 38.45, SD = 19.37), t(54) = 2.09, p = .041, or of the neutral pictures (M = 33.44, SD = 20.10), t(54) = 4.23, p < .001, and recalled a higher percent of the positive pictures than of the neutral pictures, t(55) = 2.06, p = .045. Older adults recalled a higher percent of the positive pictures (M = 35.91, SD = 20.85) than of the neutral pictures (M = 26.55, SD = 18.68), t(55) = 2.68, p = .01, but percent of positive and of negative (M = 31.80, SD = 22.54) pictures recalled did not differ, t(54) = 1.23, p = .22. Percent of negative pictures recalled did not differ from percent of neutral pictures recalled, t(54) = 1.41, p = .16.

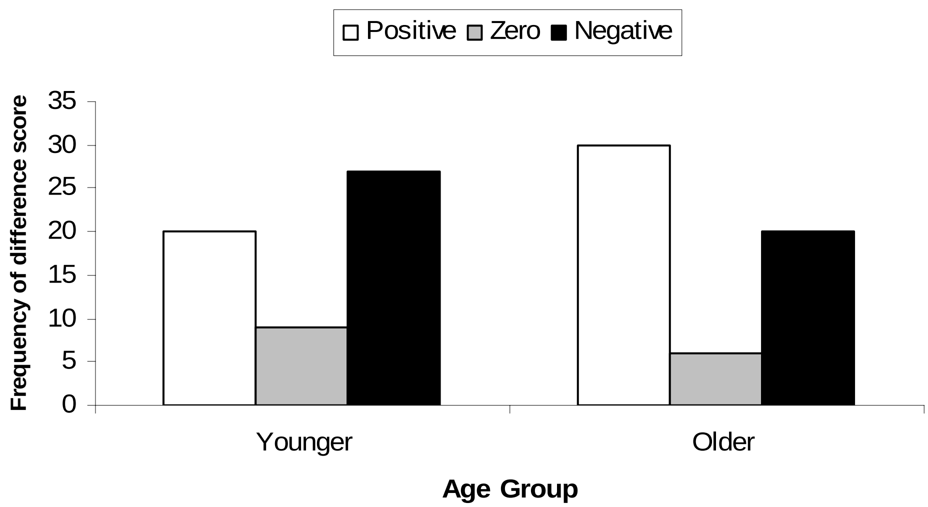
2.2.3 Additional Analyses and Discussion of Additional Analyses

It is possible that the set of pictures chosen in Experiment 1 ended up being mostly low in personal relevance for that sample, and that this accounts for the age X valence interaction observed in the overall analysis. To determine whether study pictures were indeed perceived as low in personal relevance, the number of study pictures rated as high or low in personal relevance for each valence by each participant in Experiment 1, according to the mean split described in the Results section, were analyzed with a repeated measures ANOVA with valence (positive, negative, neutral) and personal relevance level (low, high) as the within subjects variables, and age group (younger, older) as the between subjects variable. Results partially confirmed this idea, as there was a significant main effect of personal relevance level, $F(1, 110) = 21.49$, $p < .001$, which was qualified by an interaction between personal relevance level and valence, $F(2, 220) = 5.62$, $p = .004$. There was no interaction between age, personal relevance, and valence ($p = .12$). Paired t-tests showed that greater numbers of positive pictures were rated as low in personal relevance ($M = 9.49$, $SD = 3.93$) compared to high in personal relevance ($M = 6.51$, $SD = 3.93$), $t(111) = 4.01$, $p < .001$. The same held true for neutral pictures (low personal relevance: $M = 9.86$, $SD = 3.31$; high personal relevance: $M = 6.14$, $SD = 3.31$; $t(111) = 5.94$, $p < .001$). However, the numbers of negative pictures rated as high or low in personal relevance were not significantly different ($p = .10$).

Because many of the pictures were low in personal relevance to participants, this may be why Experiment 1 found a positivity bias in older adults' memory for pictures. By this logic, other studies (e.g., Kensinger et al., 2002) may not have found evidence of a positivity bias in older adults' memory because they may have used pictures which were perceived as more personally relevant by participants.

As noted by Charles and Carstensen (2007), "Older adults represent a heterogeneous group, and the mean differences…belie the vast differences observed among older adult populations" (p. 320). The literature is currently unclear as to how well these differences that provide evidence of a positivity bias in older adults' cognitive processing represent older adults as a whole, given the great inter-individual variability. Evidence for inter-individual variability can be found in Experiment 1. When difference scores are created by subtracting the number of negative pictures recalled from the number of positive pictures recalled for each participant (Figure 4), it can clearly be seen that few older adults actually display the mean pattern of recall found in Experiment 1 (recalling equal numbers of positive and negative pictures). In fact, most older adult participants recalled greater numbers of positive than negative pictures (a 'positivity bias'), and a substantial number recalled greater numbers of negative than positive pictures (a 'negativity bias'). This pattern is the mirror image of that seen in the younger adults: Most younger adult participants displayed a negativity bias, although a substantial number displayed a positivity bias.

Figure 4. Number of participants in each age group in Experiment 1 that recalled more positive than negative pictures (Positive), equal numbers of positive and negative pictures (Zero), and more negative than positive pictures (Negative).



2.3 Discussion

Consistent with the studies of both Charles et al. (2003) and Mather and Knight (2005), there was a significant age X valence interaction in recall of emotional and neutral pictures. Specifically, younger adults displayed a negativity bias, in line with a number of other studies of various cognitive processes (see Rozin & Royzman, 2001, for a review). Younger adults recalled more negative relative to positive and neutral pictures, whereas older adults showed a boost in recall for both positive and negative pictures relative to neutral. The literature has been unclear whether the positivity bias in older adults' memory represents an increase in memory for positive compared with negative and neutral material (e.g., Charles et al., 2003, Experiment 1) or a decrease in memory for negative material (e.g., Charles et al., 2003, Experiment 2), relative to younger adults. The present results are squarely in line with the latter.

The present manipulation of instructions—either to passively view or to actively rate study pictures—did not influence recall for positive, negative, and neutral pictures in younger and older adults. Thus, it appears that differences in instructions between the studies of Charles et al. (2003) and Kensinger et al. (2002) do not explain why one study did and the other did not find a positivity bias in memory for older adults.

With respect to recognition performance, age and valence did not interact, which is in line with the findings of Charles et al. (2003). Nevertheless, as recognition accuracy was near ceiling (see Table 3 for mean accuracy scores), this may have precluded finding any age differences in recognition performance, or an age x valence interaction. For this reason, the recognition results should be viewed with caution.

Recall order output analyses did not provide evidence that the positivity bias in older adults' picture recall was due to the order in which items of different valences were recalled, thereby discarding another plausible alternative account.

The second aim of Experiment 1 was to determine whether the personal relevance of study material modulates the positivity bias in older adults' memory. What is novel here, and particularly relevant to the current debate about whether a positivity bias exists in older compared to younger adults, is the finding that personal relevance of the pictures did determine whether an age X valence interaction was found. When recalled pictures were classified as either high or low in personal relevance, an age X valence interaction emerged only for pictures rated as low in personal relevance. There were no differences in recall of the different valence types for younger adults but the positivity bias emerged in older adults: They recalled more positive than both negative and neutral pictures. This is interpreted to mean that when to-be-remembered pictures are more personally relevant, older and younger adults incidentally encode both positive and negative pictures to a greater extent than neutral pictures, resulting in the typically seen boost in recall for emotional, relative to neutral, items (e.g., Cahill & McGaugh, 1995). In contrast, when pictures are lower in personal relevance, it is possible that older adults may engage in emotion regulation and preferentially encode positive, relative to negative and neutral, pictures, which may result in better recall of positive pictures.

Although older adults reported greater positive, and less negative, affect on the PANAS-X compared to younger adults, regression analyses indicated that affect was not related to recall for any valence type. Also, both younger and older adults reported more positive relative to negative affect when each age group was considered separately, which argues against a mood congruency explanation of the age X valence interaction. Participants also rated positive pictures as being most personally relevant, followed by negative and neutral pictures. However, participants' personal relevance ratings for recalled and not recalled pictures did not differ, suggesting that personal relevance of the pictures *per se* does not determine which pictures will later be recalled.

The reasonable conclusion is that differences in personal relevance of picture sets used across studies may well account for whether a positivity bias is or is not observed in older adults' memory. Studies that have found a positivity bias may have used pictures that were relatively low in personal relevance to older adult participants, whereas studies that did not find a positivity bias may have used pictures that older adults found to be high in personal relevance. The present study suggests that a variable previously not considered—personal relevance—may be the "active ingredient" in the emergence of this age difference in memory.

Chapter 3
Experiment 2: Attention and Memory for Emotional Pictures in Aging

3.1 Introduction

In the second experiment, attention during presentation (study) of pictures was directly manipulated by dividing attention during encoding using another concurrently performed task. Dividing attention during encoding typically produces a decrement in later memory compared to when encoding is done under conditions of full attention (e.g., Anderson, Craik, & Naveh-Benjamin, 1998; Fernandes & Moscovitch, 2000). Previous work has demonstrated that only stimuli which are attended to are susceptible to interference effects from dividing attention at study. For instance, dividing attention at study has been shown to disrupt performance on explicit, but not implicit, tests (e.g. Jacoby, Toth, & Yonelinas, 1993; Parkin, Reed, & Russo, 1990). Therefore, it was predicted that dividing attention at study should result in greater decrements to memory for the pictures, but only for those pictures to which the participant is actively attending. Pictures to which participants do not attend in the first place should not be affected by a division of attention to the same extent as pictures which do receive attentional processing.

If older adults show a positivity bias because they pay more attention to positive pictures at encoding, then memory should be worse for positive stimuli when attention is divided, compared to memory under full attention. Also, memory for negative pictures should be less affected by dividing attention in older than in younger adults, because older adults are hypothesized to avoid attending to negative stimuli (e.g., Mather & Knight, 2005), whereas younger adults often display a negativity bias. Thus, it is predicted that an interaction of Attention X Valence will emerge that is modified by age group (i.e., a 3-way interaction). What is more, this interaction may only emerge for the passive, and not the active viewing condition. That is, if older adults pay less attention to negative stimuli, then memory should be relatively unaffected by dividing attention, compared to the effect on positive stimuli (to which they are preferentially attending). However, when asked to actively rate pictures by valence, older adults would be forced to attend equally to pictures of each valence type, hence we should see an effect of attention, but it would not interact with valence or age group.

Mather and Knight (2005) have previously addressed the effects of dividing attention during study of emotional pictures, but did not manipulate encoding instructions. In their study, older and younger adults passively viewed positive, negative, and neutral IAPS pictures and were then given an incidental recall test for the pictures. During encoding of the pictures, half of the participants from each age group viewed pictures under full attention, and half viewed pictures while completing a distracting task (divided attention). According to Mather and Knight, older adults use cognitive control strategies to implement their emotion regulation goals. That is, older adults are believed to actively decrease processing of negative pictures. Note that these authors claim that the positivity bias results from a decrease in attentional resources devoted to processing of negative information, rather than resulting from an increase in attentional resources devoted to the processing of positive pictures. Thus, dividing attention during encoding was hypothesized to prevent older adults from being able to use cognitive control strategies, and to lead to higher recall of negative pictures in older adults. Results of their study confirmed this hypothesis: Under full attention, older adults' recall consisted of a greater proportion of positive pictures relative to younger adults' recall, whereas under divided attention, older adults' recall consisted of a greater proportion of negative pictures relative to younger adults' recall.

The Mather and Knight (2005) study did have limitations. For one, Mather and Knight used participants' subjective ratings to divide pictures into positive, negative, and neutral "sets" with the sets being roughly equal in number. IAPS ratings were used to break ties to determine to which set a given picture would belong, although the percentage of pictures for which valence was determined in this manner was not stated. That participants' subjective ratings were used to classify some pictures into valence sets and IAPS ratings were used to classify others may reduce the degree to which the purported "subjective ratings" are valid subjective ratings of participants. Another limitation is that Mather and Knight did not report proportions of positive relative to negative pictures recalled within each age group, but claimed that older adults "remember[ed] more positive than negative pictures" (p. 564) when pictures were encoded under full attention. By not demonstrating greater recall of positive relative to negative pictures, it is unclear whether their 'positivity bias' is the result of recalling more positive or less negative information, relative to younger adults.

To recapitulate, the goal of Experiment 2 was to determine whether dividing attention at encoding would affect whether older adults display a positivity bias in memory for the pictures presented at study, and whether this effect would depend upon encoding instructions given to participants. Thus, the variables that were manipulated included: attention (full, divided) and encoding instructions (passive, active). As mentioned in Experiment 1, an Age x

Valence interaction is expected to emerge only for recall and not for recognition performance, in the full attention condition. In terms of personal relevance, it is predicted that the positivity bias in older adults' recall will emerge only for pictures low in personal relevance, in the full attention condition thereby also providing a replication of Experiment 1. However, it is expected that dividing attention at encoding will disrupt this pattern of results such that the positivity bias will not emerge for older adults for pictures low personal relevance. Dividing attention at encoding should prevent older adults from preferentially encoding positive pictures.

3.2 Method and Results

3.2.1 Method

Participants. Sixty-four people took part in this study: Thirty-two healthy community-dwelling older adults (61 – 93 years of age; 24 female) were recruited through the University of Waterloo’s Research in Aging Participant pool, and 32 younger adults (18 – 25 years of age; 21 female) were recruited from undergraduate psychology classes (see Table 5 for participant characteristics). For participating, older adults received $10 remuneration and younger adults received course credit. For both age groups, inclusion criteria were: fluency in English, normal or corrected-to-normal vision and hearing, no current or history of neuropsychological impairment, and no head injury resulting in unconsciousness for more than 1 minute. For older adults, an additional exclusion criterion was a score of less than 26 on the MMSE. Older adults had a higher full scale IQ (FSIQ), $F(1, 62) = 21.75$, $p < .01$, as estimated by the NART-R, but did not differ from young with respect to years of education ($p > .05$).

Table 5

Participant characteristics for Experiment 2. Mean values with standard deviation in parentheses.

	Age group			
Characteristic	Younger		Older	
Age in years	20.38	(1.91)	72.53	(7.58)
MMSE score	-	-	29.31	(0.93)
Education (years)	14.63	(1.41)	13.50	(3.02)
FSIQ	103.60	(8.40)	112.98	(7.68)
PANAS-X (percent positive)	55.18	(12.24)	64.41	(13.82)
PANAS-X (percent negative)	34.47	(11.71)	28.71	(8.74)

Apparatus. The same computer, monitor, and software were used as in Experiment 1.

Stimuli. The same 96 pictures and six practice pictures from Experiment 1 were used. The distracter task used for divided attention conditions was a digit monitoring task. For this task, two 117-item lists of randomly generated odd and even two digit numbers were created. Twenty sets of three odd numbers in a row occurred in the first list (odd digit list), and 20 sets of three even numbers in a row occurred in the second list (even digit list), with placement of the sets of odd or even numbers in a row within each list being identical between the two lists. Two additional 20-item lists of randomly generated odd and even numbers were created for practice purposes. In these practice lists, three sets of three odd or even numbers in a row occurred, with placement of sets of three numbers being identical between the two practice lists.

Procedure. Procedures were virtually identical to those in Experiment 1, except for the addition of the divided attention (DA) conditions. Thus, Experiment 2 had four experimental conditions. Two were the full attention conditions from Experiment 1 (passive instructions, active instructions), and two were the corresponding DA conditions (passive instructions, DA; and active instructions, DA). In each condition, half of the participants in each age group completed digit monitoring with the odd digit lists; the other half received the even digit lists. Participants first practiced either viewing or categorizing the practice pictures, or practicing the digit monitoring task (counterbalanced for order). Afterwards, they practiced either viewing or categorizing the pictures while carrying out the digit monitoring task. During the study phase of the DA conditions, participants viewed or categorized pictures while completing the digit monitoring task. For the digit monitoring task, number lists were presented auditorily at a rate of one number every two seconds. Participants were told that they would hear a tape recorded voice reading a list of odd and even two digit numbers, and were asked to say yes out loud to indicate when they heard three (odd or even, depending on the list) numbers in a row. In the study phase of the DA conditions, participants were asked to divide their efforts equally between viewing/categorizing pictures and carrying out digit monitoring.

3.2.2 Results

Memory for pictures

Recall. Two coders independently matched recall responses to the IAPS pictures from study and agreed on 96% of picture descriptions, resolving coding discrepancies by discussion, and consensus agreement. Only one picture description from a younger adult's recall and four picture descriptions from older adults' recall could not be coded and so were excluded from the recall totals. Mean number of pictures recalled, shown in Table 6, was analyzed in a repeated-measures ANOVA with valence (positive, negative, and neutral) as the within-subject factor and age (younger, older), instruction (passive, active), and attention (full, divided) as the between subjects factors.

Table 6

Mean number of pictures recalled for each age group in Experiment 2 as a function of valence type and instruction condition. Standard deviations are in parentheses.

		Age group and Valence type					
		Younger adults			Older adults		
Attention Condition	Instruction Condition	Positive	Negative	Neutral	Positive	Negative	Neutral
Full	Passive	5.38	5.25	4.13	4.25	4.00	3.38
		(2.67)	(1.91)	(2.30)	(1.98)	(2.27)	(2.07)
	Active	5.50	6.25	4.00	5.00	3.50	3.75
		(2.07)	(2.76)	(2.07)	(1.60)	(1.20)	(3.37)
Divided	Passive	2.13	3.13	1.75	2.88	3.25	1.25
		(0.99)	(1.88)	(2.25)	(1.96)	(1.98)	(1.16)
	Active	5.38	4.75	4.00	3.38	3.38	2.75
		(2.33)	(1.83)	(2.14)	(1.30)	(1.60)	(1.67)

There was a main effect of age, F(1, 56) = 5.80, p = .02, η^2 = .094, with younger adults (M = 12.91, SD = 5.61) recalling more pictures than older adults (M = 10.19, SD = 4.63). There was also a main effect of valence, F(2, 112) = 8.82, p < .001, η^2 = .14, with better recall of both negative and positive (p = .87) pictures, relative to neutral pictures (ps < .01). There was a main effect of instruction F(1, 56) = 5.80, p = .019, η^2 = .094, with participants recalling a greater number of pictures in the active condition (M = 12.91, SD = 4.55) than in the passive condition (M = 10.19, SD = 5.68). There was also a main effect of attention condition F(1, 56) = 13.16, p = .001, η^2 = .19, with participants recalling a greater number of pictures in the full attention condition (M = 13.59, SD = 5.18) than in the DA condition (M = 9.50, SD = 4.61). No interactions reached significance (all ps > .09), including the age x valence interaction (p = .50). Because there were no interactions with instruction condition, this factor was excluded from further analyses.

Recognition. Accuracy of recognition performance was computed the same way as in Experiment 1. Because there was no main effect of instructions (p = .37), and because no interactions with instructions reached significance (all ps > .05), results without instruction condition are reported.

There was a main effect of attention, F(1, 60) = 9.59, p = .003. Participants were more accurate in the full attention condition (M = 0.79, SD = .34) than in the DA condition (M = 0.58, SD = .21). No other main effects or interactions reached significance (all ps > .08). See Table 7 for means.

Table 7

Mean recognition accuracy for each age group in Experiment 2 as a function of valence type and attention condition. Standard deviations are in parentheses.

	Age group and Valence type					
	Younger			Older		
Attention Condition	Positive	Negative	Neutral	Positive	Negative	Neutral
Full	0.84 (0.14)	0.87 (0.11)	0.85 (0.12)	0.72 (0.49)	0.73 (0.46)	0.75 (0.46)
Divided	0.63 (0.29)	0.64 (0.32)	0.64 (0.26)	0.50 (0.19)	0.52 (0.19)	0.52 (0.23)

Digit monitoring accuracy. Accuracy for the distracter task was calculated as hit rate – false alarm rate, and was analyzed with a univariate ANOVA with age (younger, older) and instruction condition (active, passive) as between subjects variables. Younger adults (M = 0.91, SD = .12) were more accurate than older adults (M = .72, SD = 0.30), $F(1, 28) = 20.93$, $p < .001$. There was a main effect of instruction condition, $F(1, 28) = 73.10$, $p < .001$, which was qualified by a significant interaction between age group and instruction condition, $F(1, 28) = 23.99$, $p < .001$. However, bivariate correlations showed no relation between digit monitoring accuracy and number of pictures recalled of any valence, for any age group or instruction condition (all $ps > .07$).

Affect measure. Raw PANAS-X scores were converted to percents as in Experiment 1. Considered separately, each age group reported greater positive ($M_{Younger}$ = 55.18, $SD_{Younger}$ = 12.24; M_{Older} = 64.41, SD_{Older} = 13.82) than negative ($M_{Younger}$ = 34.47, $SD_{Younger}$ = 11.71; M_{Older} = 28.71, SD_{Older} = 8.74) affect, $t_{Younger}(31) = 8.52$, $p < .001$; $t_{Older}(31) = 13.05$, $p < .001$. However, comparing age groups, older adults reported greater positive affect, $F(1, 62) = 7.98$, $p = .006$ and less negative affect, $F(1, 62) = 4.96$, $p = .029$ than younger adults. Bivariate correlations found no relation between negative or positive affect and recall of pictures of any valence for any age group and any attention condition (all $ps > .05$), except that for older adults in the full attention condition, greater positive affect was related to increased recall of neutral pictures, $r = 0.63$, $p = .009$.

Further analyses verified that a number of other factors did not influence the pattern of results. Specifically, FSIQ was not related to recall for any valence, for any age group or attention condition ($ps > .05$), except that for younger adults in the full attention condition, greater recall of negative pictures was related to lower FSIQ, r = -0.61, p = .012, and for older adults in the DA condition, greater recall of positive pictures was related to higher FSIQ, r = 0.51, p = .041. There was no effect of order of PANAS-X administration, or of picture list (1 or 2), on recall (all ps > .09). Unlike in Experiment 1, there was no difference in recall between pictures of medium-high and medium-low arousal (p = .45), nor did arousal level interact with any other variables (all ps > .20). There was no effect of gender on recall for any valence (ps > .1), or on affect scores (ps > .05).

Participant ratings of pictures

Valence. There was a main effect of valence, $F(2, 124) = 401.45$, $p < .001$. Consistent with the normative valence ratings (Lang et al., 2001), simple contrasts indicated that positive pictures were given higher valence ratings (M = 5.99, SD = 1.01) than neutral pictures (M = 3.55, SD = .79), $F(1, 62) = 214.11$, $p < .001$ or negative pictures (M = 1.30, SD = .85), $F(1, 62) = 520.21$, $p < .001$, and that negative pictures were given lower ratings than neutral pictures, $F(1, 62) = 417.35$, $p < .001$. There was no interaction between age group and valence type, p = .83, and no main effect of age group, p = .91.

Arousal. For participant ratings of arousal, there was a main effect of valence type, $F(2, 124) = 13.69$, $p < .001$. Consistent with the normative ratings, simple contrasts indicated that positive (M = 4.26, SD = 1.42) and negative (M = 3.95, SD = 1.28) pictures were not rated as significantly different in arousal, $F(1, 62)$ = .2.68, p = .11. Inconsistent with the normative ratings, both negative ($F(1, 62) = 15.33$, $p < .001$) and positive ($F(1, 62) = 31.16$, $p < .001$) pictures were rated as more arousing than neutral (M = 3.46, SD = 1.21) pictures. There was no interaction between age group and valence type (p = .80), and no main effect of age group (p = .061).

Personal relevance. Mean rated personal relevance of pictures was analyzed with a repeated-measures ANOVA, with valence (positive, negative, and neutral) and memory status (recalled, not recalled) as within–subjects variables, and age (younger, older) and attention condition (full, divided) as between subjects variables. There was a main effect of valence, $F(2, 100) = 36.14$, $p < .001$, with positive pictures ($M = 3.82$, $SD = 1.55$) rated as more personally relevant than both negative ($M = 2.77$, $SD = 1.28$; $F(1, 50) = 41.92$, $p < .001$) and neutral ($M = 2.56$, $SD = 1.27$; $F(1, 50) = 64.33$, $p < .001$) pictures, which did not differ from each other $F(1, 50) = 1.68$, $p = .20$. There was a main effect of attention $F(1, 50) = 10.27$, $p = .002$. Rated personal relevance was higher for participants in the full attention condition ($M = 3.57$, $SD = 1.19$) compared to participants in the DA condition ($M = 2.53$, $SD = 1.19$). There was also an interaction between valence and memory status, $F(2, 100) = 3.61$, $p = .031$. For neutral pictures only, rated personal relevance of recalled pictures ($M = 2.91$, $SD = 1.70$) was higher than that of pictures not recalled ($M = 2.31$, $SD = 1.21$), $t(54) = 2.91$, $p = .005$. There was an interaction between valence and attention, $F(2, 100) = 4.38$, $p = .015$, but no other main effects or interactions were significant (all ps > .1).

Personal relevance: High/low split

A mean split based on average ratings of personal relevance for older and for younger adults for positive ($M_{Younger} = 3.76$, $M_{Older} = 3.72$), negative ($M_{Younger} = 2.73$, $M_{Older} = 2.66$), and neutral ($M_{Younger} = 2.89$, $M_{Older} = 2.94$) pictures was used to classify recalled pictures as either high or low in personal relevance. These data were then analyzed in the same manner as in Experiment 1.

For pictures high in personal relevance viewed under full attention, there was a main effect of valence, $\underline{F}(2, 60) = 19.23$, $\underline{p} < .001$, $\eta^2 = .39$. A greater number of positive pictures ($\underline{M} = 3.78$, $\underline{SD} = 2.48$) was recalled relative to both negative ($\underline{M} = 2.69$, $\underline{SD} = 1.99$; $\underline{F}(1, 30) = 10.57$, $\underline{p} = .003$) and neutral ($\underline{M} = 1.94$, $\underline{SD} = 1.68$; $\underline{F}(1, 30) = 34.38$, $\underline{p} < .001$) pictures, and a greater number of negative pictures was recalled relative to neutral pictures, $\underline{F}(1, 30) = 10.02$, $\underline{p} = .004$. There was no main effect of age ($\underline{p} = 0.10$), and no significant age X valence interaction ($\underline{p} = .27$). For pictures high in personal relevance viewed under DA, there was no main effect of valence ($\underline{p} = .061$) or age ($\underline{p} = .48$), and no age x valence interaction ($\underline{p} = .83$).

For pictures low in personal relevance viewed under full attention, there was no main effect of valence ($\underline{p} = .11$) or age ($\underline{p} =.68$), and no interaction of age x valence ($\underline{p} = .35$). For pictures low in personal relevance viewed under DA, there was a marginal effect of valence, $\underline{F}(2, 60) = 3.09$, $\underline{p} = .053$, $\eta^2 = .093$. A greater number of negative pictures ($\underline{M} = 2.06$, $\underline{SD} = 1.34$) was recalled relative to neutral pictures ($\underline{M} = 1.38$, $\underline{SD} =1.68$), $\underline{F}(1, 30) = 4.29$, $\underline{p} = .047$, but recall of negative pictures did not differ from recall of positive pictures ($\underline{M} = 1.63$, $\underline{SD} = 1.18$), $\underline{F}(1, 30) = 2.73$, $\underline{p} = .11$, and recall of positive pictures did not differ from recall of neutral pictures, $\underline{F}(1, 30) = 1.14$, $\underline{p} = .30$. There was no main effect of age ($\underline{p} = .29$), and no age x valence interaction ($\underline{p} = .54$).

Additional Analyses

It is possible that the sample size (64 participants) did not provide adequate power to detect a significant age x valence x attention interaction for picture recall. To address this, additional analyses were conducted to show how the pattern of the age x valence interaction found in Experiment 1 becomes stronger when data from the 32 participants from the full attention condition in Experiment 2 are added to the Experiment 1 analyses. Experiment 1 consisted of 112 participants, and the valence X age interaction was significant with an effect size (η^2) of .036. Adding the 32 participants from the full attention condition in Experiment 2 (who completed the same tasks as participants in Experiment 1, but also practiced digit monitoring and practiced a DA condition), the effect size for the age x valence interaction increases to .038. Inferring from this, it is possible that an increase in sample size in Experiment 2 would have produced a significant age x valence interaction in the full attention condition, and perhaps a significant age x valence x attention interaction.

Examining the age x valence interaction separately in the full and DA conditions, the age x valence interaction in the full attention condition had an effect size of .051, whereas in the DA condition, the age x valence interaction had an effect size of .002 . Thus, it is possible that with more power, the pattern of results would show a significant age x valence interaction under full attention, replicating results from Experiment 1. A non-significant age x valence interaction under conditions of DA would show the disruptive effects of dividing attention at encoding on the positivity bias in older adults' recall. In addition, it is possible that an insufficiently large N contributed to the null findings in the low personal relevance data in the full attention condition of Experiment 2.

3.3 Discussion

The failure of Experiment 2 to replicate the age x valence interaction found in Experiment 1 is curious. Participants in the full attention condition completed the same tasks (with the exception of practicing the digit monitoring task and practicing dual-tasking) as participants in Experiment 1. It is possible that the lower power of Experiment 2 (which contained only 64 participants compared to the 112 participants in the first experiment) contributed to this null finding, as well as the failure to replicate the positivity bias in older adults' recall of pictures low in personal relevance.

It is interesting to note that Mather and Knight (2005) observed a positivity bias in older adults' recall of emotional pictures with the same number of participants as in Experiment 2. Thus, it is possible that a factor other than low power contributed to the null findings. For instance, the manipulation of encoding instructions may have created "noise" in the data which precluded finding a significant age x valence interaction, or an age x valence interaction in the pictures low in personal relevance. Because Mather and Knight have found evidence that dividing attention disrupts the positivity bias in older adults' memory for emotional pictures, and because the data from Experiment 2 may have been particularly "noisy" due to the manipulation of encoding instructions, the present conflicting results should not be taken as strong evidence that attention at encoding does not play a role in whether a positivity bias is observed in older adults' memory.

Chapter 4

Summary of Studies and General Discussion

This thesis sought to determine factors which influence the positivity bias in older adults' memory, using realistic pictorial stimuli. In the first experiment, older and younger adults viewed a series of positive, negative, and neutral pictures. Encoding instructions were manipulated such that participants either passively viewed the pictures, or actively categorized the pictures by valence. Results from an incidental free recall test indicated that younger adults displayed a negativity bias in recall whereas older adults recalled equal numbers of positive and negative pictures, although they recalled fewer pictures overall compared to younger adults. These results are consistent with the idea that the 'positivity bias' in older adults' memory is the result of a decrease in memory for negative information, rather than an increase in memory for positive information.

Encoding instructions had no effect on the positivity bias, indicating that this factor did not contribute to the cross-study differences in observing a positivity bias. Instead, another factor, personal relevance of study pictures, was shown to moderate the positivity bias in older adults' memory. Specifically, the positivity bias emerged for pictures that participants rated as low in personal relevance, but not for pictures high in personal relevance, indicating that personal relevance of study materials may underlie the cross-study differences in the literature regarding the positivity bias in memory. The findings of this thesis suggest that the positivity bias in older adults' memory occurs when information being remembered is not particularly personally relevant; when information is not self-relevant, older adults may engage in emotion regulation to decrease the impact of on their memory of non-relevant negative information. In contrast, when material is self-relevant, older adults may eschew their emotion regulation goals to process all information that is self-relevant, regardless of its valence. Put simply, older adults can focus on the negative if they have to (as in the case for material that is high in personal relevance), but will avoid committing negative material to memory if it is not personally relevant (likely in the effort of maintaining positive affect). As a test of this idea, it would be interesting to see whether older adults display a positivity bias for information that would be crucial to their well-being, such as when making health decisions. Although some evidence suggests that older adults do display a bias in attention and memory for positive information when making health care decisions in computer-based scenarios (Löckenhoff & Carstensen, 2007), it is unclear how well these laboratory situations generalize to real-life health care decision making processes. These findings also suggest that future studies should routinely gather data on the personal relevance of study materials and include this variable in their analyses or stratify analyses based on personal relevance levels.

There was no evidence of a positivity bias in older adults' recognition performance, and recall output order could not account for this bias, as there was no evidence to suggest that older adults recalled positive pictures earlier in recall, or that older adults recalled negative pictures later in recall, relative to younger adults. Thus, output interference does not seem to play a role in whether a positivity bias is observed in older adults' memory.

In the second experiment, attention to study pictures was directly manipulated through use of a divided attention paradigm. From the results of Experiment 2, it is unclear whether attention to pictures influences the positivity bias in older adults' recall, and this may have been due to the smaller sample size used (64 participants), compared to the sample size of Experiment 1 (112 participants). However, as discussed in Experiment 2, the effect size of the age x valence interaction was much larger in the full attention condition compared to the DA condition. The idea that dividing attention at encoding may disrupt the positivity bias in older adults' memory agrees with Mather and Knight (2005), in which a positivity bias in older adults' recall for pictures emerged when these were encoded during full attention, but was disrupted when pictures were encoded under DA. Mather and Knight suggest that older adults may use cognitive control (attentional) strategies to regulate their emotions but when they are distracted and face increased cognitive load, they are unable to use these strategies to implement emotion regulation goals.

Moreover, from the discussion of studies in the general introduction, it is clear that the positivity bias in memory is far from robust. As such, it seems possible that a number of factors may contribute to whether a positivity bias in older adults' memory is observed. Results from this thesis demonstrate that factors such as the personal relevance of the study material influence whether older adults display a positivity bias in memory for emotional stimuli.

A further avenue to explore the role of personal relevance in memory would be to determine whether memory performance would benefit more from processing emotional material in a personally relevant manner in older adults than in younger adults. In an experiment that would test this hypothesis, both older and younger adults would view a series of positive, negative, and neutral pictures matched on the dimensions of valence and arousal and be asked to process the pictures in three ways: (1) in a personally relevant manner (e.g., imagining how they would feel if they were in the situation portrayed in each of the pictures), (2) in an emotional manner (e.g., deciding whether each picture is positive, negative, or neutral), or (3) for perceptual content (e.g., counting the number of different colours in each picture). Participants would then complete a surprise recall test for the pictures. If the older adults recalled a greater proportion of pictures processed in a personally relevant manner compared to the younger adults, this would support the idea that older adults' memory performance can be especially enhanced by processing information in a personally relevant manner. Moreover, the study could determine whether processing material in a personally relevant manner affects memory for positive, negative, or neutral materials to a different extent, and whether aging modulates these effects.

As Mather and Knight (2005) have shown that attention to stimuli can affect the positivity bias in older adults' memory, another avenue of investigation would be to provide converging evidence that older adults pay more attention to positive (or less attention to negative) stimuli compared to younger adults. This hypothesis could by tested using the attentional blink (AB) paradigm (Raymond, Shapiro, & Arnell, 1992; Shapiro, Caldwell, Sorensen, 1997), which involves rapid serial visual presentations after which participants report whether a visual target had been presented. Studies have found that participants are unable to detect the presentation of a second target if it is presented less than 500 msec after a first (i.e., a blink in attention occurs). Importantly, it has been shown that the AB is shorter when the second target is an emotional word (e.g., Ogawa & Suzuki, 2004), indicating that emotional words capture attention. The magnitude of the AB of older and younger adults for positive, negative, and neutral words and pictures could be compared to determine whether positive stimuli capture the attention of older adults to a greater extent than negative or neutral stimuli, relative to younger adults. Specifically the AB of older adults should be shortest for positive stimuli, relative to negative and neutral stimuli, whereas the AB of younger adults should be shortest for negative stimuli. This would provide support for the idea that attention to positive stimuli plays a role in the positivity bias.

Although tangential to the data of Experiments 1 and 2, it is intriguing to consider how the positivity bias in older adults' memory for emotional stimuli could be related to neuropsychological functioning. According to Ochsner and Gross (2005), many neuroimaging studies provide evidence that the prefrontal cortex plays an important role in the cognitive control of emotions (emotion regulation). If older adults use cognitive control strategies dependent upon frontal lobe functioning to implement their emotion regulation goals, it is possible that medical conditions which adversely affect frontal lobe functioning, such as cardiovascular disease and frontal lobe dementias (e.g., Raz, Rodrigue, Kennedy, & Acker, 2007), would render older adults less able to use these strategies, decreasing the likelihood that they would show a positivity bias in memory or attention.

In addition, a number of studies have shown that older adults who perform memory tasks as well as younger adults display bilateral activation in the brain, whereas low performing older adults display unilateral activity (e.g., see Cabeza, 2002). Relative to unilateral activation, bilateral activation is seen as evidence of greater recruitment of neural resources to perform a task. As such, it is possible that older adults who display bilateral activation patterns when performing memory tasks may be more able to implement emotion regulation goals (Mather & Knight, 2005) and so be more likely to demonstrate a positivity bias in memory.

It seems likely that other factors may play a role in determining whether any given older adult would display a positivity bias in attention or memory. In this vein, it has been shown that although adults generally experience a decrease in negative affect over the life span, individual differences in personality traits are related to differences in the decline of negative affect experienced over time. For example, Charles, Reynolds, and Gatz (2001) found that individuals who scored higher on the neuroticism personality trait experienced an attenuated decrease of negative affect over the life span. In addition, Kunzmann, Little, and Smith (2000) demonstrated that declines in functional abilities and presence of chronic illnesses contributed to increases in negative affect among the oldest old. Therefore, future work should focus on identifying factors that moderate or mediate the positivity bias in older adults' cognitive processing, and should integrate these findings into studies by controlling for these variables, to provide a more complete account of this phenomenon, and to better characterize late life cognitive processing of emotional material.

Although Experiment 2 was unable to demonstrate a role of attention at encoding in the positivity bias in older adults' memory for emotional stimuli (possibly due to low power and "noisy" data from the encoding instruction manipulation), the finding in Experiment 1 that the positivity bias in older adults' memory is moderated by the personal relevance of study materials is intriguing. The onus on future studies will be to make a point of collecting data about the personal relevance of stimuli to participants to further elucidate the role of personal relevance in older adults' emotional memory.

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Appendix

Characteristics of IAPS pictures used in study. Mean IAPS-normed ratings for valence and arousal ratings, with standard deviations in parentheses.

List 1				List 2			
Title	Picture number	Valence rating	Arousal rating	Title	Picture number	Valence rating	Arousal rating
Positive – no people, medium-low arousal							
Nature	5201	7.06 (1.71)	3.83 (2.49)	Nature	5220	7.01 (1.50)	3.91 (2.27)
Sky	5593	6.47 (1.57)	3.98 (2.31)	Sky	5991	6.55 (2.09)	4.01 (2.44)
Dog	1510	7.01 (2.07)	4.28 (2.47)	Dog	1500	7.24 (1.88)	4.12 (2.50)
IceCream	7340	6.68 (1.63)	3.69 (2.58)	Pancakes	7286	6.36 (1.72)	4.44 (2.44)
Positive – no people – medium-high arousal							
Gold	8500	6.96 (1.64)	5.60 (2.40)	Money	8502	7.51 (1.72)	5.78 (2.49)
Fireworks	5910	7.80 (1.23)	5.59 (2.55)	Fireworks	5480	7.53 (1.63)	5.48 (2.35)
Mountains	5600	7.57 (1.48)	5.19 (2.70)	Mountains	5700	7.61 (1.46)	5.68 (2.33)
Jaguar	1650	6.65 (2.25)	6.23 (1.99)	Jaguars	1722	7.04 (2.02)	5.22 (2.49)
Positive – people – medium-low arousal							
Mother	2540	7.63 (1.51)	3.97 (2.33)	Mother	2310	7.06 (1.52)	4.16 (2.01)
Family	2395	7.49 (1.69)	4.19 (2.40)	Family	2299	7.27 (1.53)	3.95 (2.22)
Father	2165	7.63 (1.48)	4.55 (2.55)	Father	2057	7.81 (1.28)	4.54 (2.41)
Couple	4700	6.91 (1.94)	4.05 (1.90)	Couple	2530	7.80 (1.55)	3.99 (2.11)
Positive – people – medium-high arousal							

Skier	8021	6.79 (1.44)	5.67 (2.37)	Skier	8193	6.73 (1.58)	6.04 (2.19)
HangGlider	8161	6.71 (1.64)	6.09 (2.24)	HangGlider	5626	6.71 (2.06)	6.10 (2.19)
Bride	2208	7.35 (1.68)	5.68 (2.34)	Wedding	4626	7.60 (1.66)	5.78 (2.42)
WaterSlide	8496	7.58 (1.63)	5.79 (2.26)	Children	2216	7.57 (1.31)	5.83 (2.20)
Negative – no people – medium-low arousal							
Cemetery	9001	3.10 (2.02)	3.67 (2.30)	Cemetery	9000	2.55 (1.55)	4.06 (2.25)
BurntBldg	9471	3.16 (1.35)	4.48 (2.02)	Ruins	9470	3.05 (1.51)	5.05 (1.98)
Cigarettes	9830	2.54 (1.75)	4.86 (2.63)	Garbage	9290	2.88 (1.52)	4.40 (2.11)
Smoke	9280	2.8 (1.54)	4.26 (2.44)	Rat	1280	3.66 (1.75)	4.93 (2.01)
Negative – no people – medium-high arousal							
Ship	9621	3.22 (1.76)	5.76 (2.05)	Shipwreck	9620	2.70 (1.64)	6.11 (2.10)
Jet	9622	3.10 (1.9)	6.26 (1.98)	Bomb	9630	2.96 (1.72)	6.06 (2.22)
RoachOn Pizza	7380	2.46 (1.42)	5.88 (2.44)	Roaches	1274	3.17 (1.53)	5.39 (2.39)
FliesOnPie	7360	3.59 (1.95)	5.11 (2.25)	PieW/bug	7359	2.92 (1.70)	5.36 (2.19)
Negative – people – medium-low arousal							
Homeless Man	9331	2.87 (1.28)	3.85 (2.00)	Bum	2750	2.56 (1.32)	4.31 (1.81)
Pollution	9342	2.85 (1.41)	4.49 (1.88)	Pollution	9341	3.38 (1.89)	4.50 (2.1)
SadGirls	2455	2.96 (1.79)	4.46 (2.12)	Girl	2276	2.67 (1.66)	4.63 (1.93)
Man	2490	3.32 (1.82)	3.95 (2.00)	ElderlyWoman	2590	3.26 (1.92)	3.93 (1.94)
Negative – people – medium-high arousal							

Attack	6530	2.76 (1.86)	6.18 (2.02)	Attack	6360	2.23 (1.73)	6.33 (2.51)
AimedGun	6244	3.09 (1.78)	5.68 (2.51)	AimedGun	6243	2.33 (1.49)	5.99 (2.23)
Car Accident	9920	2.50 (1.52)	5.76 (1.96)	CarAccident	9910	2.06 (1.26)	6.20 (2.16)
DyingMan	3230	2.02 (1.30)	5.41 (2.21)	Hospital	3220	2.49 (1.29)	5.52 (1.86)
Neutral – no people – medium-low arousal							
Mushroom	5531	5.15 (1.45)	3.69 (2.11)	Mushrooms	5532	5.19 (1.69)	3.79 (2.20)
Traffic	7595	4.55 (1.46)	3.77 (2.22)	Traffic	7590	4.75 (1.55)	3.80 (2.13)
CarCrash	7920	4.51 (1.40)	3.87 (2.15)	Car	7096	5.54 (1.26)	3.98 (1.87)
Agate	7820	5.39 (1.41)	4.21 (2.05)	Agate	7830	5.26 (1.38)	4.08 (2.11)
Neutral – no people – medium-high arousal							
Volcano	5920	5.16 (1.92)	6.23 (2.08)	Lava	5940	4.23 (1.68)	6.29 (1.85)
Bomber	6910	5.31 (2.28)	5.62 (2.46)	Aircraft	6900	4.76 (2.06)	5.64 (2.22)
Turtle	1945	4.59 (1.68)	4.42 (2.03)	Lizard	1121	5.79 (1.61)	4.83 (1.98)
Leopard	1310	4.60 (1.62)	6.00 (1.80)	Tiger	1726	4.79 (2.10)	6.23 (2.19)
Neutral – people – medium-low arousal							
Musician	2487	5.20 (1.80)	4.05 (1.92)	Man	2485	5.69 (1.36)	3.74 (1.84)
Runner	8465	5.96 (1.49)	3.93 (2.34)	Runner	8010	4.38 (1.86)	4.12 (2.08)
Smoking	2749	5.04 (1.39)	3.76 (2.03)	Beer	2600	5.84 (1.85)	4.16 (1.74)
Office	7550	5.27 (1.40)	3.95 (1.91)	Couple	4605	5.59 (1.52)	3.84 (2.12)
Neutral – people – medium-high arousal							
Motor	8260	6.18 (1.80)	5.85 (2.18)	Motorcycle	8251	6.16 (1.68)	6.05 (2.12)

cyclist							
Boxer	8232	5.07 (1.80)	5.10 (2.21)	Boxer	8060	5.36 (2.23)	5.31 (1.99)
Volcano Skier	8192	5.52 (1.53)	6.03 (1.97)	IceClimber	8191	6.07 (1.73)	6.19 (2.17)
Jet	7620	5.78 (1.72)	4.92 (2.11)	Boy	9411	4.63 (1.58)	5.37 (1.97)