EFFECTS OF AGING AND EMOTIONAL VALENCE ON ITEM DIRECTED FORGETTING

AND SOURCE ATTRIBUTIONS

by

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Effects of Aging and Emotional Valence on Item Directed Forgetting and Source Attributions

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Abstract

Two experiments investigated the effects of aging and emotion on intentional forgetting.

Experiment 1 compared 36 young (aged 18-28, $M = 20.22$, $SD = 3.12$) and 36 older adults (aged

65-85, $M = 71.53$, $SD = 5.44$) on item directed forgetting and source attributions (i.e., assigning

a 'remember', 'forget', or 'new' tag during recognition) of positive, negative, and neutral words.

Older adults' directed forgetting was reduced for positive words and their source attributions

were differentially affected by emotion. Emotion had no effect on young adults' performance.

Experiment 2 examined the role of attention in older adults' intentional forgetting. Thirty-six

older adults (aged 65-91, $M = 73.92$, $SD = 7.55$) completed an emotional item directed

forgetting task that incorporated a probe-detection task during encoding to assess the allocation

of attention across valence conditions. Older adults again showed reduced directed forgetting for

positive words and emotional effects in source attributions; however, results from the probe-

detection task indicated that older adults' attention may not have been influenced by the

emotional tone of stimuli during encoding.

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Effects of Aging and Emotional Valence on Item Directed Forgetting and Source Attributions

Previous research has identified a divergent trajectory for older adults, characterized by declines in cognition (Salthouse, 2004) and maintenance or even improvement in the processing of emotional information (Carstensen & Mikels, 2005; Mather, 2012; Mather & Carstensen, 2005; Scheibe & Carstensen, 2010). Indeed, a growing body of research suggests that older adults may be just as good as their young counterparts at attending to and remembering emotional relative to neutral information; however, little is known about how emotion would affect the ability to intentionally forget and how this would change with age. Although often perceived as one of the "sins" of memory (Schacter, 1999), forgetting has adaptive value, allowing us to forget information that becomes outdated or irrelevant. Thus, the overarching question addressed by this thesis was whether emotion would facilitate or hinder the ability to intentionally forget information and how this would change as a function of age. Such questions have significant societal relevance, given the current increase in aging populations in Canada (Statistics Canada, 2007). Moreover, the investigation of factors affecting cognition in late life is crucial to our understanding of how to improve these abilities, and may contribute to the development of effective cognitive training or intervention programs for older adults.

Age-Related Changes in Cognition

Although getting older is often accompanied by gains in wisdom, losses in several other aspects of mental functioning are also experienced. Noticeable deficits in cognition begin to emerge at around age 65, and often include declines in fluid intelligence (i.e., cognitive flexibility, reasoning skills, speed of processing) and memory (Craik, 1994; Hedden & Gabrieli, 2004; Mather, 2010; Salthouse, 2004; Verhaeghen, 2012). However, aging does not affect all forms of memory in a uniform fashion. For example, semantic memory (i.e., memory for general

facts and world knowledge) and implicit memory (e.g., unconscious memory that results from priming) appear to be relatively unaffected by the aging process. In contrast, regions of memory responsible for remembering recent events (i.e., episodic memory) and manipulating information within memory (i.e., working memory) show robust declines with age (Craik, 1994; Hedden & Gabrieli, 2004; Mather, 2010). A comparison of these systems reveals that, in general, those functions that require effortful self-initiated processing seem to show the most substantial decline.

Several theoretical explanations have been put forward for why such age-related changes in cognition occur (see Glisky, 2007 for a review). For example, Salthouse (1996) suggested that increases in age lead to a general reduction in the speed at which many processing operations can be executed. As such, the theory suggests that when a cognitive task is at hand, constraints on older adults' processing speed prevent successful execution of relevant processes in the available time. This slowing with age has been demonstrated on a variety of behavioural measures, such as the Digit Symbol Substitution Test from the Wechsler Adult Intelligence Scale (see Salthouse, 1996 for a review). A second theory assumes an age-related reduction in mental energy, which is defined as the amount of resources available for carrying out various cognitive operations (Craik & Byrd, 1982). As such, those mental processes requiring allocation of mental energy are thought to show the most robust age-related declines. Finally, a third theory, that is most relevant in the current context, suggests that a decrement in the ability to downgrade or inhibit processing of distracting information contributes to age differences in cognition (Hasher & Zacks, 1988; Lustig, Hasher, & Zacks, 2007; May, Hasher, & Kane, 1999; Verhaeghen, 2012). According to this inhibitory deficit theory of aging, inhibition works to promote efficient processing of relevant information by preventing interference from irrelevant information. Three functions of

inhibition, as suggested by Lustig, Hasher, and Zacks (2007), are to (1) prevent the *access* of irrelevant information to working memory, (2) to *delete* irrelevant information that manages to slip into working memory, and (3) to suppress or *restrain* pre-potent but inappropriate responses. Altogether, inhibition operates to constrain processing to task-relevant information only.

The inhibitory deficit theory has gained considerable attention in the cognitive aging literature with evidence accumulating for older adults' reduced capacity to inhibit processing of irrelevant information (e.g., Hasher, Quig, & May, 1997; Yang & Hasher, 2007; Zacks, Hasher, & Radvansky, 1996). For example, Hasher and colleagues (1997) demonstrated reduced control over no-longer-relevant material with age, such that older adults allowed irrelevant information to be further processed when it should have been abandoned. Consistent with these findings, Zacks and colleagues (1996) showed an age-related reduction in the suppression of irrelevant information, even when explicit directions to forget that information were provided (i.e., directed forgetting). Moreover, this susceptibility to irrelevant and distracting information has shown to persist even after controlling for general age-related slowing (Yang & Hasher, 2007). In addition to behavioural findings, evidence at the neural level shows that older adults' ability to downgrade cortical activity associated with task-irrelevant information is reduced, despite a preserved ability to enhance activity associated with task-relevant information (Gazzaley, Cooney, Rissman, & D'Esposito, 2005). Taken together, this small sample of a vast literature demonstrates a reduced capacity to monitor and control irrelevant information with age, supporting Hasher and Zack's (1988) inhibitory deficit theory.

Although the research and theories presented in this section paint a picture of loss and decline in cognitive function with age, there are certain processes that exhibit preservation or even enhancement in late life. In particular, research suggests a stability of emotional functioning

with age, whereby older adults are often found to report greater well-being, to invest more time in their emotional lives, and are better able to bounce back from negative mood states than their young counterparts (Charles & Carstensen, 2009; Hedden & Gabrieli, 2004; Isaacowitz & Blanchard-Fields, 2012; Mather, 2010; Mather, 2012). Interestingly, this stability in emotion regulation and well-being in older adults seems to have far reaching effects on how emotional information is processed and stored in memory (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). The following section briefly reviews this notion of emotional enhancement in cognition and how it is affected by the aging process.

Aging and Emotional Information Processing

Emotional information is more attention grabbing and salient in memory than neutral information, a claim supported by several empirical studies (see Hamann, 2001; Labar & Cabeza, 2006, for reviews). For example, emotional stimuli have been shown to capture and guide attention at early and late stages of processing (e.g., Langeslag & van Strien, 2009), and tend to persist in memory (e.g., Kensinger & Corkin, 2003). A growing body of research has been dedicated to understanding how factors, such as one's age, affect the ability to process emotional information. Although findings suggest that older adults perform closer to their young counterparts on tasks involving processing of emotional memoranda, a divergence in biases toward emotional stimuli is often observed (Carstensen & Mikels, 2005). For example, several studies indicate that young adults remember negative better than positive or neutral information (i.e., a *negativity bias*; e.g., Charles, Mather, & Carstensen, 2003; Kensinger, 2008; Kensinger & Corkin, 2003), whereas older adults show differentially greater attention (e.g., Isaacowitz, Allard, Murphy, & Schlangel, 2009) and better memory for positive information (e.g., Charles et al., 2003; Kensinger, 2008; Thomas & Hasher, 2006). This shift in emotional bias with age has

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been termed the age-related positivity effect in the literature, and is characterized not only by a preference for positive, but also an avoidance of negative stimuli relative to young adults (see Reed & Carstensen, 2012, for a review).

The positivity effect has been observed in several behavioural and neuroimaging studies of attention and memory. For example, when assessing attention to emotional stimuli, Isaacowitz and colleagues (2006) found that older adults preferred positive over negative information, whereas young adults only showed an attentional bias toward negative stimuli. An earlier investigation by Mather and Carstensen (2003) showed a similar pattern of results with a dot-probe paradigm. Here, older adults exhibited slower reaction times (RT) to detect a dot-probe following the presentation of negative relative to neutral faces, suggesting a reduced allocation of attentional resources toward negative stimuli; contrastingly, young adults did not show this pattern. When investigating age by emotion interactions in memory, Charles and colleagues (Experiment 1, 2003) found that both recall and recognition performance for negative images decreased across young, middle-aged, and older adults. As well, only the older participants showed a benefit for positive relative to negative or neutral images in memory. Extending these results to verbal stimuli, Kensinger (2008) demonstrated a memory advantage for positive words in the recall and recognition of older adults. The opposite was true for young adults, who instead demonstrated an advantage for negative words. At the neural level, Kisley, Woods, and Burrows (2007) found that reactivity of the late positive potential (LPP) – an event-related potential (ERP) waveform elicited by emotional stimuli – reduced linearly with age in response to negative images. Langesleg and van Strien (2009) produced similar results, demonstrating a negativity bias in the LPP of young relative to older adults, but also found that these electrophysiological effects coincided with behavioural positivity effects in free recall. Finally, as assessed with

functional magnetic resonance imaging (fMRI), Mather and colleagues (2004) showed reduced amygdala reactivity to negative pictures in older relative to young adults.

Altogether, the above empirical findings provide evidence for the existence of age-related positivity effects in attention and memory. Given these findings, the question emerges as to why a bias toward the positive increases with age. The socioemotional selectivity theory (SST) as proposed by Carstensen (1995) may shed some light on this question. The theory contends that our motivation and goals directly correspond to our perception of time. When time is perceived as expansive, as it is in youth, goals tend to focus on future horizons and so energy may be devoted toward activities such as knowledge acquisition. However, when we perceive boundaries on our time (e.g., in old age or the terminally ill), the SST proposes a shift in motivation to prioritize emotionally meaningful goals such as emotion regulation and leading a meaningful life (see Carstensen, Fung, & Charles, 2003 for a review). As a result, approaching life's end is accompanied by an emphasis on information relevant to emotional goals, thus leading to an avoidance of negative information and an enhancement of positive information in both attention and memory (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). Falling in line with this, research has demonstrated that positivity effects occur during instances of effortful processing, whereby older adults recruit cognitive resources to elaborate on positive and diminish negative content in attention and memory. More specifically, Mather and Knight (Experiments 2-3, 2005) showed that older adults with greater cognitive control were more likely to show a positivity preference in memory relative to those with low cognitive control. Moreover, when attention was divided at encoding, leaving little resources to enhance on positive information, the positivity bias disappeared in older adults.

Together, these results suggest that older adults may recruit mechanisms of cognitive control to elaborate on positive information so that it can be better remembered later. According to the SST, this effortful enhancement may reflect a motivation to fulfill emotion regulation goals. However, whether the age-related positivity effect emerges also seems to depend, in part, on the characteristics of the emotional stimuli. Emotion is conceptualized as a two-dimensional construct, varying in both valence (i.e., how positive or negative) and arousal (i.e., how exciting or calming; Lang, Greenwald, Bradley, & Hamm, 1993; Russell, 1980). Both valence and arousal have been found to enhance memory, but how the brain processes emotional information depends on where the stimuli fall on each of these continuums. For example, arousing information has been found to activate more automatic pathways in the brain (i.e., amygdalar-hippocampal networks), whereas non-arousing but valent information activates regions associated with cognitive control (i.e., prefrontal-hippocampal networks; Kensinger & Corkin, 2004). Following from the controlled processing account of positivity effects (e.g., Mather & Knight, 2005), one would postulate that the effect should be more likely to occur for non-arousing, valent stimuli that recruit controlled processes (i.e., pre-frontal processes) during encoding. Consistent with this, Kensinger (2008) showed an age-related positivity effect for low arousing, but not for highly arousing, emotional words. As such, the characteristics of the emotional memoranda may be important for determining whether positivity effects will be observed.

Taken together, the findings presented in this section demonstrate the existence of age-related positivity effects in attention and memory and how these effects may be rooted in a motivation to satisfy emotional goals, as outlined by the SST. Although there is a wealth of evidence to support a bias toward the positive in attention and memory (e.g., Charles et al., 2003;

Isaacowitz et al., 2006; Kensinger, 2008; Mather & Carstensen, 2003; Mather & Knight, 2005; Thomas & Hasher, 2006), there is little evidence to suggest how older adults' positivity preference would affect instances where forgetting might be more favourable.

Although forgetting is generally thought to reflect a lapse of memory, when intentional, it can be incredibly useful, particularly in instances where previously learned material becomes outdated. Thus, despite its negative connotation, forgetting allows memory to operate efficiently by deleting no-longer-relevant information (MacLeod, 1998). Given the beneficial nature of forgetting, it is important to understand how certain factors, such as aging and emotion affect this ability, yet a review of the literature reveals that few studies have explicitly examined this question; this describes the focus of the current experiments. The following sections will review the literature on intentional forgetting, with a focus on how aging and emotion have each been found to affect this ability. The review is organized into three sub-sections, including (1) the methods and theory of intentional forgetting, (2) the effects of age on intentional forgetting, and (3) the effects of emotional content on intentional forgetting.

Intentional Forgetting

Methods and theory. Intentional forgetting can be thought of as an active process. Different from the common conceptualization of forgetting as information fading from memory, intentional forgetting occurs when we actively suppress further processing or retrieval of no-longer-relevant material in memory. In the laboratory, the most common method for measuring intentional forgetting is with a directed forgetting paradigm (Bjork, 1970; MacLeod, 1998). Two variations of this paradigm exist that differ primarily in the presentation of stimuli and the timing of the memory instruction (i.e., a cue to remember or forget; see Basden & Basden, 1996 for a review of methods). In the list method (e.g., Minnema & Knowlton, 2008; Sego, Golding, &

Gottlob, 2006), two groups of participants receive a list of words for study, followed by a memory cue that designates the preceding list as either to be remembered (TBR) or to be forgotten (TBF), depending on the group. Both groups then receive a second list of items, presented as TBR. In the item method, stimuli are presented one at a time, each followed by a cue to either remember or forget (e.g., Bailey & Chapman, 2012; Hauswald, Schulz, Iordanov, Kissler, 2010; Thompson et al., 2011). In a typical directed forgetting experiment, participants are led to believe that memory will be assessed for only those words designated as TBR; however, a memory test for all words regardless of cue is administered following the study phase. Results of this memory test generally reveal the *directed forgetting effect*, indexed by reduced memory for items cued as TBF relative to those cued as TBR (MacLeod, 1998). The current investigation focuses on the item method as it allows for a within subjects comparison of how emotion affects the ability to intentionally remember or forget, as opposed to a between subjects comparison with the list method. As well, the item method is more suitable for using lists of intermixed positive, negative, and neutral stimuli, which may be important for eliciting emotional effects in cognitive processing (Dewhurst & Perry, 2000). Thus, the following sections will focus on reviewing literature relevant to item directed forgetting.

Within the literature, there have been two main theoretical accounts that attempt to explain the underlying cognitive mechanisms responsible for the directed forgetting effect. One hypothesis attributes directed forgetting to the selective rehearsal of items (MacLeod, 1998). According to this view, items are maintained in working memory until a memory cue (i.e., to remember or forget) is presented. If the cue is an instruction to remember, participants engage in elaborative rehearsal of that item. On the other hand, if the cue is an instruction to forget, the item is dropped from rehearsal. As a result, TBR items that are selectively rehearsed become

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committed to memory, whereas memory traces for unrehearsed TBF items passively decay, resulting in the directed forgetting effect. The second account attributes forgetting to more cognitively demanding processes. Zacks and colleagues (2006) proposed that the presentation of a forget cue activates an attentional mechanism (i.e., inhibition) that serves to prevent further processing of the TBF item. As such, through an active withdrawal of attention, the TBF item is removed from working memory. Thus, the two accounts offer relatively different explanations for directed forgetting effects. On the one hand, the selective rehearsal account suggests that remembering is active while forgetting is passive. On the other, the inhibitory account proposes that forgetting and remembering are both effortful active processes.

Several recent behavioural studies support the inhibitory account of directed forgetting. For example, Fawcett and Taylor (2008) investigated the attentional demands of directed forgetting by asking participants to detect a dot-probe following the presentation of a memory cue. They hypothesized that if forgetting activates an inhibitory mechanism, then reaction times (RTs) to detect probes should be slower following a cue to forget than a cue to remember, due to a withdrawal of attention. Results were consistent with this hypothesis, suggesting that directed forgetting may not be due to passive decay of TBF items, but a more cognitively demanding process. Falling in line with this, Taylor (2005) showed greater magnitude of inhibition of return (IOR) following peripherally presented forget (F)-cued words relative to remember (R)-cued words. IOR is a phenomenon defined by slower detection of a target stimulus that appears in the same rather than different location of a previously attended cue. Taylor interpreted this as suggesting that compliance with a cue to forget may involve engagement of an active mechanism, preventing participants from attending to the spatial location of a previously presented F-cue. Taking it a step further, Wylie and colleagues (2008) revealed neuroimaging

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evidence supporting the inhibitory account for the directed forgetting effect. With the fMRI technique, they found activation of frontal regions associated with controlled processing (e.g., inhibition) in response to TBF stimuli. Similarly, neurophysiological data also show enhanced frontal activity in response to F-cues (Paz-Caballero, Menor, & Jiménez, 2004; van Hooff & Ford, 2011). Altogether, these findings counter the idea of a passive decay of TBF information and instead suggest that an active mechanism may work to stop the processing of stimuli preceding a "forget" cue.

Considering the evidence for age-related deficits in inhibitory processing and the contribution of inhibition to directed forgetting effects, it is not surprising that an interest has been taken in understanding how aging affects the ability to intentionally forget. If older adults experience difficulty in suppressing irrelevant information, as purported by Hasher and Zacks' (1988) inhibitory deficit hypothesis, then a decline in performance with age should be observed when comparing young and older adults on directed forgetting.

Age differences in item directed forgetting. Several studies have documented a reduction in directed forgetting performance with advancing age (e.g., Andres, Van der Linden, & Parmentier, 2004; Hogge, Adam, & Collette, 2008; Earles & Kersten, 2002; Sego, Golding, & Gottlob, 2006; Titz & Verhaeghen, 2010; Zacks et al., 1996). For instance, Zacks and colleagues (Experiments 1A and 1B, 1996) found that, compared to young adults, older adults have a reduced ability to engage in item directed forgetting for verbal stimuli. Overall, the older group recalled and recognized fewer TBR items and showed a greater tendency to produce TBF items, reducing the magnitude of directed forgetting, compared to the younger group. The authors interpreted these findings as evidence for an age-related decline in the ability to downgrade processing of TBF items, and more generally, as support for the inhibitory deficit theory of aging

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(Hasher & Zacks, 1988). Consistent with this, but with a more unique form of stimuli, Earles and

Kersten (2002) demonstrated an age decrement in the ability to intentionally forget action

phrases (e.g., "nod head"). Further reinforcing these findings, a meta-analysis put forward by

Titz and Verhaeghen (2010) showed that even when controlling for age differences in baseline

recall, older adults have a reliably smaller directed forgetting effect than young adults.

Altogether, the aforementioned studies provide insight into how age can affect intentional

forgetting, with young adults showing a tendency to outperform their older counterparts. The

majority of these age comparison studies, however, have focused on directed forgetting of non-

emotional information. Considering the evidence for age-related positivity effects in cognition, it

is reasonable to expect that differential effects of emotion in older adults' intentional forgetting

would be observed. However, a review of the relevant literature reveals that to date, there is only

published research to suggest how emotion might affect directed forgetting in young adults.

Emotion and item directed forgetting. The general finding that emotional material

forms a stronger representation in memory (Labar & Cabeza, 2006) has given rise to interest in

how emotion might affect instances where we would prefer to forget. If we remember emotional

information better than neutral information, then it would logically follow that such information

might be more difficult to forget, even when explicit instructions to do so are provided. Research

attempting to address this question via item directed forgetting has, so far, provided mixed

findings. For instance, when Hauswald and colleagues (2010) asked participants to engage in

directed forgetting for negative and neutral images, participants only forgot the neutral stimuli.

In other words, the directed forgetting effect was completely abolished for negative pictures in

recognition; a similar pattern of results has been seen in tests of recall as well (Otani et al.,

2011). Contrastingly, a recent fMRI investigation by Nowicka et al. (2011) observed successful

forgetting for both negative and neutral pictures, but with a smaller effect for negative stimuli. More specifically, there was greater recognition of negative TBR and TBF images relative to the neutral stimuli, suggesting that negative content facilitated identification of TBR pictures, but hindered forgetting of TBF pictures. Interestingly, the fMRI results also revealed differences in brain activation during attempts to forget emotional or neutral information, such that attempts to forget negative pictures activated a distributed network of brain regions, while neutral images activated only the right lingual gyrus. Thus, trying to forget negative stimuli appeared to recruit greater resources than attempts to forget the neutral stimuli. Adding to the mixed findings, Yang and colleagues (2011) observed no difference in directed forgetting of negative and neutral images despite ERP results suggesting that forgetting negative stimuli might be more effortful.

The literature concerning emotional directed forgetting of verbal stimuli tells a similar story. Bailey and Chapman (2012) found that emotional words were resistant to forgetting, as indexed by smaller directed forgetting effects for emotional (i.e., positive and negative) relative to neutral words in both recall and recognition. However, more recently, Brandt, Nielsen, and Holmes (2013) observed directed forgetting for both negative and neutral words, and found a greater effect for negative as opposed to neutral words (the authors did not assess directed forgetting for positive words).

Together, these studies show mixed findings regarding the effects of emotion on item directed forgetting. Overall, it appears that in most cases, emotional pictures tend to be disruptive to directed forgetting. However, studies assessing verbal stimuli have shown both emotional disruption (Bailey & Chapman, 2012) and facilitation (Brandt et al., 2013). Brandt and colleagues briefly discuss the discrepancies within the literature, suggesting that emotional pictures may be more difficult to forget than emotional words, potentially explaining the

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seemingly mixed findings. However, this does not explain why Bailey and Chapman (2012) found a modulation of emotional tone on directed forgetting, while Brandt et al. (2013) did not, even though both studies used words as stimuli. Instead, the answer may be found by comparing their methodologies. Bailey and Chapman presented words and cues simultaneously, while Brandt and colleagues used the typical procedure of a word followed by a cue to remember or forget. Given research suggesting that emotional stimuli may be more effortful to forget (Nowicka et al., 2011), the simultaneous presentation of a word and cue in Bailey and Chapman (2012) may have not given the participant enough time to actively suppress processing of the emotional stimuli. Thus, currently, Brandt and colleagues' (2013) is the only study of traditional item directed forgetting using emotional and non-emotional verbal stimuli. However, the authors only made use of negative and neutral words, and so the effect of positive words in the context of traditional item directed forgetting remains unknown. Moreover, very few of these studies have attempted to disentangle the contributions of valence and arousal. Only one of the above studies (Bailey & Chapman, 2012) used high and low arousing emotional stimuli, yet their low arousing emotional stimuli were still significantly more arousing than the neutral stimuli. As previously discussed, the two dimensions of emotion, valence and arousal, have each been shown to differentially affect information processing (e.g., Kensinger, 2004). Following from this, it is reasonable to expect that each of these dimensions would have distinct effects on intentional forgetting.

As seen in this section, further research is required to fully understand the effects of emotion on item directed forgetting, how the dimensions of valence and arousal contribute to these effects, and also how the effects of emotion on intentional forgetting would differ as a function of age. Considering the age differences in emotional processing discussed earlier, it

seems logical to expect that emotion might have a differential impact on young and older adults' intentional forgetting. To the best of our knowledge, the literature has yet to examine age differences in item directed forgetting of positive, negative, and neutral words.

The Current Experiments

To briefly review, the literature presented here demonstrates a reduction in directed forgetting with age, which may be related to older adults' reduced ability to inhibit irrelevant information (Hasher & Zacks, 1988; Titz & Verhaeghen, 2010; Zacks et al., 1996). Second, although mixed, the literature suggests that emotion may act as a salient factor affecting the ability to forget in young adults (e.g., Brandt et al., 2013; Hauswald et al., 2010). However, whether age and emotion interact to affect directed forgetting performance is largely unknown. This question is particularly interesting in light of research suggesting a preference for positive information or avoidance of negative information in late life (Reed & Carstensen, 2012). Given these findings, it is important to understand how a bias toward one type of information might affect certain cognitive abilities, such as intentional forgetting. Thus, the primary goal of this thesis was to determine whether aging affects two important processes: the ability to *remember* and *forget* emotional (i.e., positive and negative) and neutral information, matched on a relatively low level of arousal. The use of low arousing emotional words matched to the arousal of neutral words represents a unique aspect of this project, as the individual contribution of each dimension (i.e., arousal and valence) has not yet been determined within the emotional directed forgetting literature. Since valence and arousal have distinct effects on information processing (Kensinger et al., 2004) and are differentially important for eliciting positivity effects (Kensinger, 2008), their contributions to age-related changes in emotional processing and

forgetting should be clearly disentangled. By controlling for arousal, this thesis may take a step toward pinpointing the contribution of valence to emotional directed forgetting.

To investigate these questions, two experiments were conducted, each of which adopted an item directed forgetting task for emotional information. Experiment 1 explored age differences in the ability to intentionally forget emotional and neutral words matched on arousal. As well, it assessed how emotion would affect source attributions in the context of directed forgetting, using a tagging recognition paradigm (i.e., identifying a word as one that was TBR, TBF, or New during recognition; Thompson et al., 2011). Experiment 2 sought to determine the role of attention in older adults' intentional forgetting, by combining a secondary task (i.e., a probe-detection task) with an item directed forgetting task.

At a broad level, it is expected that this thesis will contribute to literature surrounding the interaction of emotional processing and cognition in young and older adults. Examination of these factors and how they impact cognition is particularly important in the context of a rapidly aging society and may help in informing the development of cognitive intervention programs for older adults. Moreover, the study will fill gaps in the intentional forgetting literature by assessing the contributions of valence to directed forgetting performance, and how this changes as a function of one's age.

Experiment 1: Aging and Emotional Effects on Item Directed Forgetting and Source Attributions

The purpose of the first experiment was to examine how the ability to intentionally forget emotional information changes across the lifespan. To investigate this, young and older adults were compared on an item directed forgetting task where they studied a series of intermixed positive, negative, and neutral words, each followed by a cue to *remember* or *forget*. Unbeknownst to the participant, a later recognition task would test their memory for both TBR and TBF words. While a typical directed forgetting experiment usually involves an old/new recognition test in which participants simply identify words as old (i.e., studied) or new, the current study adopted a tagging procedure during recognition where participants were asked to assign a source to each word (see Thompson et al., 2011). The tagging procedure provides an added layer of information by indicating how well participants attribute sources (i.e., TBR or TBF cues) to words recognized as old. Moreover, this procedure has not yet been used in a study of directed forgetting of emotion. As such, this study provides insight not only into how emotion affects remembering and forgetting processes, but also how it affects the ability to assign a source to these words across young and old adults. Thus, the first experiment attempts to address the following questions: (1) Do young and older adults differ in directed forgetting of low arousing emotional information, and (2) how do age and emotion affect the ability to accurately tag an item at recognition?

Based on previous research, young adults were expected to exhibit a greater directed forgetting effect (i.e., larger memory difference between TBR and TBF words) than older adults, regardless of emotional valence. With respect to valence effects in directed forgetting, the expected pattern of results in the younger group was hypothesized to go one of two ways.

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Considering the mixed literature, young adults were expected to show either a reduction in performance for emotional relative to neutral words (e.g., Hauswald et al., 2011; Otani et al., 2011) or no emotional effect in directed forgetting (e.g., Brandt et al., 2013; Yang et al., 2011). Turning to older adults, research has shown a bias toward positive and away from negative information in the service of emotion regulation goals (Reed & Carstensen, 2012), particularly when this information is low in arousal (Kensinger, 2008). Considering this, older adults' tendency to avoid the negative may facilitate forgetting of that information, resulting in greater directed forgetting for negative compared to positive or neutral words. The literature has also suggested that older adults do not simply show a bias toward positive information, but actually engage in a controlled enhancement of that content during encoding (e.g., Mather & Knight, 2005). As such, the enhancement of this material may cause those items to be more resistant to forgetting, leading to a reduction in directed forgetting for positive relative to negative or neutral words.

In terms of source attribution performance in the tagging recognition task, we expected a general decline in the ability to correctly assign a source to a word with age, which would support the established evidence for age-related deficits in source memory (McIntyre & Craik, 1987). Based on findings that older adults exhibit an advantage in memory for emotional sources (e.g., May, Rahhal, Berry, & Leighton, 2005) and an age-related stability or even enhancement in emotional processing (e.g., Kensinger, 2008), emotion might play a differentially larger role in older adults' source attributions between remember and forget cues. Finally, consistent with the findings of Thompson et al. (2011), more F than R responses to New words were expected because, as a result of engaging in directed forgetting, it is more likely for F items to be confused with New words due to a weaker memory trace for those items relative to R items. This effect,

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however, may lessen with age considering that older adults show a reduced ability to engage in

directed forgetting relative to young adults (Zacks et al., 1996).

Method

  Participants. Thirty-six young adults (aged 18-28 years; *M* = 20.22, *SD* = 3.12) and 36

older adults (aged 65-85 years; *M* = 71.53, *SD* = 5.44) participated in this study. Young adults

were recruited from the Ryerson University undergraduate psychology participant pool and from

advertisements posted around the Ryerson University campus. Older adults were recruited from

the Ryerson Senior Participant Pool. Young adults recruited from the psychology participant

pool were compensated with one course credit for an introductory psychology course; all other

participants were compensated with $10 per hour of participation. All participants were tested in

the Psychology Research and Training Centre of Ryerson University.

  To verify that the two age group samples were representative of their own age group

norms, a battery of questionnaires and tasks was administered to the two age groups including

the Shipley Institute of Living Vocabulary test to measure English proficiency (Shipley, 1946),

the Positive and Negative Affective Schedule for current affective state (PANAS; Watson, Clark,

& Tellegen, 1988), the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988), the

Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) and the Digit

Symbol Substitution Test (DSST; Wechsler, 1981) as a measure of psychomotor speed.

Consistent with the literature (e.g., Yang & Ornstein, 2011), older adults were more educated,

had higher self-reported health ratings, higher vocabulary scores, and slower psychomotor speed.

Moreover, older adults scored higher in positive and lower in negative affect, and had lower

scores on both the depression and anxiety measures. Older adults were also screened for

cognitive impairment with the Short Blessed Test (SBT; Katzman et al., 1983). Performance on

these measures is displayed in Table 1.

Table 1

Sample Characteristics by Age Group for Experiment 1

Measure	Older Adults M (SD)	Young Adults M (SD)	p-value
Age in years	71.53 *(5.44)*	20.22 *(3.12)*	.000
Years of education	15.89 *(2.11)*	13.90 *(2.79)*	.001
Age learned English	0.35 *(1.43)*	1.17 *(2.31)*	.080
PANAS: Positive Affect	34.89 *(8.43)*	28.72 *(7.84)*	.002
PANAS: Negative Affect	11.42 *(3.53)*	13.50 *(4.88)*	.041
CES-D	7.42 *(5.56)*	16.61 *(8.81)*	.000
BAI	3.25 *(4.19)*	13.08 *(6.61)*	.000
Vocabulary[a]	37.25 *(1.71)*	27.86 *(3.56)*	.000
DSST	58.81 *(15.76)*	85.97 *(11.36)*	.000
Health Rating[b]	8.32 *(1.15)*	7.46 *(1.82)*	.019
Short Blessed Test	0.53 *(1.21)*	--	--

Note: A detailed description of each measure can be found on page 19. [a]Assessed with the Shipley Institute of Living Vocabulary test (Shipley, 1946); [b]measured on a scale ranging from 1 (poor) to 10 (extremely healthy).

Participants' data were excluded and replaced based on the following criteria: (1) English learned after age six; (2) a score lower than 20 on the Shipley Institute of Living Vocabulary test; (3) a score higher than 26 on the BAI, suggesting presence of anxiety symptoms; (4) presence of uncontrolled medical conditions (e.g., high blood pressure, diabetes); or (5) presence of psychiatric conditions or neurological disorders affecting cognition (e.g., stroke, prolonged periods of unconsciousness, dementia, and head injury). Older adults were excluded if they scored greater than or equal to six on the SBT, suggesting cognitive impairment. Four older adults and 23 young adults' data were excluded and replaced based on these criteria. The data from one older adult and four young adults were excluded and replaced due to technological issues (e.g., program malfunctioning).

Materials. The experiment was programmed with E-Prime 2.0 (Psychology Software Tools, Inc.). Stimuli were displayed against a white background in black Courier New size-18

font, and displayed on a 17" PC laptop with a viewing distance of approximately 60 cm.

Responses were recorded from the keyboard during the recognition task, using the 'z', space bar, and '.' keys for 'R', 'New', and 'F' responses respectively (see page 23).

     Stimuli. Table 2 displays the stimuli characteristics. A list of 120 words with 40 of each valence was selected from the Affective Norms for English Words database (ANEW; Bradley & Lang, 1999, see Appendix 1). Words were selected based on their valence and arousal norms, each ranging from 1 to 9, with 1 representing words high in negative valence and low arousal, and 9 representing words high in positive valence and high arousal, respectively. Importantly, the mean valence rating for positive words was significantly greater than the mean valence rating for negative, $t(38) = 31.84$, $p < .001$, and neutral words, $t(38) = 17.60$, $p < .001$. Similarly, the mean valence rating for neutral words was significantly greater than that of negative words, $t(38) = -13.60$, $p < .001$. To isolate the effects of valence, only low arousal words (ranging from 3.0-5.8) were chosen. Here, positive words were matched to negative ($p = .360$) and neutral words ($p = .475$), and neutral matched to negative words ($p = .070$). Finally, the three emotion conditions were matched on word length and frequency, all $ps > .588$.

Table 2

Stimuli Characteristics

	N	Valence Rating		Arousal Rating	
		M (SD)	Range	*M (SD)*	Range
Positive	40	7.39 *(0.40)*	6.7-8.1	4.38 *(0.63)*	3.0-5.4
Negative	40	2.64 *(0.61)*	1.6-3.6	4.45 *(0.51)*	3.3-5.8
Neutral	40	5.01 *(0.55)*	4.0-6.0	4.20 *(0.40)*	3.4-5.0

Note: Ratings for valence based on a scale ranging from 1 (negative) to 9 (positive).
Ratings for arousal based on a scale ranging from 1 (non-arousing) to 9 (high arousal).

The 120 words were split into two lists of 60, matched on valence, arousal, word length, and frequency. These two lists were equally often used as 'old' and 'new' lists in the recognition task, counterbalanced across participants. Each list was further evenly divided into two lists of 30, each serving as either a TBR or TBF list, counterbalanced across participants. The TBR and TBF lists included 10 words from each valence, and were always matched on the critical variables of arousal, word length, and frequency. An additional 15 neutral words were selected from the ANEW database, three used for practice trials and 12 used for buffer trials.

Procedure. Upon arrival to the lab, participants were introduced to the experiment and informed consent was collected. Participants were told to study a series of sequentially presented words, and to remember those followed by the cue 'RRRR' and forget those followed by the cue 'FFFF'. Participants were aware that a memory test would follow the study phase, but were not aware that their memory for words cued as 'FFFF' would be tested.

Encoding. During the encoding phase, participants completed 12 buffer trials (six at the beginning and six at the end of the encoding list) and 60 experimental trials (30 R and 30 F trials); memory for buffers was not tested. Prior to the experimental trials, participants completed three practice trials to familiarize themselves with the task. If required, participants could repeat the practice trials. The experimental trials were presented in a pseudo-randomized fashion, such that no more than three trials of each valence or cue condition occurred in a row. As shown in Figure 1, each trial began with a fixation-cross presented at the centre of the screen for 1000 ms, which was replaced by a word for 3000 ms. After the word, a blank screen appeared for 1500 ms as an inter-stimulus interval, followed by the memory cue ('RRRR' for remember, 'FFFF' for forget) for 1000 ms, and another blank screen for 500 ms before proceeding to the next trial.

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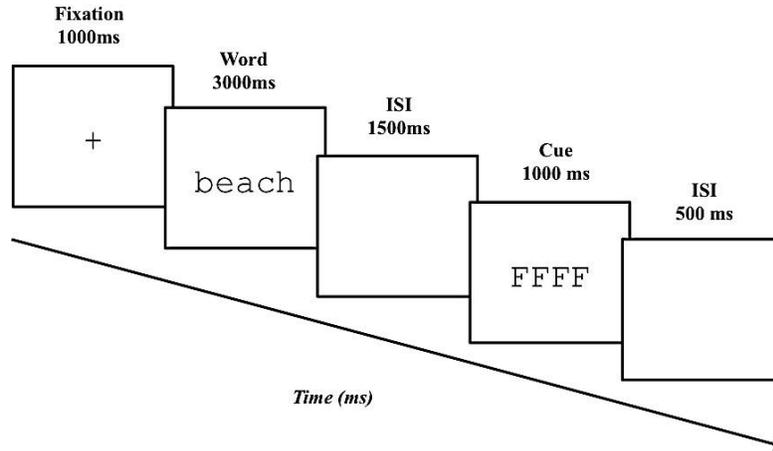
Figure 1. TBF trial from the encoding phase of the item directed forgetting task.

Filler task. Following encoding, participants completed the Digit-Symbol Substitution

Test (DSST; Wechsler, 1981) for two minutes, as a filler task.

Recognition. After the filler task, participants completed a recognition test in which the

60 previously studied words were presented (not including buffers), intermixed with 60 new

words. Here, participants were asked to determine whether each word was a TBR, TBF, or New

word by pressing designated keys on the keyboard (i.e., 'z', '.', and space bar, labeled as 'R', 'F',

and 'NEW', respectively). The 120 trials were presented sequentially, in a pseudo-randomized

order, with no more than three words from each cue or valence condition occurring in a row.

Each trial began with a fixation-cross at the centre of the screen for 1000 ms, replaced by a word

that remained on the screen until a response was detected. Following the response, a blank screen

was presented for 500 ms before proceeding to the next trial.

Following the recognition task, participants completed a series of paper-pencil tests and

questionnaires. The PANAS was administered to measure affective state, the Shipley Vocabulary

test to measure vocabulary level, the CES-D as a screen for depression, the BAI as a screen for

anxiety, the SBT as a screen for cognitive impairment (older adults only), and a background

questionnaire to collect demographic information (e.g., years of education, gender). Finally, participants were debriefed and compensated.

Statistical analyses. To test hypotheses surrounding the directed forgetting effect (i.e., greater memory for TBR relative to TBF stimuli), discrimination accuracy (i.e., Pr) scores were calculated as per the two-high threshold model (Snodgrass and Corwin, 1988). This model is built on the idea that each participant has two distinct memory thresholds, one for recognizing old items and one for rejecting new items, and that only items exceeding each of these thresholds will be correctly recognized or rejected, respectively. To calculate Pr, the false alarms (i.e., 'Remember' [R] or 'Forget' [F] responses made to New items) were subtracted from the hit rates, or proportion of old words that participants identified as 'old' (i.e., R and F responses, combined), for each emotion by cue condition. The resulting scores were submitted to a 2 (age: young, old) $\times$ 2 (cue: remember, forget) $\times$ 3 (emotion: negative, positive, neutral) mixed-model analysis of variance (ANOVA) with age as the only between-subjects variable. To distinguish discrimination accuracy from response bias, recognition bias scores (i.e., Br) were further calculated according to the two-high threshold model, using the following formula: Br = false alarms / (1 − Pr). Importantly, to avoid the problem of a division by zero in the calculation (i.e., where Pr = 1), hits and false alarms were adjusted to 0.99 and 0.01 for the values of 1 and 0 respectively. The resulting scores were then entered into a 2 (age) $\times$ 2 (cue) $\times$ 3 (emotion) mixed-model ANOVA.

To determine the effects of age and emotion on the ability to correctly assign a source to a word, correct source attributions to TBR and TBF items were analyzed (see Thompson et al., 2011). Correct source attributions were calculated as the proportion of old words attributed a correct source out of the number of old items correctly recognized as old. For example, the

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correct source attributions for TBR items were calculated based on the formula: R responses to TBR items / (R responses to TBR items + F responses to TBR items). The correct source attribution data were then submitted to a 2 (age) × 2 (word type: TBR or TBF) × 3 (emotion) mixed-model ANOVA.

Last, we examined source attributions made to New items, calculated as the proportion of TBR or TBF attributions made to New items out of the total number of New items recognized as old (i.e., attributed either an R or F response). For example, R misattributions to New items were calculated using the formula: R responses to New items / (R responses to New items + F responses to New items). To test the hypothesis of higher F tags to New items, a comparison was made between R tags and F tags assigned to New items. To determine the effects of age and emotion on source attributions of New items, a 2 (age) × 3 (emotion) ANOVA was conducted on the proportion of New items assigned an F tag. Remember tags assigned to New items were not included in the analysis as they are simply the inverse of the F tags assigned to New items.

All statistical analyses were conducted using IBM SPSS Statistics 19.0, with alpha levels set at .05, unless specified otherwise. Follow up ANOVAs and *t*-tests were conducted where appropriate to follow up any significant effects or interactions. Where necessary, corrections for multiple post-hoc comparisons were made using the Bonferonni technique.

Results

The results of Experiment 1 are presented in three sections. The first section summarizes the results on item-based recognition, focusing on directed forgetting performance (i.e., discrimination accuracy and recognition bias). The second section reports the results on source attribution performance (i.e., correctly identifying a word as TBR, TBF, or New). As well, the second section reports on source attributions made to New words (i.e., tagging a New word as TBR or TBF). The third section reports on potential confounding variables in the results.

Item-based recognition. Table 3 displays the hit rates, false alarm rates, discrimination accuracy (i.e., Pr), and recognition bias (i.e., Br) scores separated by age group, emotion condition, and cue. Table 4 presents the summary of the effects in the ANOVA.

Table 3

Hits, False Alarms, Pr, and Br as a Function of Age, Emotion, and Cue

	Older Adults		Younger Adults	
	TBR	TBF	TBR	TBF
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
Negative				
Hits	.82 *(.14)*	.71 *(.17)*	.84 *(.16)*	.64 *(.20)*
False Alarms	.08 *(.10)*	.25 *(.20)*	.06 *(.10)*	.21 *(.13)*
Pr	.74 *(.17)*	.45 *(24)*	.78 *(.21)*	.43 *(.19)*
Br	.32 *(.26)*	.44 *(.26)*	.35 *(.33)*	.38 *(.20)*
Positive				
Hits	.84 *(.12)*	.75 *(.19)*	.84 *(.14)*	.64 *(.24)*
False Alarms	.18 *(.16)*	.18 *(.17)*	.08 *(.12)*	.23 *(.16)*
Pr	.65 *(.18)*	.56 *(.23)*	.76 *(.18)*	.41 *(.21)*
Br	.52 *(.31)*	.43 *(.28)*	.39 *(.29)*	.43 *(.29)*
Neutral				
Hits	.80 *(.16)*	.68 *(.19)*	.81 *(.12)*	.59 *(.23)*
False Alarms	.09 *(.10)*	.18 *(.19)*	.05 *(.09)*	.18 *(.14)*
Pr	.71 *(.20)*	.50 *(.23)*	.76 *(.15)*	.41 *(.21)*
Br	.35 *(.26)*	.32 *(.26)*	.22 *(.22)*	.32 *(.24)*

Table 4

Summary of ANOVA Results for Discrimination Accuracy in Experiment 1

Effect	Df	F	MSE	P	η_p^2
A	1, 70	.105	.004	.747	.002
E	1.695, 2.359	.114	.002	.861	.002
C	**1, 70**	**131.434**	**7.990**	**<.001**	**.652**
A × E	2, 140	.759	.015	.450	.011
A × C	**1, 70**	**11.331**	**.689**	**.001**	**.139**
E × C	**2, 140**	**3.424**	**.085**	**.035**	**.047**
A × E × C	**2, 140**	**3.528**	**.087**	**.032**	**.048**

Note: A = Age, E = Emotion, C = Cue; significant effects displayed in bold font.

The analysis on discrimination accuracy scores (i.e., Pr) revealed a main effect of cue, $F(1, 70) = 131.43, p < .001, \eta_p^2 = .65$, with a greater recognition of TBR ($M = .73, SD = .15$) than TBF items ($M = .46, SD = .19$). This suggests an overall directed forgetting effect across age groups. All other main effects were not significant, $ps > .747$.

The age by cue interaction was significant, $F(1, 70) = 11.33, p < .01, \eta_p^2 = .14$. Further investigation of this interaction revealed that young adults had higher accuracy for TBR items than older adults (young: $M = .77, SD = .15$; older: $M = .69, SD = .14$), $t(70) = -2.03, p < .05$. On the other hand, young adults had reduced accuracy to TBF items than older adults (young: $M = .42, SD = .16$; older: $M = .51, SD = .20$), $t(70) = 2.105, p < .05$. Together, these results suggest greater directed forgetting in young relative to older adults. This interaction is displayed in Figure 2.
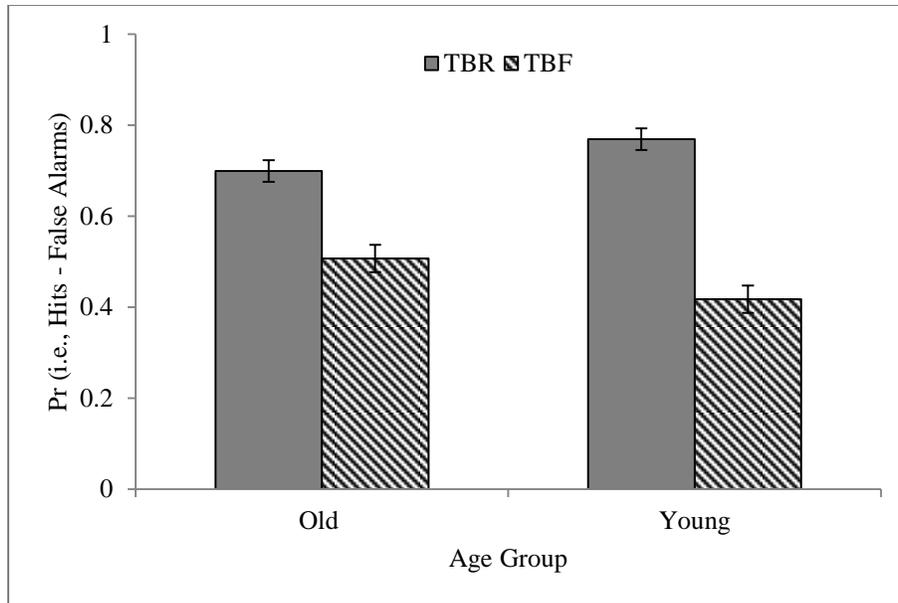
Figure 2. Discrimination accuracy performance for TBR and TBF items as a function of age. Error bars represent the standard errors of the means.

In addition, the emotion by cue interaction was significant, $F(2, 140) = 3.42$, $p < .05$, $\eta_p^2 = .05$, and was qualified by a three-way interaction between age, emotion, and cue, $F(2, 140) = 3.53$, $p < .05$, $\eta_p^2 = .05$. To unpack this three-way interaction, follow-up ANOVAs were run on each age group. These analyses showed that the emotion by cue interaction was not significant for young adults ($p = .999$), suggesting that their directed forgetting was not affected by the emotional valence of stimuli. On the other hand, the emotion by cue interaction was significant for the older adult sample, $F(2, 70) = 5.96$, $p < .01$, $\eta_p^2 = .15$. Subsequent paired sample t-tests showed that, across the three emotion conditions, older adults showed significant directed forgetting for negative (TBR items, $M = .74$, $SD = .17$; TBF items, $M = .45$, $SD = .24$, $t[35] = 5.93$, $p < .001$) and neutral items (TBR items, $M = .71$, $SD = .20$; TBF items, $M = .50$, $SD = .23$, $t[35] = 4.88$, $p < .001$), but not for positive items (TBR items: $M = .65$, $SD = .18$; TBF items: $M = .56$, $SD = .23$, $p = .10$). This suggests that older adults had difficulty engaging in directed forgetting for positive stimuli, relative to the other two conditions. Additional follow-up t-tests

revealed that older adults also recognized more positive ($M = .56$, $SD = .23$) than negative TBF items ($M = .45$, $SD = .24$), $t(35) = -3.05$, $p < .01$, and more positive TBF items than young adults ($M = .41$, $SD = .21$), $t(70) = 2.96$, $p < .01$, suggesting an age-related positivity effect for positive TBF items. The age by emotion by cue interaction is displayed in Figure 3.
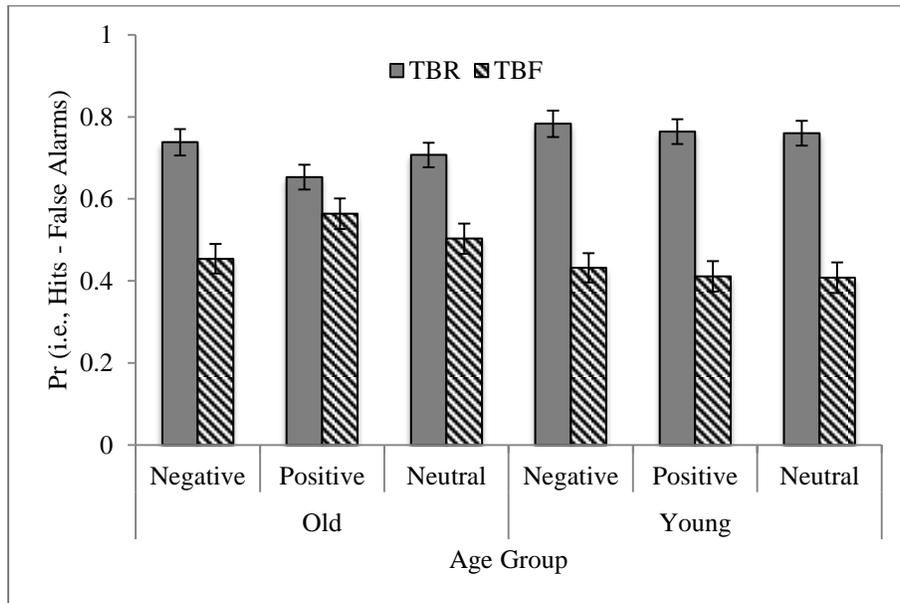

Figure 3. Discrimination accuracy for TBR and TBF items as a function of age and emotion. Error bars represent the standard errors of the means.

The resulting scores from the recognition bias calculation (i.e., Br) were .5 or less, indicating a relatively conservative rather than liberal recognition bias (see Snodgrass & Corwin, 1988). When these scores were submitted to the 2 (age) × 2 (cue) × 3 (emotion) ANOVA, a main effect of emotion was observed, $F(2, 140) = 17.35$, $p < .001$, $\eta_p^2 = .20$. Follow-up paired sample *t*-tests revealed that participants were biased to classify emotional items as old (i.e., as TBR or TBF), indexed by higher Br for positive ($M = .44$ $SD = .25$) relative to neutral items ($M = .30$, $SD = .20$), $t(71) = 5.72$, $p < .001$, and higher Br for negative ($M = .37$, $SD = .20$) than neutral words $t(71) = 3.31$, $p < .01$. Moreover, Br was higher for positive relative to negative items, $t(71) = 2.73$, $p < .01$. A three-way emotion by cue by age interaction was also significant, $F(2, 140) =$

3.694, $p < .05$, $\eta_p^2 = .05$. To unpack this interaction, an ANOVA was performed on each age

group, revealing that the interaction was only significant for the older, $F(2, 70) = 5.54$, $p < .01$,

$\eta_p^2 = .137$, but not younger sample, $p = .606$. Follow-up *t*-tests showed that older adults had

higher Br scores for positive TBR items ($M = .52$, $SD = .31$) relative to negative ($M = .32$, $SD = .26$), $t(35) = 3.71$, $p < .01$ or neutral ($M = .35$, $SD = .26$) TBR items, $t(35) = 3.43$, $p < .01$. As

well, they had higher Br for negative ($M = .44$, $SD = .26$) relative to neutral TBF items, $t(35) = 4.10$, $p < .001$. This interaction is displayed in Figure 4. Table 5 presents a summary of the
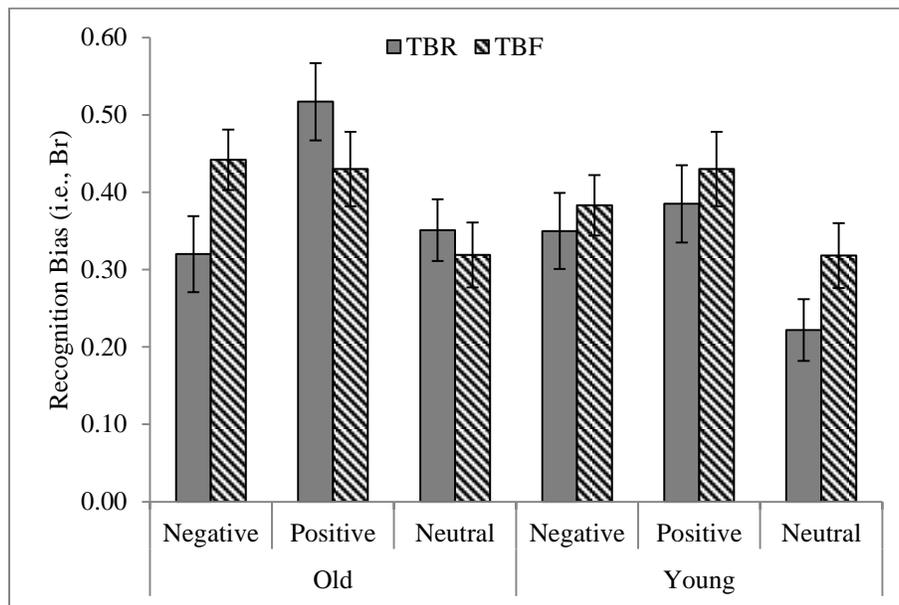
ANOVA.

Figure 4. Recognition bias scores for TBR and TBF items as a function of age and emotion. Error bars represent standard errors of the means.

Table 5

Summary of the ANOVA Results for Recognition Bias in Experiment 1

Effect	Df	F	MSE	P	η_p^2
A	1, 70	1.221	.253	.273	.017
E	**2, 140**	**17.353**	**.688**	**<.001**	**.199**
C	1, 70	1.306	.094	.257	.018
A × E	2, 140	.792	.031	.455	.011
A × C	1, 70	1.227	.088	.272	.017
E × C	2, 140	2.253	.088	.109	.031
A × E × C	**2, 140**	**3.694**	**.144**	**.027**	**.050**

Note: A = Age, E = Emotion, C = Cue; significant effects displayed in bold font.

Source attributions. Table 6 presents a summary of the ANOVA on the correct source attribution data.

Table 6

Summary of ANOVA Results for Source Attributions in Experiment 1

Effect	Df	F	MSE	P	η_p^2
A	**1, 70**	**23.241**	**1.235**	**<.001**	**.249**
E	2, 140	2.707	.102	.070	.037
WT	1, 70	.246	.020	.621	.004
A × E	2, 140	1.637	.062	.198	.023
A × WT	1, 70	1.517	.123	.222	.021
E × WT	**2, 140**	**16.001**	**.693**	**<.001**	**.186**
A × E × WT	**2, 140**	**6.695**	**.290**	**.002**	**.087**

Note: A = Age, E = Emotion, WT = Word Type; significant effects displayed in bold font.

The analysis revealed a main effect of age, $F(1, 70) = 23.24$, $p < .001$, $\eta_p^2 = .25$, with better source attribution performance in young ($M = .73$, $SD = .11$) relative to older adults ($M = .62$, $SD = .08$). There was also a marginally significant effect of emotion $F(2, 140) = 2.71$, $p =$

.070. Follow-up paired *t*-tests showed marginal differences across emotion conditions with greater overall source attributions to neutral (*M* = .70, *SD* = .16) relative to negative (*M* = .66, *SD* = .15) or positive words (*M* = .65, *SD* = .15), *ps* < 0.57. All other main effects were not significant (*ps* > .621).

The emotion by word type interaction was also significant, $F(2, 140) = 16.00$, $p < .001$, $\eta_p^2 = .19$, and was qualified by a three-way interaction between age, emotion, and word type, $F(2, 140) = 6.70$, $p < .01$, $\eta_p^2 = .09$. Similar to the recognition data, follow-up ANOVAs on each age group showed that the emotion by word type interaction was only significant for older adults, $F(1.64, 57.28) = 16.25$, $p < .001$, $\eta_p^2 = .32$. For positive items, older adults had higher source attribution accuracy for TBR items (*M* = .74, *SD* = .22) than for TBF items (*M* = .45, *SD* = .27), $t(35) = 4.10$, $p < .001$. Interestingly, a reverse effect was observed for negative items, with lower accuracy for TBR items (*M* = .51, *SD* = .23) than for TBF items (*M* = .67, *SD* = .24), $t(35) = -2.60$, $p < .05$. For the neutral items, TBR (*M* = .68, *SD* = .21) and TBF items (*M* = .66, *SD* = .23) did not differ, $p > .697$. Across emotion conditions, the TBR words showed lower source attribution for negative relative to positive, $t(35) = -4.45$, $p < .001$, and neutral items, $t(35) = -3.65$, $p < .001$. In contrast, source attribution accuracy for TBF items was higher for negative and neutral than for positive items, *ps* < .001. Consistent with the corrected item recognition data, emotional valence did not impact source attribution accuracy in the young adult sample, $p > .201$. This interaction is displayed in Figure 5.
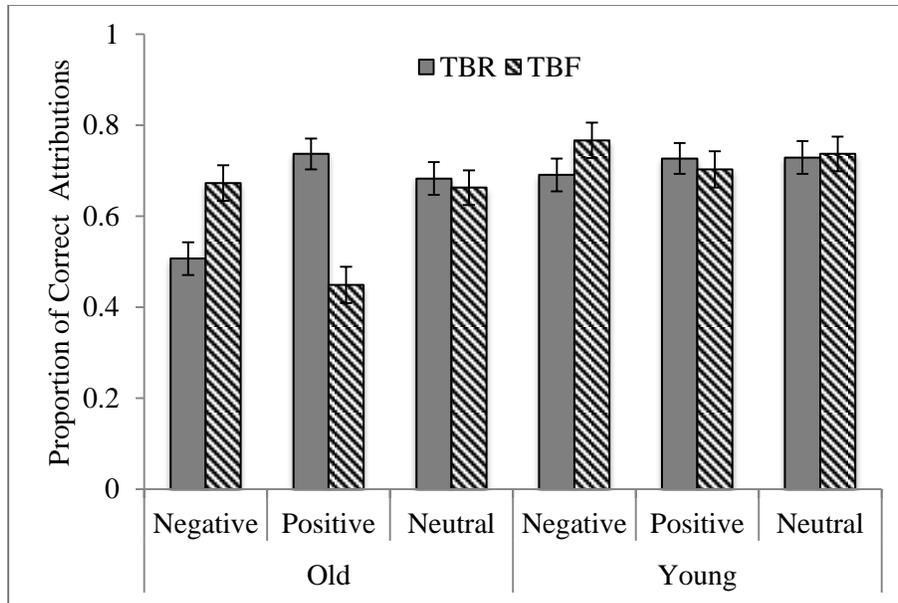
Figure 5. Proportion of old words attributed a correct source as a function of word type and emotion. Error bars represent standard errors of the means.

Last, source attributions assigned to New items were examined. The data of eight participants who did not make source attributions to New items were excluded from this analysis. Overall, New items were assigned more F tags ($M = .70$, $SD = 22$) than R tags ($M = .30$, $SD = .22$), $t(63) = -7.44$, $p < .001$. When examining the effects of age and emotion on source attributions to New words, the ANOVA revealed a main effect of age, $F(1, 62) = 15.61$, $p < .001$, $\eta_p^2 = .20$, explained by a higher proportion of F tags assigned to New words in the young ($M = .80$, $SD = .19$) relative to older group ($M = .61$, $SD = .20$). There was also a main effect of emotion, $F(2, 124) = 7.28$, $p < .01$, $\eta_p^2 = .11$, which was qualified by a significant age by emotion interaction, $F(2, 124) = 3.63$, $p < .05$, $\eta_p^2 = .06$. Here, older adults assigned significantly fewer F tags to positive New items ($M = .46$, $SD = .30$) and neutral New items ($M = .63$, $SD = .27$) than young adults (positive: $M = .78$, $SD = .27$; neutral: $M = .79$, $SD = .29$), ts > 2.32, ps $< .05$. However, the two groups did not differ in F tags assigned to negative New items (young, $M = .83$, $SD = .22$; older, $M = .73$, $SD = .28$), $t(62) = -1.57$, $p > .122$. Across emotions, older adults

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assigned significantly fewer F tags to positive than negative, $t(31) = 3.88$, $p < .001$, or neutral

New items, $t(31) = -3.17$, $p < .01$. In contrast, young adults' assignment of F tags to New items

did not differ across emotions, $ps > .339$. This interaction is illustrated in Figure 6.
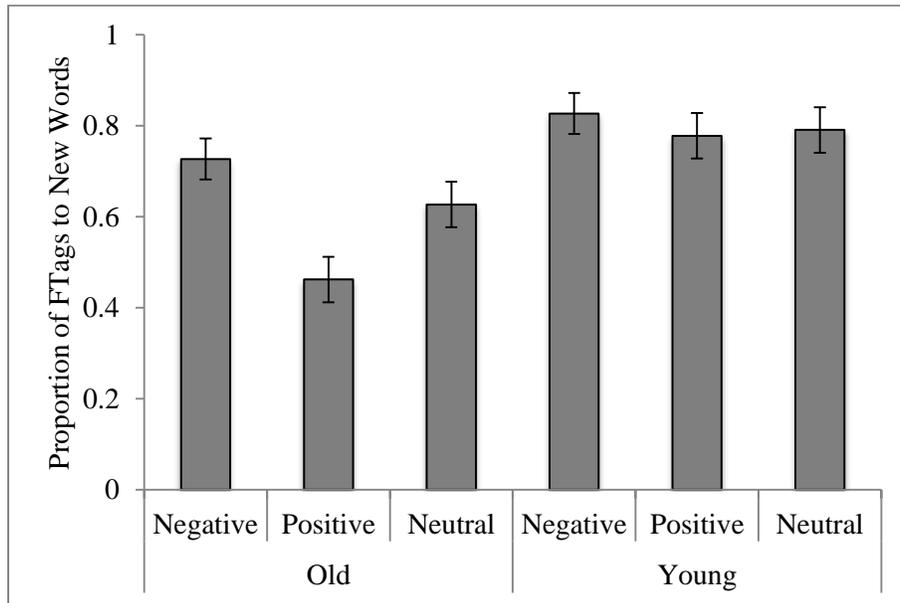
Figure 6. Proportion of New words attributed an F tag as a function of age and emotion. Error

bars represent standard errors of the means.

Potential confounding variables. As can be seen from the Sample Characteristics (Table

1), young and older adults differed on several of the external measures that were administered.

Considering this, it was important to determine whether any of these differences could be

contributing to the observed age effects found in directed forgetting. In order to determine this,

correlation analyses were conducted between those variables showing significant age differences

and the magnitude of directed forgetting (i.e., TBR discrimination − TBF discrimination).

Significant correlations were revealed between the BAI ($r = .242$, $p < .05$), Shipley ($r = -.239$, p

$< .05$), and DSST ($r = .409$, $p < .001$) and directed forgetting. To determine whether these

variables could be mediating the age effects on directed forgetting, mediation analyses were

performed according to Hayes' technique (Hayes, 2012). The main effect of age on directed

forgetting remained significant after controlling for BAI scores ($p < .05$) and Shipley

performance ($p < .01$), but became non-significant ($p > .28$) after controlling for the DSST score.

This finding suggests that the effects of age on directed forgetting may be partially mediated by a

general age-related slowing in processing speed.

Discussion

  The goal of the first experiment was to investigate the effects of age and emotion on the ability to intentionally forget. Overall, the study sought to address the following research questions: (1) Are there age differences in item directed forgetting of emotional information?, and (2) how do age and emotion affect the ability to correctly attribute a source to a previously studied item during recognition? To address these questions, young and older adults were compared on an item directed forgetting task, modified to incorporate positive, negative, and neutral stimuli that were matched on low arousal ratings. Moreover, a tagging recognition procedure developed by Thompson et al. (2011) was adopted to examine source attribution performance. This section summarizes the primary findings of the first experiment. A discussion of the broad theoretical implications of the findings and their relation to previous research can be found in the General Discussion section.

  Item directed forgetting effects. In general, the discrimination accuracy results replicated the directed forgetting effect, indexed by a greater recognition of TBR relative to TBF items (MacLeod, 1998). In terms of age differences, it was predicted that young adults would show a greater magnitude of directed forgetting relative to the older group, which was supported by an interaction between age and memory cue. Further investigation revealed that this interaction was driven by young adults' tendency to remember more TBR and fewer TBF items than older adults, suggesting a reduction in directed forgetting performance with age.

  Regarding the effects of age and emotion, it was hypothesized that young adults' directed forgetting of emotion would be either reduced or unaffected by emotion, given the mixed findings in literature (e.g., emotional disruption: Hauswald et al., 2010, and no effect: Brandt et al., 2013; Yang et al., 2011). On the other hand, in line with the socioemotional selectivity

framework of Carstensen (1995), a disruption of directed forgetting for positive information (or facilitation for negative information) was expected in the older group. The results of Experiment 1 largely supported these hypotheses, revealing an interaction between age, emotion, and memory cue. Further investigation of this interaction revealed that young adults' intentional forgetting was not affected by the valence of words. Indeed, directed forgetting occurred across the three emotion conditions in the younger group to almost an equal extent, which is consistent with some recent findings (e.g., Brandt et al., 2013; Yang et al., 2011). When assessing the effects of emotion on older adults' performance, in line with predictions, the data showed directed forgetting for negative and neutral, but not for positive words. More specifically, older participants remembered more positive than negative TBF items, and more positive TBF items than young adults, suggesting an age-related positivity effect for words cued as TBF (Reed & Carstensen, 2012).

When investigating recognition biases, older and younger adults were found to have a general bias to classify emotional items as old, which is consistent with prior findings (Hauswald et al., 2010; Kapucu, Rotello, Ready, & Seidl, 2008; Windmann & Kutas, 2001). In addition to this, emotional valence was found to differentially affect older and younger adults' recognition bias toward the two cue conditions (i.e., TBR vs. TBF). More specifically, older adults showed a bias to classify positive relative to negative and neutral information as previously studied. This was particularly true for positive TBR items, which had considerably higher Br scores relative to negative or neutral TBR items (see Figure 4). This may suggest that older adults' were biased to classify positive stimuli in the current study as 'to-be-remembered'.

Source attributions. Using a tagging recognition procedure (see Thompson et al., 2011), the effects of age and emotion on the ability to assign a source to a word were examined. Using

the same procedure, Thompson and colleagues' found that young adults were able to correctly attribute a source to a word 75% of the time. Replicating these findings, the results from Experiment 1 showed a comparable accuracy rate of 73% in young adults. When comparing young and older adults, it was predicted that a general age-related decrement in source accuracy would emerge. Consistent with this hypothesis, older adults showed a reduced source attribution rate of 62%.

With respect to the effects of age and emotion, it was initially predicted that emotion might impact older adults' source attribution performance to a larger extent than young adults. The findings from Experiment 1 supported this prediction, such that the source attributions of older but not young adults were affected by emotion. Specifically, for older adults, source attribution accuracy was lower for TBF relative to TBR positive words, and also lower for TBR negative relative to TBF negative words; there was no difference in the proportion of correct source attributions of neutral words for older adults. This finding was presumably due to older adults' natural intention to remember positive and forget negative information, driven by their prioritized emotion regulation goals, as purported in the socioemotional selectivity theory (Carstensen, 1995).

Lastly, as predicted, the analysis on the misattributions of new words (i.e., tagging a new word as TBR or TBF) showed a tendency to classify a new item as TBF. This was consistent with the findings of Thompson and colleagues (2011) who found that out of the misattributions made to new words, participants attributed it as a TBF word 71% of the time. The authors interpreted this finding as suggesting that participants may be actively forgetting the TBF items, leading to a weaker memory trace for those stimuli relative to the TBR items. As a result of this, it is more likely that participants will confuse an unstudied new item as TBF rather than TBR.

On the contrary, if TBR and TBF items had a similar representation in memory, then differences in the proportion of misattributions made to new items would not be expected. Consistent with Thompson et al., Experiment 1 showed a nearly identical pattern of findings with participants misattributing a new word for a TBF as opposed to TBR item 70% of the time. When comparing young to older adults, it was predicted that the older group would be less likely to attribute an F tag to a new word than young adults. This prediction was rooted in the idea that if older adults have a reduced capacity to inhibit the processing of irrelevant stimuli – in this case, TBF items – they should also have a stronger representation of those items in memory than young adults, who were able to successfully suppress TBF items. If the memory trace for TBF items is stronger, there should not be as many misattributions of F responses to New items. This falls in line with Thompson et al.'s (2011) argument that higher misattribution of F responses to New items arise because of an unequal representation of TBR and TBF items in memory, with the former being stronger than the latter. Since older adults had a stronger trace in memory for the TBF items relative to young adults, they may be less likely than their young counterparts to assign an F tag to a New word when in a state of uncertainty. The data from Experiment 1 fell in line with this hypothesis, with reduced F misattributions to New words in the older sample. Regarding emotional effects, if older adults showed reduced directed forgetting of positive stimuli then they should show a reduced tendency to misattribute positive new items as TBF. Again, data generally supported this prediction (see Figure 5). In contrast, young adults' source attribution performance was not affected by emotion.

In sum, three main findings emerged from Experiment 1: (1) low arousing emotional words matched on arousal to neutral words are not disruptive to young adults' directed forgetting or source attributions; (2) older adults' intentional forgetting of positive information is reduced

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relative to that of negative and neutral information; and (3) emotion may be disruptive to older adults' ability to assign a source to a word within the context of directed forgetting. Overall, the findings provide evidence that emotional valence may serve as a salient factor that affects older adults' item and source processing. As well, it adds to the literature by supporting the findings of Brandt et al. (2013) that emotional valence may not be disruptive to young adults' ability to follow an instruction to forget. Finally, findings from the tagging procedure replicated and extended the results of Thompson and colleagues (2011) to an older sample, further supporting the applicability of this procedure to future directed forgetting studies.

Although informative, the results of Experiment 1 raise some interesting questions. As previously discussed, research has suggested that older adults may engage in a controlled enhancement of positive information in an effort to fulfill emotional goals (e.g., Mather & Knight, 2005). However, whether older adults were using such a strategy during the encoding phase of directed forgetting cannot be fully addressed with the current data. The results present preliminary evidence to suggest that older adults may be biased to classify positive items as ones that they were supposed to remember in the context of directed forgetting, as indicated by the recognition bias analyses. This may suggest that a mechanism at recognition, and not encoding, is driving the emotional effects observed in the older adult sample. As such, the second experiment sought evidence for whether the positivity effect that emerged for the positive TBF items in the current experiment could be a result of effortful, controlled processing during encoding.

Experiment 2: The Role of Attention in Older Adults' Directed Forgetting

The results of the first experiment suggest that older adults may have difficulty engaging in forgetting of low arousing positive information, even when provided with an explicit direction to do so. Compared to young adults, whose intentional forgetting was not affected by emotion, older adults showed the directed forgetting effect for negative and neutral words only. Several studies support the notion of a positivity effect in attention (Isaacowitz et al., 2006) and memory (Kensinger, 2008), whereby older adults avoid negative and show a bias for positive information (Reed & Carstensen, 2012). Moreover, research has suggested that this positivity effect may be specific to instances of controlled processing, whereby older adults recruit cognitive resources to enhance positive and diminish negative content in memory. Results from the first experiment are limited in that conclusions regarding differences in the allotment of cognitive resources across emotion conditions during the encoding of older adults cannot be drawn. Thus, the goal of the second experiment was to address the main research question of whether older adults' reduced directed forgetting could be due to enhanced processing of positive stimuli causing those items to be more resistant to forgetting.

One way to address this question is to examine the resources that older participants are allocating to each emotion condition during encoding. If older adults do in fact exert energy toward emotion regulation, as posited by the SST, then this motivational state should affect where attention is allocated (see Mather & Carstensen, 2005 for a review). Behaviourally, this can be investigated using a probe-detection task, often used to measure selective attention. For example, Mather and Carstensen (2003) used a dot-probe detection task to investigate age differences in attention and memory for emotional and neutral faces. Older and young participants saw two side-by-side faces, one neutral and one emotional (i.e., positive or

negative), followed by a probe that appeared in the location of one of the faces. Older adults

were faster to respond to the probe if it appeared behind a positive as opposed to neutral face,

and slower to respond if it appeared behind a negative rather than neutral face. As such, how

much attention older adults allocate to certain stimuli seems to be affected by whether that

information is positive, negative, or neutral. Thus, in the second experiment, a probe-detection

task was combined with the same item directed forgetting task from Experiment 1. During

encoding, words were presented for study on an item-by-item basis, each followed by a memory

cue. While the word was on the screen, a probe appeared either to the left or right of the word,

and participants had to indicate the location of the probe via button response. Different from the

first experiment, Experiment 2 was carried out with older adults only. This was driven by the fact

that young adults did not show an emotional effect in their directed forgetting performance, and

thus were not expected to show a bias in their attention toward any one of the emotion

conditions. The second experiment also sought to replicate the emotional effects found with

older adults in the first experiment.

Based on the findings of the first experiment and the assumption of the socioemotional

selectivity framework, it was predicted that older adults would show greater attention toward

positive relative to neutral or negative words, indexed by faster RTs to detect probes during trials

involving a positive word. Regarding the directed forgetting effect and source attribution

performance, the same pattern of results as in the first experiment was expected. However, it is

important to note that the secondary task incorporated into the paradigm could potentially affect

the resources left to effectively encode the memoranda.

Method

Participants. Thirty-six older adults (aged 65-91 years, $M = 73.92$, $SD = 7.55$) from the Ryerson Senior Participant Pool participated in this study. All participants were tested in the Psychology Research and Training Centre at Ryerson University, and were compensated $10 per hour of participation.

The final sample characteristics are displayed in Table 7. Participants were healthy, without any diagnosed neurologic or psychiatric disorders. Participants were excluded and replaced based on the same criteria as Experiment 1, for which the data of two participants were replaced. One participant's data was excluded and replaced due to program failure.

Table 7

Sample Characteristics for Experiment 2

Measure	Older Adults M (SD)
Age in years	73.92 *(7.55)*
Years of education	16.42 *(2.98)*
Age learned English	.14 *(0.83)*
PANAS: Positive Affect	34.11 *(7.04)*
PANAS: Negative Affect	11.97 *(4.19)*
CES-D	10.69 *(7.84)*
BAI	4.22 *(5.75)*
Vocabulary[a]	37.33 *(2.38)*
DSST	65.44 *(15.05)*
Health Rating[b]	8.50 *(1.16)*
Short Blessed Test	.78 *(1.29)*

Note: A detailed description of each measure can be found on page 19.
[a]Assessed with the Shipley Institute of Vocabulary test. [b]Assessed using a scale ranging from 1 (poor) to 10 (extremely health).

Materials. The experiment was programmed and displayed using E-Prime version 2.0. All stimuli were displayed against a white background in black Courier New size-18 font, and

displayed on a 17" PC laptop with a viewing distance of approximately 60 cm. Responses to probes were recorded from the laptop keyboard, using the 'z' (for probes to the left) and '.' (for probes to the right) keys. Responses for the recognition task were recorded using the 'z', space bar, and '.' keys for R, New, and F responses respectively.

Stimuli. The word stimuli for this experiment were identical to the stimuli used in Experiment 1 (Table 2 for characteristics and Appendix 1 for a list of the stimuli). The probe was presented as a black asterisk (i.e., '*'), appearing either to the left or right of each word. Seventy-two probes appeared throughout the experiment, and were equally as often presented on the left or right, with no more than three consecutive probes appearing on the same side.

Procedure. The procedure for Experiment 2 was nearly identical to that of Experiment 1, with the exception of the added probe-detection task during encoding. Upon arrival to the lab, participants were introduced to the experiment and informed consent was collected. Participants were told that a series of words would be presented one-by-one for study, and that they should try to remember those followed by the cue 'RRRR' and forget those followed by the cue 'FFFF'. In addition to this, they were told that while they studied the words, a black asterisk would appear either to the left or right of the word. Participants were instructed to press a designated key on the keyboard to indicate which side the asterisk appeared on (i.e., 'z' for left, '.' for right). Similar to Experiment 1, participants were aware that a memory test would follow, but were not aware that their memory for words cued as 'FFFF' would be tested.

Encoding. During the encoding phase, participants completed 12 buffer trials, six at the beginning and six at the end of the list, and 60 experimental trials (30 TBR and 30 TBF). Similar to Experiment 1, memory for buffers was not tested. Prior to the experimental trials, participants completed three practice trials to familiarize themselves with the task. If needed, they could

repeat the practice trials. As shown in Figure 7, each trial began with a fixation point for 500 ms, followed by a word, which remained at the centre of the screen for 3000 ms. Five-hundred ms following the onset of the word, a black asterisk (i.e., '*') appeared on either the left or right of the word and stayed on the screen for up to 2500 ms (i.e., end of word presentation). During these 2500 ms, the participant was required to respond to the location of the asterisk by pressing designated keys on the keyboard ('z' key for left, '.' key for right). If the participant responded before the end of the 2500 ms, the probe disappeared, and the word remained on the screen until the end of the 3000 ms. Following the word, a blank screen appeared for 1500 ms as an ISI, after which the memory cue ('RRRR' or 'FFFF') appeared for 1000 ms. After the cue, another ISI occurred for 500 ms before proceeding to the next trial.
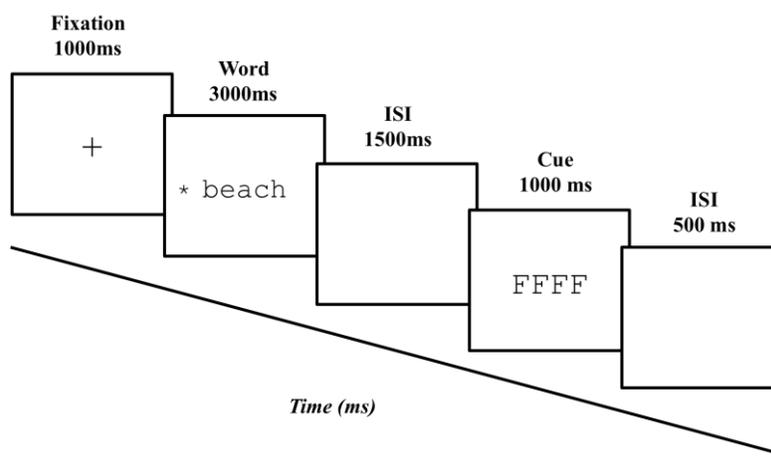
Figure 7. TBF trial from the combined probe-detection and item directed forgetting task.

Filler task. Following the encoding task, the DSST was administered as a filler task between encoding and recognition for two minutes.

Recognition. The procedure for the recognition task was identical to that of Experiment 1 (see page 23). Following recognition, participants completed the PANAS, Shipley Vocabulary test, CES-D, BAI, SBT, and a background questionnaire. Finally, they were debriefed and compensated for their time.

Statistical analyses. To test the hypotheses surrounding probe RTs, the trials on which the participant correctly detected the location of the probe were selected. Using these trials only, the RTs were trimmed for outliers that fell above or below 2.5 standard deviations of the mean. The data were then submitted to an ANOVA with emotion (i.e., negative, positive, neutral) as the only within-subjects variable.

Discrimination accuracy (i.e., Pr) and recognition bias (i.e., Br) scores were computed to determine replication of the directed forgetting effects found in the older sample from Experiment 1. The procedure for computing these scores was identical to that of Experiment 1 (see page 25; Snodgrass & Corwin, 1988). These scores were then submitted to a 2 (cue: remember, forget) × 3 (emotion: negative, positive, neutral) ANOVA.

Next, source attributions made to TBR and TBF items were analyzed according the procedure outlined on pages 24 and 25. Briefly, correct source attributions were indexed as the proportion of old words that were attributed a correct source, divided by the total number of items recognized as old for each word type (e.g., R responses to TBR items / [R responses to TBR items + F responses to TBR items]). As well, misattributions to New words were calculated as the number of TBR or TBF attributions made to New items out of the total number of New items recognized as old (e.g., R responses to New items / [R responses to New items + F responses to New items]). The resulting scores from each of these calculations were then submitted to two separate repeated measures ANOVAs with emotion (negative, positive, neutral) as the only within-subjects variable.

Analyses were conducted using SPSS version 19.0 with alpha levels set at .05 unless specified otherwise. Follow up ANOVAs and *t*-tests were conducted where appropriate to

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unpack any significant effects or interactions. Where necessary, corrections for multiple post-hoc comparisons were made using the Bonferonni technique.

Results

The results for Experiment 2 are presented in three sections. The first section summarizes the results from the analysis exploring emotional effects on probe-detection RTs. The second section presents the discrimination accuracy and recognition bias analyses looking at the effects of emotion on directed forgetting. Finally, the last section summarizes the source attribution results including correctly attributed sources and misattributions made to New words.

RT analysis. Table 8 displays the reaction times and proportional error rates to detect the probes for each emotion condition in milliseconds.

Table 8

Mean Reaction Times (ms) and Proportional Error Rates to Detect Probes as a Function of Emotion

Valence	RTs *(SD)*	Error Rates
Negative	691.81 *(208.96)*	.01
Positive	669.16 *(195.98)*	.01
Neutral	682.05 *(203.46)*	.01

No significant effects were revealed in the analysis on RTs to detect a probe, $p = .162$. The reaction times to detect probes were relatively equal across the three valence conditions, with a marginally significant difference between positive and negative trials, $p = .059$. Since accuracy was at ceiling, it was not further investigated.

Item-based recognition. Table 9 displays the hits, false alarms, and discrimination accuracy scores (i.e., Pr), and recognition bias (i.e., Br) as a function of emotion and cue. Table 10 presents the summary of the ANOVA on discrimination accuracy.

Table 9

Hits, False Alarms, Pr, and Br as a Function of Emotion and Cue

		Older Adults	
		TBR	TBF
		M (SD)	*M (SD)*
Negative			
Hits		.78 *(.21)*	.66 *(.21)*
False Alarms		.08 *(.09)*	.21 *(.18)*
Pr		.71 *(.22)*	.46 *(.24)*
Br		.36 *(.31)*	.38 *(.28)*
Positive			
Hits		.74 *(.23)*	.66 *(.24)*
False Alarms		.15 *(.17)*	.13 *(.12)*
Pr		.59 *(.25)*	.53 *(.25)*
Br		.39 *(.29)*	.32 *(.31)*
Neutral			
Hits		.68 *(.22)*	.61 *(.21)*
False Alarms		.09 *(.11)*	.11*(.12)*
Pr		.59 *(.20)*	.49 *(.23)*
Br		.27 *(.30)*	.25 *(.24)*

Table 10

Summary of ANOVA Results for Discrimination Accuracy in Experiment 2

Effect	Df	*F*	*MSE*	*P*	η_p^2
E	2, 70	1.532	.030	.223	.042
C	**1, 35**	**16.835**	**.960**	**<.001**	**.325**
E × C	**2, 70**	**5.434**	**.188**	**.006**	**.134**

Note: E = Emotion, C = Cue; significant effects displayed in bold font.

The discrimination accuracy analysis revealed a significant directed forgetting effect, as indexed by the main effect of cue, $F(1, 35) = 16.84$, $p < .001$, $\eta_p^2 = .33$. In general, there was a greater recognition of TBR (*M = .63, SD = .20*) relative to TBF (*M = .49, SD = .19*) items. All other main effects were not significant, *ps > .223*.

There was a significant interaction between emotion and cue, $F(2, 70) = 5.43$, $p < .01$, η_p^2 = .13, suggesting that older adults' directed forgetting was affected by emotion. Follow-up paired sample t-tests revealed that across emotion conditions, older adults showed directed forgetting for negative (TBR items, $M = .71$, $SD = .22$; TBF items, $M = .46$, $SD = .24$, $t[35] = 5.31$, $p <$ .001) and neutral items (TBR items, $M = .59$, $SD = .20$; TBF items, $M = .49$, $SD = .23$, $t[35] =$ 2.09, $p < .05$), but not for positive items (TBR items, $M = .59$, $SD = .25$; TBF items, $M = .53$, $SD = .25$, $p > .299$). Additional t-tests revealed that for TBR items, the older group remembered more negative than positive, $t(35) = 3.49$, $p < .01$, and neutral, $t(35) = 4.06$, $p < .001$ words. This interaction is displayed in Figure 8.
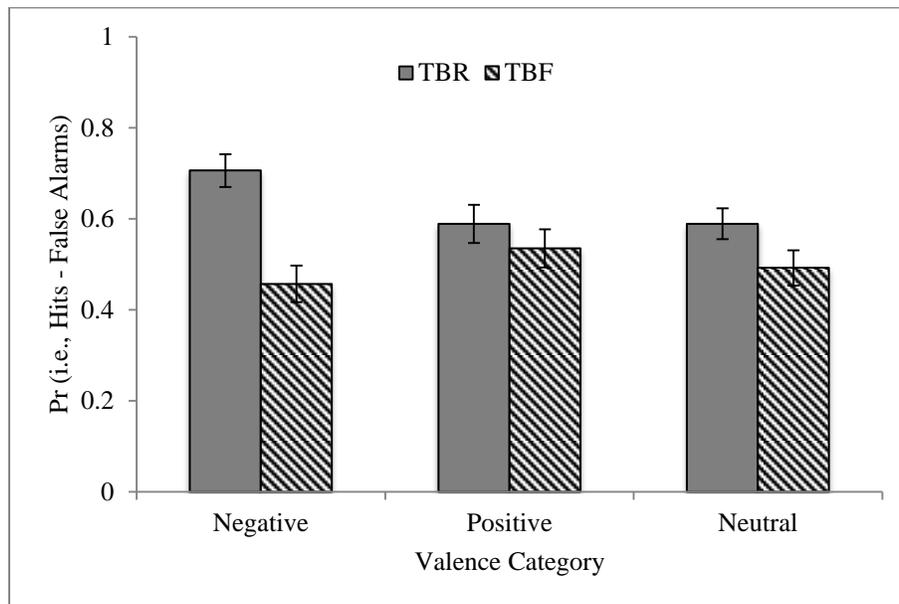

Figure 8. Discrimination accuracy for TBR and TBF items as a function of emotion. Error bars represent the standard errors of the means.

When analyzing recognition bias, the resulting Br scores for each emotion condition were all less than .5, indicating a conservative recognition bias. Table 11 displays the summary of the ANOVA on recognition bias.

Table 11

Summary of ANOVA Results for Recognition Bias in Experiment 2

Effect	Df	F	MSE	P	η_p^2
E	**2, 70**	**8.588**	**.263**	**<.001**	**.197**
C	1, 35	.833	.033	.368	.023
E × C	2, 70	1.031	.038	.362	.029

Note: E = Emotion, C = Cue; significant effects displayed in bold font.

The analysis revealed a main effect of emotion, $F(2, 70) = 8.60$, $p < .001$, $\eta_p^2 = .20$; all other main effects and interactions were not significant, $ps > .362$. Follow-up analyses revealed a higher Br for positive ($M = .36$, $SD = .26$) relative to neutral words ($M = .26$, $SD = .24$), $t(35) = 2.95$, $p < .01$, and a higher Br for negative ($M = .37$, $SD = .31$) relative to neutral words, $t(35) = 3.72$, $p < .01$ (see Figure 9).
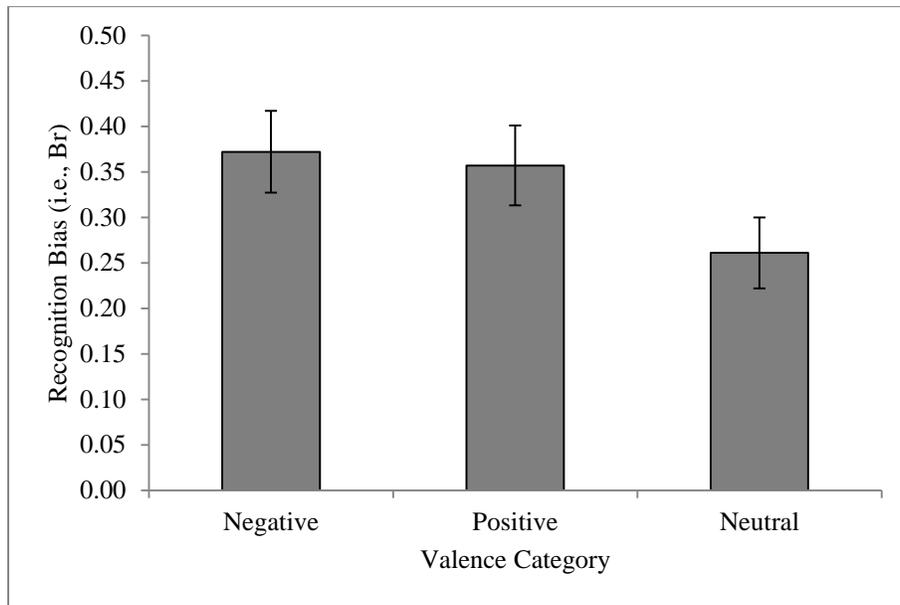

Figure 9. Recognition bias scores as a function of emotion. Error bars represent standard errors of the means.

Source attributions. Table 12 displays the values for the ANOVA ran on correct source attributions.

Table 12

Summary of ANOVA Results for Source Attributions in Experiment 2

Effect	Df	*F*	*MSE*	*P*	η_p^2
E	2, 70	.018	.001	.983	.001
WT	1, 35	.029	.004	.866	.001
E x WT	**2, 70**	**18.123**	**.908**	**<.001**	**.341**

Note: E = Emotion, WT = Word Type; significant effects displayed in bold font.

Next, correct source attributions made to old words were analyzed as a function of emotion and word type. All main effects were non-significant, $ps > .866$. Similar to the results of Experiment 1, there was an interaction between emotion and word type, $F(2, 70) = 18.12$, $p < .001$, $\eta_p^2 = .34$. Follow-up *t*-tests revealed that for positive words, older adults had higher correct source attributions to TBR items ($M = .69$, $SD = .22$) than TBF items ($M = .50$, $SD = .26$), $t(35) = 3.11$, $p < .01$. The opposite pattern was seen for negative items, with higher correct source attributions to TBF ($M = .72$, $SD = .26$) relative to TBR items ($M = .46$, $SD = .28$), $t(35) = -3.51$, $p < .01$. No differences were observed for source attributions made to neutral TBR and TBF items, $p = .626$. Across emotions, negative TBR items were assigned fewer correct source attributions than positive TBR items, $t(35) = -4.30$, $p < .001$, while positive TBF items were assigned fewer correct source attributions than negative TBF items, $t(35) = 3.90$, $p < .001$. This interaction replicates that found in Experiment 1 and is displayed in Figure 10.
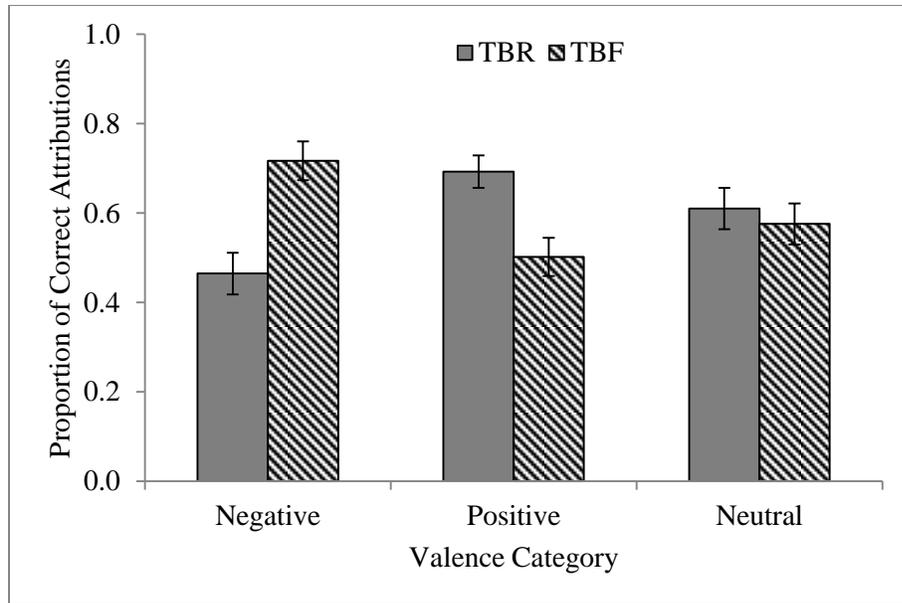
Figure 10. Proportion of old words attributed a correct source as a function of word type and emotion. Error bars represent standard errors of the means.

When misattributions to New items (i.e., attributing a New word as TBR or TBF) were examined, the data of eight participants who did not make any misattributions to New items were excluded. Overall, a higher proportion of F (M = .55, SD = .22) relative to R tags (M = .45, SD = .22) were assigned, but this difference was not statistically significant, p = .201. When comparing across valence categories, consistent with Experiment 1, the ANOVA revealed a main effect of emotion, $F(2, 54)$ = 7.97, $p < .01$, η_p^2 = .23. Paired sample t-tests showed that this effect was driven by a higher proportion of F tags assigned to negative (M = .71, SD = .26) relative to positive (M = .43, SD = .31), $t(27)$ = 3.80, $p < .01$, and neutral items (M = .52, SD = .35), $t(27)$ = 2.70, $p < .05$. F tags assigned to positive items did not differ from those assigned to neutral items, p = .237 (see Figure 11).
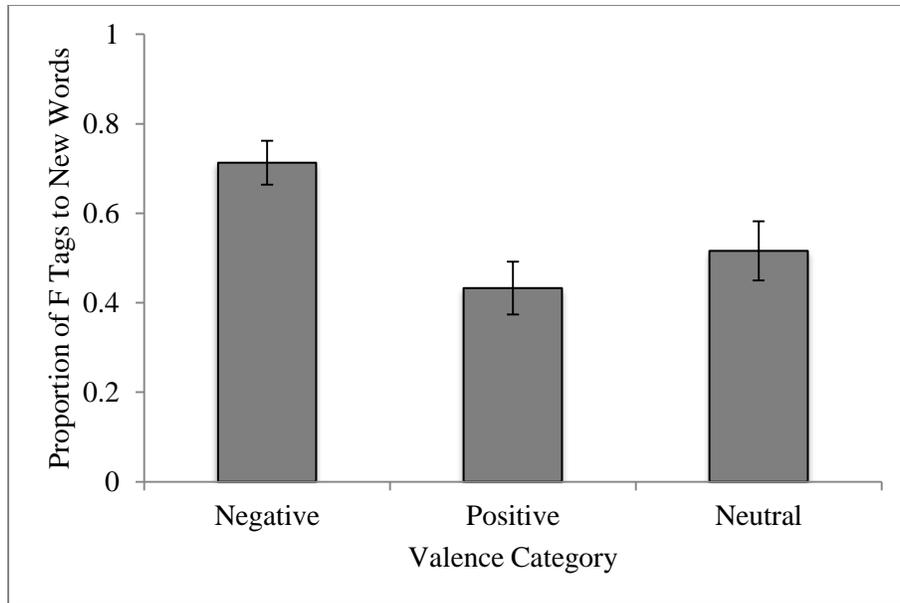
Figure 11. Proportion of New words attributed an F tag as a function of emotion. Error bars

represent standard errors of the means.

Discussion

The goal of Experiment 2 was to investigate the role of attention in older adults' directed forgetting of emotional information. Specifically, the study sought to determine if older adults' reduced directed forgetting for positive information found in Experiment 1 was a result of an enhancement of that information during encoding. In order to address this goal, a probe-detection task was incorporated into the encoding phase of an item directed forgetting paradigm for positive, negative, and neutral words. While studying words, participants were required to respond to the location of a probe that appeared either to the left or right of the word. This paradigm allowed us to assess the allocation of attention to stimuli of differing emotional valences, based on the RTs to detect probes. If older adults are recruiting cognitive resources to enhance positive or diminish negative information in an attempt to fulfill emotional goals, then this motivation should also affect their allocation of attention; thus, they may be faster to detect probes appearing simultaneously with a positive word relative to probes presented with a neutral or negative word (e.g., Mather & Carstensen, 2003; Mather & Carstensen, 2005). A second goal of Experiment 2 was to replicate the findings of the first experiment. That is, it was asked whether older adults would show a similar pattern of reduced directed forgetting of positive information and similar emotional effects for source attribution performance. This section summarizes the main findings that emerged from Experiment 2. The larger theoretical implications of the results will be touched upon in the General Discussion section.

Probe-detection. Attentional demands during encoding were assessed using a probe-detection task that was inserted into the study phase of directed forgetting. In general, the valence of the trial during which a probe was presented did not appear to affect older adults' attention. This was illustrated by relatively equal RTs to detect probes across the three emotion

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conditions. There was, however, a marginally significant difference between positive and neutral trials, indexed by reduced reaction times to detect probes during presentation of a positive word. The fact that reaction times were not affected by emotion may suggest that the probe-detection task in the current experiment may not have been sensitive enough to measure attentional resources during encoding like that of Mather and Carstensen (2003).

Item directed forgetting effects. Results of Experiment 2 revealed a significant directed forgetting effect with greater recognition of TBR relative to TBF words (MacLeod, 1998). When examining the effects of emotion on older adults' directed forgetting, results were comparable to that of the first experiment: Older participants showed directed forgetting for negative and neutral words but reduced directed forgetting of positive information. Different from Experiment 1, there was only a general recognition bias to classify emotional information as old, as opposed to a differential emotional bias across cue conditions.

Source attributions. Again, replicating the findings of Experiment 1, older adults' source attributions were affected by valence. Specifically, reduced accuracy to negative TBR relative to negative TBF items was found. As well, correct source attributions were lower for positive TBF than positive TBR items. When examining misattributions made to New words, older adults showed fewer F tags assigned to positive relative to negative words. This pattern of findings is generally consistent with those from the first experiment.

In sum, results of Experiment 2 largely replicated that of the first experiment, with reduced directed forgetting for positive information in older adults and differential emotional effects in source attribution performance. Results from the probe-detection task, however, did not fall in line with predictions. Instead, emotion did not affect older adults' reaction times to detect probes.

General Discussion

Overall, the main goals of this thesis were (1) to examine age differences in the intentional forgetting of emotional information; (2) to understand how age and emotion would affect the ability to assign a source to a word in the context of directed forgetting; and (3) to assess the role of attention in older adults' directed forgetting of emotional information. Although forgetting is often considered maladaptive, understanding how we forget is just as important as understanding how we remember critical information. Moreover, on a daily basis, we are faced with an influx of information that varies in emotional tone. Therefore, it is important to understand how we come to prioritize different types of information (i.e., emotional vs. non-emotional) in memory through processes such as intentional forgetting. This thesis provides some insights into how factors such as age and emotion might affect instances in which we would prefer to forget.

To address these goals, two experiments were conducted. In Experiment 1, young and older adults were compared on an item directed forgetting task of positive, negative, and neutral words. Furthermore, a tagging recognition procedure was adopted to explore the effects of aging and emotional valence on source attributions. Experiment 2 aimed to determine the role of attention in older adults' intentional forgetting of emotional information using a probe-detection task that was incorporated into the encoding phase of the same item directed forgetting task used in Experiment 1. Additionally, the second experiment sought to replicate the findings of the first.

Aging and Emotional Effects on Item Directed Forgetting

Results from the first experiment demonstrated an age-related decrement in the directed forgetting effect, as indexed by greater accuracy to TBR and reduced accuracy to TBF items in the young relative to older sample. In general, this finding is consistent with the literature (e.g.,

Andres, Van der Linden, & Parmentier, 2004; Hogge, Adam, & Collette, 2008; Earles &

Kersten, 2002; Sego, Golding, & Gottlob, 2006; Titz & Verhaeghen, 2010; Zacks et al., 1996).

On a theoretical level, the results provide support for the inhibitory deficit theory of aging,

proposed by Hasher and Zacks (1988). As previously mentioned, directed forgetting has been

purported to reflect the activation of an inhibitory mechanism that actively withdraws attention

from and prevents further processing of TBF stimuli (e.g., Fawcett & Taylor, 2008; Paz-

Caballero et al., 2004; Taylor, 2005; van Hooff & Ford, 2011; Wylie et al., 2008; Zacks et al.,

1996). If a mechanism of this sort is indeed responsible for directed forgetting, then according to

Hasher and Zacks' theory, older adults should show a reduced ability to inhibit processing of

TBF information. The results reported here are consistent with this hypothesis with older adults

showing greater accuracy to TBF items relative to young adults.

Regarding emotional effects on intentional forgetting, young adults' performance did not

differ across the three valence conditions. Some research has suggested that directed forgetting is

reduced or abolished in young participants when emotional stimuli are incorporated as

memoranda (e.g., Bailey & Chapman, 2012; Hauswald et al., 2010; Nowicka et al., 2011; Otani

et al., 2012). However, the current research falls in line with findings suggesting that emotional

information is not disruptive to young adults' ability to actively follow an instruction to forget

(e.g., Brandt et al., 2013; Yang et al., 2011). As discussed previously, these discrepancies in the

literature may be explained by differences in materials, such as whether the study used pictorial

or verbal stimuli. For example, the majority of studies demonstrating emotional disruption in

directed forgetting have used images (e.g., Hauswald et al., 2010). These stimuli may elicit

greater emotional reactions, producing a stronger trace in memory that is difficult to suppress

even when an explicit instruction to do so is provided. On the other hand, the current research

and that of Brandt et al. (2013) used verbal stimuli, which may not evoke as great of an emotional reaction as picture stimuli. Thus, the effects of emotion in directed forgetting may be material specific, possibly explaining the discrepancies between the literature and the current study.

The current study also took a novel step toward teasing apart the contributions of arousal and valence in directed forgetting by controlling for arousal across emotion conditions and isolating the effects of valence. This is particularly important considering research suggesting that these two dimensions activate distinct cognitive and neural mechanisms during processing (e.g., Kensinger et al., 2004). The fact that intentional forgetting was observed in young adults suggests that positively and negatively valenced words that are just as nonarousing as neutral words may not be resistant to intentional forgetting. As well, the lack of an emotional effect on young adults' directed forgetting could be a result of relatively low arousing stimuli adopted in the current investigation (ranging between 3.0 and 5.8, according to ANEW norms). Kensinger and colleagues (2004) suggest that arousing stimuli activates more automatic pathways in the brain (i.e., amygdalar-hippocampal networks), while low-arousing but emotional information activates frontal regions associated with more controlled processing. Since engagement in item directed forgetting requires the execution of similar controlled regions (e.g., Wylie et al., 2008), it may be that the processes required for directed forgetting overrode those needed for enhancing on low-arousing but emotional information in young adults. However, it is difficult for the current studies to support these explanations, as they did not directly compare the contributions of valence and arousal. Future research is warranted to further delineate the specific role of each dimension.

In contrast to their younger counterparts, older participants' directed forgetting was differentially affected by the emotional valence of words. In both experiments, older adults showed directed forgetting for negative and neutral items, but not for positive words. As well, they were found to recognize a greater proportion of TBF positive items than young adults. Together, these results are indicative of an age-related positivity effect in the TBF data (Reed & Carstensen, 2012). Working within a socioemotional selectivity framework, these findings may be best explained by older adults' increased emphasis on emotionally gratifying goals (Carstensen, 1995; Carstensen & Mikels, 2005; Mather & Carstensen, 2005). More specifically, it may be that older adults invested more cognitive resources to enhance positive information during encoding in an attempt to regulate their current emotional state. This would support prior research suggesting that older adults' positivity preference is rooted in controlled processing (Knight et al., 2007; Mather & Knight, 2005). As a result of this enhancement, positive items may have developed a stronger trace in memory, causing them to be more resistant to forgetting. Further support for this account may be obtained by contrasting the findings of Experiment 1 with a recent investigation by Barber and Mather (2012) on retrieval induced forgetting (RIF). RIF involves the *unintentional* forgetting of non-retrieved information, induced by the retrieval of only certain details of that information. In Barber and Mather's study, older adults were just as likely to show RIF for emotional as for non-emotional information. Since RIF is unintentional, occurring outside conscious awareness, it may not evoke the controlled enhancement of positive information in older adults that elicits positivity effects. That is, if the amount of available cognitive resources modulates the positivity effect in older adults, then it should not appear when processing occurs without conscious control. The current investigation made use of a directed forgetting paradigm where forgetting is *intentional* and within the participant's conscious

control; this might explain why the results of the current work demonstrate a pattern consistent with age-related positivity effects whereas Barber and Mather's (2012) findings do not.

Moving away from a controlled processing account of positivity effects, another plausible explanation may be that older adults simply are not motivated to recruit additional resources to forget information relevant to their emotional goals (i.e., positive stimuli). Such a perspective may also serve to explain the significant directed forgetting effect found for negative words. That is, it is in line with older adults' emotional processing goals to remove attention from negative stimuli and toward positive stimuli in an attempt to regulate emotion (Isaacowitz et al., 2006; Mather & Carstensen, 2003; Reed & Carstensen, 2012). As such, negative information may have facilitated implementation of a cue to forget, while positive information hindered this ability

Taken together, the findings related to the directed forgetting task support the notion that positive valence may be a salient variable affecting older adults' ability to intentionally forget. Data from the second experiment, however, suggest that emotion may not have affected older adults' attention during encoding. This might suggest that the probe manipulation was not sensitive enough to assess attentional allocation during encoding. One way to modify this could be to bring the current manipulation closer to that found in Mather and Carstensen's (2003) investigation where probe-detection took place following the presentation of each stimulus, as opposed to coinciding with stimulus encoding. If older adults are indeed enhancing positive information during encoding, their reaction times to detect probes *following* a positive word should be sufficiently faster than after a negative or neutral word. On the other hand, the null effect in the probe-detection RT analysis might also suggest that the mechanism driving the effects observed in the discrimination accuracy analysis may be acting during retrieval as opposed to during encoding. For example, older adults may simply have a preference to classify

positive items as ones they had previously seen. This would support previous research suggesting that the emotional enhancement effect in memory may be due to biases to classify emotional items as previously studied during recognition, instead of actual recollection of the material (Dougal & Rotello, 2007; Kapucu et al., 2008). In either case, further research is required to determine the underlying mechanism driving the directed forgetting effects observed across both experiments In contrast and as reviewed above, young adults' intentional forgetting appears not to be impacted by emotional valence.

Aging and Emotional Effects on Source Attributions

The first experiment also examined how aging and emotion would affect the ability to attribute a source to a word during recognition. This was explored using a tagging procedure, adopted from Thompson and colleagues (2011). The advantage of this paradigm lies in its ability to provide information on whether the participant remembers the word as one that was TBR or TBF. This is in contrast to the typical old/new recognition procedure, which only indicates whether the participant remembers previously studying the word. In general, the current results were consistent with Thompson et al.'s, showing a 73% correct source attribution rate, and providing further support for the use of this tagging procedure in directed forgetting.

When assessing age differences in source attributions, it was found that young adults were able to correctly attribute a source to a greater extent than older adults. This suggests an age-associated decline in source memory, and is consistent with research reporting similar decrements in associative memory with age (McIntyre & Craik, 1987; Naveh-Benjamin, 2000). In terms of emotional effects, an interesting pattern emerged from the data with older adults showing reduced source accuracy to positive TBF words and negative TBR words, while no difference was observed in source attributions assigned to neutral words. Here, a speculative

explanation for these results is offered, again working within the framework of the socioemotional selectivity theory (Carstensen, 1995). As previously described, since older adults are thought to place a greater emphasis on emotional gratification, it would be in line with their goals to *remember* positive and *forget* negative information. Following from this, in the current investigation, the cues instructing older participants to forget positive and remember negative words may have conflicted with their prioritized goals, making them less likely to bind the cues and words together in these specific instances. However, the cues instructing them to remember positive and forget negative information are presumably consistent with their goals and so the source attributions for these items was not disrupted. In contrast, young adults' source attributions did not differ across the valence conditions. These age differences in emotional effects are largely consistent with the socioemotional selectivity theory, as young adults are likely less motivated to enhance on emotional information than older adults. This viewpoint is also supported by prior research showing that young adults may only instantiate emotional enhancement strategies when in certain contexts, such as when given explicit instruction to do so (e.g., Yang & Ornstein, 2011).

Limitations

The current work has some limitations. As can be seen in the sample characteristics (Table 1) of the first experiment, the young group exhibited significantly higher depression scores on the CES-D relative to the older group. Moreover, their average score was slightly above the cut-off of 16 on the CES-D, suggesting possible sub-threshold depressive symptoms. However, despite previous research showing that individuals with depression may exhibit a bias toward negative information during processing (Ridout, Astell, Reid, Glen, Ronan, & O'Carroll, 2003) and that depression could disrupt directed forgetting of emotion (Power, Dalgleish,

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Claudio, Tata, & Kentish, 2000), there was no relationship between the CES-D scores and the magnitude of directed forgetting across and within the emotion conditions in young adults (*rs* between -.25 and -.05, *ps* > .10). Moreover, in the current investigation, young adults' directed forgetting performance were largely unaffected by emotion, which would not be the expected pattern of results if the sample were depressed (e.g., Power et al., 2000). Thus, it is unlikely that the higher CES-D scores in the younger sample affected the primary findings of Experiment 1.

Second, although the studies address the contribution of valence to directed forgetting in young and older adults, they do not provide information regarding the role of arousal. Due to the number of stimuli required for each valence by cue condition, it is difficult to assess a third variable, without impacting memory performance. Further research is therefore required to delineate the contributions of arousal to directed forgetting in young and older adults, by using high and low arousal emotional and/or neutral stimuli. If high arousing information relies on activation of more automatic pathways in the brain (Kensinger et al., 2004) and positivity effects are reliant on controlled processing (Mather & Knight, 2005), then an interaction between age, arousal, and cue should not be observed.

Finally, in the chosen list of stimuli, arousal, frequency, and word length were statistically controlled for across each of the valence and cue lists whereas the degree of semantic relatedness among the items was not. Prior research in young adults has suggested that the inherent level of relatedness among emotional memoranda could enhance the likelihood of those items being remembered later (Talmi & Moscovitch, 2004). As shown in Appendix 1, the inter-item relatedness was relatively similar across the three valence categories, thus it is likely that this factor did not contribute to the reported valence effects. Moreover, in the present investigation, young adults' performance was not affected by valence and the older sample did

not differ in performance across the negative and neutral conditions. Together, these results suggest that semantic relatedness, if any, was unlikely to play a role in the observed effects.

Future Directions

The two experiments presented in this thesis provide preliminary evidence for a disruption of intentional forgetting by low arousing positive information in older adults. As well, findings from the probe-detection task suggest that an attentional mechanism may be at work during encoding that enhances processing of positive stimuli. However, what this study does not address is at what point during processing positive information affects older adults' ability to follow an instruction to forget. To address this question, future research should utilize the ERP technique, which allows for an examination of the time course of emotional effects during intentional forgetting. Moreover, research should aim to address the neural structures involved in the intentional forgetting of emotional information in older adults. Each of these avenues of research would help to further elucidate the cognitive and neural mechanisms involved in older adults' intentional forgetting of emotional information. As well, these methods would be well suited to provide a more conclusive answer to the question of whether controlled processing is responsible for reduced directed forgetting of positive information observed in older adults.

<div align="center">**Conclusions and Implications**</div>

Prior research has revealed that age and emotional valence often interact in the context of cognitive performance. However, to date, the majority of studies have focused on how these two factors affect attention and memory processes with little information offered on how young and older adults might differ in the intentional forgetting of emotional information. Although perceived as a drawback to memory performance, forgetting has many adaptive values, such as reducing clutter in memory in order to promote processing of relevant information. This thesis

sought to shed light on how age and emotion affect our ability to forget. For this purpose, young and older adults were compared on a directed forgetting task for emotional and non-emotional information. Through the emergence of an age-related positivity effect for TBF information, the findings from these two experiments suggest that emotion serves as a salient variable affecting older adults' item and source processing. More specifically, older adults may have difficulty intentionally forgetting positive information, and attributing correct sources to information that is inconsistent with their goals. In contrast, and consistent with prior findings (e.g., Brandt et al., 2013), young adults' intentional forgetting does not appear to be affected by emotional information that is matched on arousal to neutral information and relatively low in arousal ratings.

Overall, the results of this study call into question the adaptive benefit of age-related positivity effects. Prioritizing specific information over others in order to enhance well-being and regulate emotion should certainly be considered adaptive. However, this prioritization becomes less adaptive in situations where that information becomes irrelevant and needs to be forgotten or ignored. Therefore, the results of the current study may reflect an instance where older adults' tendency to enhance or elaborate on positive information disrupts cognition by reducing their ability to intentionally forget. Such findings may be particularly informative to the development of effect cognitive training and educational programs for older adults, by providing information on how certain factors affect the information processing of aging individuals.

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Appendices

Appendix 1: Stimuli selected from the Affective Norms for English Words (Bradley & Lang, 1999) database for use in Experiments 1 and 2

Negative	Positive	Neutral
alone	angel	alley
blind	bath	aloof
blister	beauty	appliance
cemetery	bed	black
coward	bird	blase
cut	bless	board
dead	breeze	cannon
death	brother	coarse
discomfort	cake	contents
dummy	carefree	context
failure	comfort	corner
fat	dream	corridor
fault	elegant	custom
feeble	gentle	dark
fever	grateful	errand
gloom	heal	excuse
grief	hug	gender
handicap	leisurely	habit
ignorance	luxury	haphazard
illness	melody	knot
immature	music	lump
impair	nature	material
inferior	ocean	medicine
lost	pillow	muddy
messy	politeness	obey
moody	protected	odd
neglect	rainbow	passage
obesity	respectful	patient
poverty	reward	privacy
rat	safe	quart
sad	satisfied	rock
scar	secure	sheltered
sick	sky	shy
slum	snuggle	spray
stink	soft	stagnant
stupid	sunset	stiff
trash	twilight	stomach
unhappy	useful	tower
useless	warmth	trumpet
waste	wise	writer