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CAN DISTRACTIBILITY FACILITATE RECALL IN OLDER ADULTS? THE ROLE OF AFFECT AND HYPER-BINDING

by

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A Thesis
Submitted in Partial Fulfillment of the Requirements for the
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A Thesis Submitted in Partial

Fulfillment of the Requirements

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in the field of Psychology

Approved by:

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As people age, they attend to and recall positive stimuli at a higher frequency than stimuli that is negative in valence. This 'positivity effect' of older adults has been repeatedly demonstrated in the fields of human attention and memory. Studies have yet to examine the positivity effect within the realm of attentional inhibition, which was the focus of the current study. In the current study, both young and older adults were shown emotional images. These images varied in valence (negative, neutral, positive) and were superimposed with emotional words (also varying in valence). In the Adaptive condition of the study, participants were instructed to respond (via key-press) only to the images while ignoring the words. In the Nonadaptive condition, participants were instructed to respond (via key-press) to both the image and the word, which required them to simultaneously attend to both sets of stimuli. At the conclusion of each condition, all participants were given an implicit memory measure (Remote Associates Task) and a word-stem task to assess if they effectively inhibited the word stimuli. An independent *t*-test revealed a significant effect of age on average amount of RAT solutions, where young participants provided significantly fewer RAT solutions than older participants. Mixed-effects ANOVA revealed a significant effect of valence by

condition on number of correct RAT solutions, with significantly more negative RAT solutions provided in the Adaptive condition relative to the Nonadaptive condition. These results suggest that valence of stimuli and condition instructions may influence distraction in both young and older adults.

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CHAPTER 1

INTRODUCTION

The study of ‘executive function’ encompasses many fields of research, including learning, memory, attention, and problem solving. The nature of the study of ‘attentional functioning’ has changed dramatically from the origin of psychological science until today. The advent of technology has allowed attentional researchers to better quantify and observe attentional processes through eye-tracking and recording of reaction times. Subsequently, the characterization of attention has changed throughout the years. William James famously wrote:

> *Everyone knows what attention is. It is the taking possession by the mind…of one out of what seem several simultaneously possible objects or trains of thought…It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state which…is called distraction (James, 1890).*

As new methods of measuring attention emerged, James’ characterization of attention as a ‘spotlight’ fell out of favor.

John Ridley Stroop developed a task used to assess not only attention, but also its ‘opposite’, distraction (Stroop, 1935). Stroop’s task has two conditions, the first is congruent (matching word and color, e.g., ‘black’) and the second is incongruent (discordant word and color, e.g., ‘green’). The Stroop task allowed researchers to quantify the effect of irrelevant information (distractors in the form of incongruent stimuli) on overall performance. Several years later, Kahneman would suggest that attention is a finite resource, which can be allocated across various tasks but is available in limited quantities (Kahneman, 1973). Attention has clearly drawn the interest of researchers for many decades. This construct has a rich history of studies which attempt to measure, isolate, and manipulate it.

Beyond understanding how attention functions, researchers in developmental psychology are interested in how attention fluctuates across the lifespan. Utilizing cross-sectional designs, cognitive aging researchers have documented how types of attention differ between young and older adults. Hasher (2007) suggested that some types of attention (e.g., selective attention) may be more vulnerable to age-related deficits than others (e.g., focused attention). Several mechanisms have been proposed to describe how underlying resources may change with age, and subsequently contribute to performance on attentional tasks.

Both micro (e.g., Inhibitory Deficit Hypothesis) and macro (e.g., Generalized Slowing Hypothesis) theories have been proposed to explain an age-related decline in attentional performance (Craik & Salthouse, 2000). A micro perspective focuses on individual variables and attempts to isolate how they contribute to the phenomenon. The macro perspective is primarily focused on understanding what variables contribute the greatest amount of variance to the observed effect.

Kahneman (1973) proposed a ‘limited capacity’ model, in which executive functions (e.g., attention) are controlled by a finite amount of cognitive resources (“cognitive effort”). As tasks are introduced and completed, resources are distributed across necessary systems (e.g., while learning new content, ‘attention’ may consume more cognitive effort than ‘problem solving’). This allocation of resources is reflected in to the name ‘limited capacity model’, as while one system is utilizing cognitive resources, another system cannot utilize these resources simultaneously. In addition to Kahneman, Salthouse (1985) also proposed a macro approach to understanding attentional failures in older adults. Salthouse and colleagues provided supporting evidence for a 'processing speed' theory, which estimated that up to 75% of age-related performance effects could be contributed to processing speed alone (Salthouse, 2004). According to the Generalized Slowing Hypothesis, reduced performance may be the result of extended processing and a delay in response (e.g., increased reaction time) may be evidence of slowing in the central nervous system.

A micro approach has also been used to examine age-related deficits in attention. Hasher and Zacks (1988) proposed that attentional performance is dependent upon three components of inhibition – access, deletion, and restraint. Access allows relevant information to be attended to, deletion removes irrelevant information to maximize efficiency, and restraint prevents initial, strongly activated information from being immediately utilized. The Inhibitory Deficit Hypothesis posits that these three components of inhibition contribute to attentional processing. Accordingly, if inhibition is damaged or degraded, attentional performance will be impacted and may result in increased errors or greater reaction time. This outcome can be observed in those with inhibitory deficits, as they are often distractible, perseverative, and demonstrate slower overall processing (Hasher & Zacks, 1988). Conversely, those who experience age-related changes in attention will also demonstrate a reduced ability to ignore irrelevant information (Carr & Dagenbach, 1994). Hasher and Zacks (1988) were the first to suggest that performance on executive functioning tasks may be linked to the control of attentional resources. These findings may have important consequences for the study of activities of daily living such as language production and memory (Kim, Hasher, & Zacks, 2007).

It is important to note that while Hasher and Zacks (1988) suggested that cognitive processes may be impacted by attentional decline, not all processes are *negatively* impacted. In their recent work, Kim, Hasher, and Zacks (2007) proposed that performance on some tasks may actually be improved by a reduction of attentional resources. The Benefits of Distractibility Theory (Kim, et al., 2007) serves as a framework for how distraction may, at times, be adaptive for older adults and allow older adults to encode contextual details that would otherwise be ignored. The Hyper-Binding Theory (Campbell, Hasher, & Thomas, 2010) posited that older adults connect or ‘bind’ intended target information with uninhibited contextual information. The underlying mechanisms responsible for this process are yet unclear.

‘Affect’ may contribute to age-related changes in inhibitory processes. The role of affect is being increasingly recognized as an important variable to consider in the study of cognitive aging. Compared to young adults, older adults report shorter and less frequent negative emotional experiences (Carstensen, Isaacowitz, & Charles, 1999). One proposed mechanism for this finding is that older adults often ignore or redirect attention away from negative stimuli. By diverting their attention from negative stimuli, older adults may be regulating their negative emotions. This age-related trend of older adults remembering more positive than negative information has been referred to as the Positivity Bias.

The association between affect and inhibitory processes (including both the benefits and detriments of distractibility) was the focus of the current project. One implication of this research is the development of interventions and programs designed to maintain or improve activities of daily living such as driving ability, reading comprehension, and social interactions. The current study explored inhibitory ability and affect in young and older adults by placing emotionally valenced target words (e.g., a neutral word such as table) within the context of real-life images from the IAPS image set. These images also varied in valence from positive (e.g., beach), to neutral (e.g., key), to negative (e.g., blood). Performance on the Remote Associates Task (Mednick, 1962) was used to assess if participants successfully ignored the emotional word stimuli.

CHAPTER 2

LITERATURE REVIEW

Age-Related Changes in Attention

Many cognitive functions change as we age, and attention is no exception. There are several types of attention (e.g., divided, selective, sustained, focused) (Rogers, 2000). Some of these types of attention may be more sensitive to the aging process than others. For instance, performance on divided and selective attention tasks show large age-related declines, whereas sustained and focused attention are typically well preserved in older adults (Rogers, 2000). Each of these types of attention will be explored in turn.

Evidence of selective attention is demonstrated when a target stimulus is mixed with distractor stimuli. This form of attention is often assessed by using a visual search paradigm, which requires the participant to locate or identify a target (e.g., finding a pen in a cluttered drawer). Selective attention is negatively affected by age, with older adults finding fewer target items and performing slower than young counterparts (Kramer & Madden, 2008). This effect is amplified when the display size or demand load increase (e.g., larger drawer or more clutter, respectively). Kramer and Madden (2008) also recorded performance in older adults when the target and distractors were very similar (e.g., finding a yellow pen amongst pencils). Each of these manipulations resulted in lower target identification rates and overall slower performance. The authors suggest this is due to an increase in task demand. This effect can be exacerbated by limiting search time (e.g., reduced time to complete the task) or requiring concurrent searches (e.g., finding a yellow pen that also has a particular logo on it). Kramer and Madden (2008) suggested that age-related declines in performance may be mediated by requiring practice and providing cues to prime the location of a target.

Older adults tend to show a larger age-related decline on tasks which require ‘dividing’ attention, or distributing attention across multiple tasks (e.g., driving while listening to the radio) (Birren, Schaie, Abeles, Gatz, & Salthouse, 2006). Performance on divided attention tasks is very sensitive to aging (Kramer and Madden, 2008; Hasher, 2007). Similar to selective attention, as task demand increases, accuracy by older adults tends to decrease. These age-related declines in performance can be aggravated by increasing the complexity of concurrent tasks (e.g., driving on a narrow bridge while simultaneously listening to a captivating book) (Birren, Schaie, Abeles, Gatz, & Salthouse, 2006). Practicing the act of multitasking (performing multiple concurrent tasks) may reduce age effects and sustain performance (Kramer & Madden, 2008).

Some types of attention demonstrate less sensitivity to age. Older adults are typically able to maintain performance on tasks which draw from both focused and sustained forms of attention (Kramer & Madden, 2008). Tasks which assess focused attention typically display a static target with distractors which appear around the target (e.g., listening to a lecture while other students arrive late and are seated in front of you). Tasks which require this form of attention do not show strong age-related deficits (Kramer & Madden, 2008). Both young and older adults perform similarly on these tasks, but older adults can improve performance by practicing (Rogers, 2000).

Similarly, performance on sustained attention tasks is also well preserved in older adults (Rogers, 2000). This form of attention is the colloquial “attention span”. Sustained attention is assessed by requiring a participant to attend to a target over a prolonged period of time (e.g., TSA agents monitoring x-ray machines for contraband items) (Kramer & Madden, 2008). One common sustained attention task is the Mackworth Clock, where participants observe a computerized analog clock. They are instructed to key-press when the second hand moves more than one ‘tick’ at a time (Lichstein, Riedel, & Richman, 2000). This task is administered over extended periods of time, sometimes in excess of two hours (Lichstein, et al., 2000). To maintain or increase performance on sustained attention tasks, both young and older adults may benefit from increasing the salience of stimuli (Kramer & Madden, 2008).

In summary, performance on attentional tasks does differ between young and older adults (Gross, Rebok, Unverzagt, Willis, & Brandt, 2011). Attentional control may be related to performance on activities of daily living for older adults (Gross, Rebok, Unverzagt, Willis, & Brandt, 2011). It should be noted that some forms of attention may be more sensitive to the aging process than others. For example, older adults perform similar to young adults on sustained and focused attention tasks (Rogers, 2000). Age-related differences in performance can be observed on tasks which draw heavily on cognitive resources, such as divided and selective attention tasks (Rogers, 2000).

Other variables beside the aging process may impact performance on attentional tasks (Quigley et al., 2012). Hasher and Zacks (1988) suggested that attentional performance may be dependent upon well-functioning inhibitory capabilities. Hasher and Zacks (1988) claim that inhibition is comprised of three components– access, deletion, and restraint. The ‘access’ function allows relevant information to enter working memory, the ‘deletion’ component removes irrelevant information to maximize efficiency, and the ‘restraint’ element prevents strongly activated information from being immediately utilized, which allows responses to be evaluated for appropriateness. The Inhibitory Deficit Hypothesis proposes a symbiotic relationship between attention and all three components of inhibition and assumes that the degradation of inhibitory systems may negatively impact performance on attention tasks (Hasher & Zacks, 1988). Older adults who have inhibitory deficits may experience cognitive overload and therefore demonstrate distractibility, perseveration, and slower processing. Likewise, poorly functioning inhibitory mechanisms may allow extraneous information to enter working memory, subsequently combining irrelevant information with target information. This mechanism of action is portrayed in detail by Campbell’s Hyper-Binding Theory (Campbell et al., 2010).

Hyper-Binding

Older adults show marked distractibility when compared to young adults (Craik, 1989; Salthouse et al., 1999; Campbell et al., 2010). Campbell et al., (2010) suggested that when distracting information enters working memory, older adults will ‘bind’ or ‘link’ the irrelevant information with target information. A brief review of distractibility research in older adults supports this claim.

Craik et al. (1989) hypothesized that when young adults were required to divide their attention among tasks, their performance on each individual task would be comparable to older adults. One implication of this theory is that older adults may have a reduced amount of cognitive resources to distribute, leading to a decline in their overall performance. This ‘Divided Attention’ hypothesis is in line with Kahneman’s

(1973) Limited Capacity model, which suggested that cognitive resources are finite and can be distributed across only a limited number of tasks before performance is negatively impacted.

Craik et al. (2010) compared performance between young adults under a divided attention condition and older adults under a full attention condition, to see if their performance would be comparable. One group of young adults was required to complete the task while simultaneously performing an auditory digit-monitoring task (inducing divided attention) whereas a control group of young adults and all older adults did not have a secondary task to complete. In the first phase, participants were shown photographs superimposed with nouns (e.g., a photograph of a sunset with the word FAN). In this task, the photograph represented the contextual information to be encoded with the presented noun. Half of the stimuli paired a related word and scene (e.g., a photograph of flowers paired with the word GARDEN) and half were not conceptually related (e.g., a photograph of flowers paired with the word OYSTER). Participants were instructed to remember both the photograph and accompanying word.

After presentation, participants were given a self-paced recognition test in which they were presented with words and required to respond “old” (had seen the word during the previous phase) or “new” (had not seen the word during the previous phase). They were additionally tested for recognition of the photograph that accompanied each word. In this recognition test, participants were presented with nouns (e.g., OYSTER) and asked to select which of the six simultaneously presented photographs (e.g., flowers, sunset) was previously paired with the word.

Young adults under the full attention condition correctly recognized an average of

85% of nouns and 65% of contextual images. Young adults under a divided attention condition recognized an average of 40% of nouns, and 30% of images. Similarly, older adults (all of whom were under full attention) recognized an average of 65% of nouns and 40% of contextual images.

In summary, young adults in the divided attention condition exhibited declines in memory for both item and context, whereas older adults demonstrated memory deficits only for contextual information. These results did not support the theory that divided attention primarily contributes to age related memory deficits observed in older adults. Craik and colleagues (2010) suggested that the use of only six images paired with several words may have contributed to memory interference and made calculation of guessing rates more difficult.

Although there is evidence of cognitive differences with age, there are some realms which do not show functional declines (Birren, Schaie, Gatz, & Salthouse, 2006). Many older adults tend to function well within the context of daily living and only exhibit deficits on laboratory tests. Artistico et al., (2010) examined the impact of context on problem-solving performance across the life span. If the effect were consistent, older adults were expected to perform well on tasks which included context (analogous to daily living tasks), but exhibit deficits on tasks they could not relate to (analogous to laboratory tests).

Young, middle, and older participants were asked to offer solutions to everyday challenges: (1) not having enough money to pay a heating bill; and (2) wanting to increase social connections after becoming single. These problems were embedded in an age-appropriate context (e.g., young context = wanting to increase social connections after moving to college, middle-age context = wanting to increase social connections after a divorce, older context = wanting to increase social connections after death of a spouse). The appropriate contexts were varied across conditions. The number of safe, practical solutions presented by the participant was used as the dependent variable. Participants were asked to list all possible solutions, including those they themselves would not use.

Participants performed optimally when solving problems embedded within a context that was age-appropriate for them. Older adults performed equally well as young and middle-aged participants when solving a problem that was framed in age-appropriate context, but generated fewer solutions for problems outside their age-appropriate context. It should be noted that older adults have had experience in each context (e.g., being young, being middle-aged) whereas other age groups have not yet experienced each context (e.g., a young person cannot yet anticipate what it's like to be old). These findings indicate that context plays a crucial role in processing for older adults and can influence the outcome of their problem solving performance - especially within familiar situations.

To examine whether context is equally important across the lifespan, both young and older adults were presented with either object names (e.g., sunglasses) or object pictures (e.g., photo of sunglasses) from the Hemera Photo Objects set (Craik & Schloerscheidt, 2011). The names or pictures were superimposed on a background scene (e.g., beach). Recognition was tested under four conditions – the background scene matching the original (e.g., beach), switched with a different presented background (e.g., picture from earlier or later in the set), blank background, or completely novel background. As hypothesized, older adults recognized fewer words overall than young adults. Unexpectedly, a unique pattern emerged across conditions. Both young and older adults recognized the most words when presented with the original background. Young adults recognized an equal number of words in both the novel and blank conditions. Interestingly, older adults recognized more words in the blank than the novel condition.

Hyper-binding is observed with information that is presented in close temporal-proximity. Older adults demonstrate a sensitivity to extraneous details when compared to young adults (Campbell, Trelle, & Hasher, 2014). Craik and Schloerscheidt (2011) proposed that recognition memory in older adults on this task was influenced by the neural activation of *both* item and context. Thus, recognition performance was best in the original background condition (e.g., beach) but performance declined with the addition of a novel context (e.g., tree). The novel background negatively influenced recognition by causing interference, whereas the blank background did not provide either a benefit or a detriment (Craik & Schloerscheidt, 2011).

In summary, hundreds of studies have investigated how context may contribute to cognitive processing. Findings have been inconsistent, especially when examining performance across the lifespan. Under certain conditions (e.g., images presented extraneously, not instructed to attend to distractors, age-appropriate information) contextual information may increase recognition in older adults. When contextual information is similar to the target or age-inappropriate, older adults tend to recognize fewer targets and, when tested for them, fewer distractors. This evidence indicates that the performance of older adults may be uniquely influenced by context, although not in a uniformly negative or positive way.

One way in which older adults may benefit from context is by forming associations between to-be-remembered information and extraneous contextual information (Campbell et al., 2010). The Hyper-Binding theory suggests that older adults connect or 'bind' the intended (e.g., target) information with distracting (e.g., contextual) information.

Campbell et al. (2010) studied hyper-binding in both young and older adults. Participants were shown red line drawings from the Snodgrass and Vanderwart (1980) stimulus set. These line drawings had unassociated words superimposed on them (e.g., line drawing of a lobster and the word 'pillow'). The line drawing-word pairs were presented as a 1-back task, where participants were asked to respond if the same line drawing (e.g., lobster) was shown consecutively. Participants were instructed to ignore the word (e.g., 'pillow', the distractor) and respond only to the image (e.g., 'lobster', the target). After a 10-minute delay, participants were asked to perform a paired-associates memory task. In this task, participants were presented with picture-word pairs (e.g., image of a lemon and the word 'house'). Some of these paired-associates were presented in the initial 1-back task. Of these initial pairs, half were preserved (e.g., lobster/pillow) and half were disrupted by pairing them with new stimuli (e.g., lobster/milk).

After a delay, they were shown only the image (e.g., lemon) and asked to provide the accompanying word (e.g., house). Young adults performed similarly across condition – that is, they recalled equal amounts of words when shown with a novel image, an original image (preserved), or a previously shown image (disrupted). Older adults, however, recalled the most pairs when they were preserved and the least pairs when they were disrupted.

Compared to young adults, older adults had greater recall for words that were originally paired, implying they remembered the seemingly unimportant connection between target (e.g., pillow) and context (e.g., lobster). When this bond between target and context was broken, it decreased recall. The lowest rate of recall was demonstrated when the target was shown with a previously presented image (e.g., disrupted pair). This phenomenon was labeled 'Hyper-Binding' (i.e., an association between both targets and distractors is remembered). The underlying mechanisms responsible for this performance pattern are still unclear.

The Hyper-Binding effect has also been examined during implicit learning (Campbell, Zimerman, Healey, Lee, & Hasher, 2012). Both young and older adults were presented line drawings from Snodgrass and Vanderwart (1980) in red and green ink. Participants were randomly assigned and asked to attend to only one color (i.e., red) of the drawings. The opposing color (i.e., green) served as a distractor. Campbell et al. (2012) used a speeded detection task to measure implicit learning. Participants were shown a target image and were required to press a button when the image was shown again. They were not informed that the images of both colors were organized into a pattern, with triplets of images (e.g., chair, lamp, candle) always presented together. Accordingly, if the participants learned the triplet pattern their reaction time was expected to be faster and this would be indicative that they had anticipated the upcoming image.

Campbell et al. (2012) examined the distractor image trials (i.e., green) to see if participants learned the triplet pattern for the unattended stimuli. As this was meant to be inhibited, both young and older adults were not expected to exhibit learning of these line drawings. Both young and older adults demonstrated faster reaction time for the attended (i.e., red) stream of images. Consistent with the Hyper-Binding Theory (Campbell et al., 2010), only older adults learned associations during the distracting stream of images (i.e., green). This was evident by faster reaction times to the target image.

The reaction time pattern inhibited by older adults implied that they learned not only the target pattern, but also the distracting pattern and they anticipated the upcoming target image and responded faster. Campbell et al. (2012) proposed that Hyper-Binding in older adults may lead to poor performance on explicit memory tasks, but better recall on implicit learning tasks. Older adults may have better knowledge of and detection for distracting events and it may contribute to better performance on implicit memory tasks. Older adults may therefore have a wider ‘bandwidth’ of attention than young adults. The ability to control attention directed toward distractors is mediated by the executive function of inhibition. Many studies have indicated that this function may be age-sensitive (Kramer & Madden, 2008).

Inhibition

In order to learn or achieve goals (both short- and long-term), thoughts and behavior must be logically prioritized (Hasher, 2007). Attentional capabilities alone are not sufficient, for to be organized, one must also block out irrelevant information. Exposure to stimuli automatically leads to activation (either explicitly or implicitly) (May & Hasher, 1998). Inhibitory mechanisms assist in this process by down-regulating activation and assisting in organization (Hasher, 2007). These mechanisms are utilized during speech/language production, memory, and social interaction (May & Hasher, 1998). If inhibition is disrupted, irrelevant information may enter working memory, subsequently slowing the processing of target information (May & Hasher, 1998). Reduction of inhibitory capability is evident in older adults, and can be exacerbated by common conditions such as mood disorders and degenerative diseases (Hasher, 2007). In summary, performance on cognitive tasks (e.g., working memory) and lifestyle interactions (e.g., social exchanges) rely heavily on inhibitory mechanisms.

Limiting activation is crucial to goal-directed performance, and those with poor inhibitory abilities may experience difficulty due to excitation or distraction from stimuli. Hasher (2007) proposed three mechanisms of inhibition – *access*, *deletion*, and *restraint*. The mechanism of *access* prevents disruptive or irrelevant information from accessing working memory (e.g., the sound of a ceiling fan while reading). The *deletion* mechanism erases or limits the processing of information that is no longer relevant (e.g., once you get milk at the supermarket, you can remove it from your mental grocery list). Lastly the *restraint* mechanism holds back strong or impulsive responses to analyze them for appropriateness (e.g., when asked "What do you put in a toaster?" the impulsive response is "toast"). This process allows less dominant responses to be considered (e.g., allowing the correct response, "bread" to be said aloud).

These mechanisms are the components of the construct of inhibition. Inhibition is a component of attention which broadly impacts many cognitive abilities. Several studies have indicated that the ability to successfully and efficiently 'inhibit' decreases with age (Hasher & Zacks, 1988). Individuals with reduced inhibitory mechanisms will be more distractible, respond inappropriately, and forget more frequently than those with healthy inhibitory control (Hasher & Zacks, 1988). Many older adults consistently display this pattern of behavior, which may stem from an inhibitory deficit and is evident in behavioral performance as well as on laboratory tasks (Hasher & Zacks, 1988). For instance, older adults typically take longer to complete the Stroop procedure than young adults, which is consistent with the Inhibitory Deficit Hypothesis (Spieler, Balota & Faust, 1996). Extraneous ‘noise’ or distractions in the environment may intensify this deficit and negatively impact performance. It follows that older adults, who experience decreasing inhibitory control, would be expected to demonstrate increased distractibility.

Age-related deficits in cognitive performance are consistently seen across studies. Several theories have been proposed to account for these outcomes, including the Generalized Slowing Hypothesis (Salthouse et al., 1989). Salthouse et al. (1989) proposed that a reduction in capacity and declines in processing speed primarily drive the performance deficits seen in older adults (Salthouse et al., 1989; Light, 1991). Salthouse et al. (2004) estimated that up to 75% of age-related changes in performance can be explained by slowing of the central nervous system, known as the Generalized Slowing Hypothesis. Salthouse and colleagues report evidence which supports this hypothesis by statistically controlling for processing speed. Although useful, this hypothesis is merely descriptive and does not attempt to understand the underlying mechanisms responsible for this change. Additionally, this hypothesis leaves approximately 25% of age-related performance yet unexplained.

The Inhibitory Deficit Hypothesis is complimentary to the Generalized Slowing

Hypothesis (Hasher & Zacks, 1988). If inhibition is truly reduced in older adults, working memory will be 'bogged down' with extraneous information (Hasher & Zacks, 1994). Due to inefficient *deletion*, information that is no longer required may persist and crowd incoming information (Hasher & Zacks, 1988). The overwhelmed working memory system may perform slower and have less capacity than someone with healthy attentional control (Hasher & Zacks, 1994).

Underlying mechanisms that may contribute to general slowing and frontal decline were examined by assessing performance on the Wisconsin Card Sorting Task (WCST) and the Tower of London Task (Bugg, Zook, DeLosh, Davalos, & Davis, 2006). Both tasks are assumed to be partially dependent on frontal lobe functioning (Bugg et al., 2006). Generalized slowing is evidenced by slower response times, which may be a function of holding unnecessary information in short-term memory. Overall reaction time and speed using a Simple Reaction Time Task (SRT) and a Choice Reaction Time Task (CRT) were examined. After accounting for processing speed, age was still a significant factor in overall performance (Bugg et al., 2006). Generalized slowing does account for some of the age-related decline seen in performance, but one or more other factors may also be involved.

One possible mechanism to explain slowing is inhibitory ability. Hasher and Zacks (1988) reported that young adults perform inhibitory tasks faster and more efficiently than older adults. They proposed that inhibition is made of three components (e.g., access, deletion, and restraint) which degrade with age. Feyereisen and Charlot (2008) investigated how aging may differentially impact each of these mechanisms of inhibition. They assumed that the three mechanisms of inhibition were equally impacted by the aging process and selected six tasks which were sensitive to age-related differences and were thought to utilize inhibitory processing. These tasks were administered in a within-subjects panel, but practice effects were not expected because each task targeted different processes (Feyereisen & Charlot, 2008).

To explore the access mechanism of inhibition, participants were given irrelevant information and asked to respond to targets (using the Reading with Distraction and Remote Associates Tasks (RAT)). This reading with distraction task was translated and adapted from an earlier study by Connelly et al. (1991). Participants were instructed to read aloud short reading passages (approximately 100 words each). Half of the reading passages (baseline) were presented in a typical format (e.g., "The storm had continued all through the night and didn't show signs of stopping"), while the distracting passages had semantically related, italicized words interspersed throughout the passage (e.g., "The storm had *terrifying* continued all through the night *fear* and didn't show signs of stopping"). Comprehension questions were administered after reading the passage, with two possible responses. One response acknowledged the distracting words (e.g., *terrifying, fear*) while the other did not (Feyereisen & Charlot, 2008). The Remote Associates Task was originally developed by Mednick in 1962. Participants were presented with three related words (e.g., fish, mine, rush) and asked to provide a fourth word (e.g., gold) which was semantically related. The correct response could be combined with each of the three words to form compound words or common phrases (e.g., goldfish, goldmine, gold rush).

The deletion mechanism was targeted by using tasks in which distractors were not immediately present but presented as prior targets (Directed Forgetting and

Listening Span Tasks) (Feyereisen & Charlot, 2008). In the Directed Forgetting Task, a series of 25 words were serially presented on a computer screen for five seconds each. After each word, memory instructions were displayed for one second (i.e., 'R' for remember and 'F' for forget). Upon completion of the total list, participants were instructed to write as many R (remember) words as possible. After a delay, participants recalled as many words as possible from both the R (remember) and F (forget) lists. A measure of inhibitory ability was based on the proportion of R (remember) and F (forget) words in the immediate and delayed recall conditions.

The Listening Span Task was adapted from DeBeni et al. (1998) and required participants to remember the last word of a series of word lists. Words were auditorily presented by a computer (e.g., cat, feather, bottle, brick, horse), and participants were required to tap the desk each time they heard an animal name (e.g., cat, horse). Upon completion of each word list, the participant repeated the final word in the list (e.g., horse). This continued, with participants naming the final word from each subsequent list (e.g., horse, span, prize), thus increasing the number of items in each block.

Lastly, Feyereisen and Charlot (2008) attempted to target the restraint mechanism by using Stroop and Hayling tasks (Andres & Van der Linden, 2000). The Stroop task had two conditions, the first was congruent (matching word and color (e.g., 'black')) and the second was incongruent (discordant word and color (e.g., 'green')). Performance on this task allowed Feyereisen and Charlot (2008) to assess the impact of irrelevant information on reading performance. Young adults had faster reading times than older adults, indicating they may have been less distracted by irrelevant information.

In Part A of the Hayling task, participants were read sentences with predictable endings (e.g., Sally watched as her house fell ___). Participants were instructed to supply the final word (e.g., down) as quickly as possible. Part B of the Hayling task was similar in structure, but participants were instructed to supply a final word that was semantically unrelated to the sentence (e.g., flag). The response time to complete the sentence was measured in both Parts A and B, with inhibitory ability based on the difference score (Andres & Van der Linden, 2000). Older adults demonstrated more errors on the Hayling task compared to young adults.

This battery of tasks was given to both young and older participants at self-selected times of the day. Participants were asked what time of day (i.e., morning, afternoon, evening) they preferred to be tested and were scheduled accordingly. Based on Hasher and Zacks (1988) Inhibitory Deficit Hypothesis, older adults were expected to experience more interference than young adults when tested on the same task. Older adults did experience more interference, reflected in their lower scores on the deletion and restraint tasks, but not on the access tasks.

Feyereisen and Charlot (2008) suggested that some mechanisms of inhibition may be more sensitive to aging (i.e., deletion and restraint) than others (i.e., access). This is similar to findings from attentional research, in which some forms of attention are more susceptible to age-related changes (i.e., divided and selective attention) than others (i.e., focused and sustained attention). While true that certain domains of cognition decline with age (e.g., inhibition), not all components of that domain necessarily decline equally (e.g., access, deletion, restraint). Some of these components may be preserved (e.g., access), while others are age-sensitive (e.g., deletion, restraint). It should be noted that performance on laboratory tasks which draw heavily on one component (e.g., deletion) may be interpreted as global decline (McDaniel & Einstein, 2000).

A task which specifically targets the deletion component of inhibition was used to assess interference processing in older adults (Hasher, Stoltzfus, Zacks, & Rypma, 1991). This task utilized the negative priming effect seen primarily in young adults (Hasher et al., 1991). Negative priming designates a target (e.g., blue pen) and presents it in the presence of several distractors (e.g., red, black, and green pens). After an initial block, the previous target (e.g., blue pen) becomes a distractor and a new target is named (e.g., now find the green pen). The new target was formerly a distractor, and the new distractor was formerly a target. This paradigm typically results in slower reaction times for young adults, in part due to greater interference (Hasher et al., 1991). The negative priming paradigm was incorporated into a selective-attention task. Participants completed a 1-back task (e.g., they were asked to respond when two identical stimuli were shown in a row) while simultaneously responding to a target stimulus (e.g., the word ‘wood’). Upon completion of the task, a new target was provided (e.g., the word ‘eye’) which was previously used as a distractor. The previous target (e.g., ‘wood’) was then used as a distractor word. Interference was quantified as delayed reaction time and false alarms in participant responses.

Negative priming effects were not observed for the older adults. Hasher et al. (1991) suggested that older adults did not process distracting information the same way as young adults. Young adults were slower when responding to a target that was formerly a distractor, whereas older adults performed similarly under the same conditions. They hypothesized that distractors were attended to, but the presence of a distractor did not impact later performance. These results are not consistent with the Hyper-Binding Theory, which assumes that older adults bind target and distractor information together. However, it should be noted that different procedures were used which may have drawn from different underlying resources.

A reduction in inhibitory actions may contribute to a paradoxical finding where older adults recall more than young counterparts (Hartman & Hasher, 1991). To understand the possible mechanisms, Hartman and Hasher (1991) presented both young and older adults with sentence stems that had unpredictable endings (e.g., “She ladled the soup into her…lap”). These sentences were presented on a computer monitor with the words of each sentence being shown in subsequent order (e.g., She, ladled, the, soup). Before the presentation of the sentence-ending word (e.g., lap), participants were instructed to guess what the next word might be. Most often, participants supplied a predictable ending such as ‘bowl’. As a dependent measure, a sentence completion task was administered using possible solutions from the previous task and was used to assess implicit learning and memory. Older adults supplied more previously used words overall than young adults, including both predictable (e.g., “bowl”) and target (e.g., “lap”) words. Young adults recalled more target words than predicted words, indicating that older adults may be less efficient at ignoring or forgetting distractors than young adults.

Benefits of Distractibility

In their recent work, Kim, Hasher, and Zacks (2007) have explored why older adults may recognize or recall distracting information more frequently than young adults and is a challenge to the impression that age is associated with a consistent decline in cognitive performance. For instance, older adults often score higher on implicit learning tasks than young adults. The Benefits of Distractibility Theory (Kim, Hasher, & Zacks, 2007) proposes that attending to distractors may be adaptive for older adults, as it allows them to remember contextual details. Better memory may result from increased or prolonged activation of distracting information, relative to young adults.

To examine this paradox, a disrupted reading task was administered to both young and older adults (Kim et al., 2007). Participants were instructed to read the passage quickly and efficiently while ignoring any extraneous (distractor) words. The reading with distraction task incorporated unrelated words (e.g., 'black' or 'foot') into a reading passage. These distractors were placed an average of every four words (e.g., "He really hoped *black* that he would *foot* get enough financial *black* aid to remain *foot* in his tiny apartment"). A different, but equally long and challenging reading passage with no distractors was also read aloud and timed. The difference in reading completion time was a measure of distractibility. After completing each passage, the Remote Associates Task (RAT) was administered. The RAT was developed to assess creativity in a population with college-level reading comprehension (Mednick, 1962). It targets the restraint function of inhibition by requiring a variety of possible solutions to be considered. It was initially formulated as a measure of creative thinking, but has been used in studies to evaluate problem solving, affect, and implicit learning (Bowden & Jung-Beeman, 2003; Campbell et al., 2010). The RAT consists of three associated words (i.e., box, tennis, maker) that are semantically related to a target word (i.e., match). The participant is instructed to supply a word, which can be combined with each of the three provided words to form a compound word or phrase (i.e., match box, tennis match, matchmaker).

The RAT meets the following criteria to be classified as an insight problem and does not guide or direct retrieval processes (e.g., provide cues or hints). Additionally, when solving problems on the RAT, participants do not explicitly report using a strategy (or ‘path of processing’) (Bowden & Jung-Beeman, 2003). Bowden and Jung-Beeman (2003) expanded the original set of RAT problems from 30 to 144. These were presented to college students and normed under three conditions; in the laboratory, under electroencephalography (EEG) and during functional magnetic resonance imaging (fMRI).

In the distracted reading task from Kim, Hasher and Zacks (2007), some of the distractor words (e.g., black, foot) were solutions on the RAT. Older adults took longer overall to read the passage, but when the solution to the RAT was previously a distractor word they were more likely to recall it. Young adults did not exhibit the same benefit, performing equally on the RAT whether or not the solution word was used as a distractor. Kim et al. (2007) concluded that distraction only benefits later performance in older adults and proposed two mechanisms. First, distractions may not be processed or encoded by young adults, indicating that young adults may be inhibiting the distractor prior to activation. Older adults may not inhibit distractors, which may lead to subsequent processing and encoding of these words. Secondly, Kim et al. (2007) suggested that both young and older adults may process the distractors, but older adults may sustain activation for longer periods of time and the increased activation may lead to greater recall or recognition. In summary, age-related declines may stem from distractibility in part as a result of reduced inhibitory capabilities. However, distraction in older adults may improve implicit learning and, subsequently, performance on later tasks (Kim, et al., 2007).

Healey, Campbell and Hasher (2008) suggested that when distraction interferes with the current task, older adults experience distractibility as a ‘cost’. That is, attending to extraneous information (e.g., a cell phone) can detract from attending to target information (e.g., driving). Under these circumstances, distractors may negatively impact performance. However, if distracting information (e.g., seeing your neighbors name on a mailbox) later becomes relevant (e.g., run into them at the store and need to remember their name), attending to those distractors may prove beneficial. Distraction may hinder performance on processing speed, reading speed, and problem solving but older adults can potentially benefit from distracting information – whether it was formerly relevant or never relevant (Healey, Campbell, & Hasher, 2008).

Whereas Hasher, Zacks and colleagues provided ample neuropsychological support for the Benefits of Distractibility Theory, Gazzaley et al., (2005) sought to use neuroimaging to investigate performance differences between young and older adults. In one such study, participants were shown a series of faces and scenes across two conditions (ignore faces/remember scene or remember faces/ignore scene). In the ‘ignore faces/remember scene’ condition, activation for the parahippocampal place area (PPA) was comparable in both young and older adults. This region of the brain is implicated in processing scene or ‘place’ information. It is reasonable to expect that this region would be activated in the condition which requires the participant to remember the scene. However, in the ‘remember faces/ignore scene’ condition, young adults showed less PPA activity than older adults. Young adults may have suppressed PPA activity when that activation was not required (e.g., ignoring scene), but older adults did not. These findings may contribute to understanding the underlying mechanisms of the Benefits of Distractibility Theory, because older adults did not successfully suppress distracting information.

Other research supports this finding, with additional neuroimaging studies by Campbell, Grady, Ng, and Hasher, 2012. They also utilized fMRI to investigate the underlying substrates of distractibility and attentional control. Campbell et al. (2012) showed Snodgrass and Vanderwart line drawings (1980) with either consonant strings (e.g., SQTGB) or words that were unrelated to the image (e.g., LIVER) superimposed on them. In the first condition, participants attended to only the letter stimuli (e.g., 'SQTGB', 'LIVER') and then in the second condition they were instructed to attend to only the line drawing (e.g., outline of a chair).

During a subsequent word fragment completion task (e.g., L_VER), older adults provided more previous distractor words (e.g., LIVER) than young adults (e.g., LOVER). Relative to older adults, young adults experienced more activation in the rostral prefrontal cortex and inferior parietal cortex. These areas of activation predicted performance on the word fragment completion task, indicating that this area may be implicated in distraction control and provide evidence for a possible neural link to increased distractibility in later adulthood (Campbell, et al., 2012; Craik & Rose, 2012).

Thomas and Hasher (2012) demonstrated that both young and older adults may benefit from distraction under specific circumstances. A distracted reading task was administered to all participants, similar to the task used by Kim et al., (2007). This task embedded unrelated words (e.g., ‘stove’ or ‘weight’) into reading passages (e.g., “I couldn’t be more *stove* in love with *weight* my family”). After a ten minute delay, participants studied a word list. Some of the words to be studied were previously used as distractors (e.g., ‘stove’ or ‘weight’). When asked to free recall words from the to-be-studied list, older adults recalled significantly more distractors than young adults. As proposed by Kim et al. (2007), there were two explanations for this benefit. Perhaps older adults did not successfully inhibit distractors and therefore process and encode the information. Alternatively, older adults may have sustained activation of distractors for longer periods of time because they did not suppress the information.

These results are consistent with the Inhibitory Deficit Hypothesis and those repeated by Gazzaley et al. (2005), which indicated that older adults may experience declines in inhibitory ability with age. To further explore these two mechanisms, Thomas and Hasher (2012) used cueing and explicit tasks. In the previous task, young adults may have encoded the distractors (e.g., ‘stove’ or ‘weight’) but not retrieved them. Thomas and Hasher (2012) hypothesized that explicitly prompting young adults (e.g., instructing them “some of the words on this list were previously shown in the reading task”) may elucidate whether the information was encoded at initial exposure. If unable to retrieve the information, it would provide support for the hypothesis that young adults inhibit distractors rather than encode them. Consistent with their hypothesis, young adults recalled more distractors when explicitly cued. This supports the theory that young adults do indeed encode distractors. By explicitly cueing young adults, transfer effects of previous distractors were observed.

Older adults benefitted from distraction on both of the above indirect recall tasks. Even when distractors were not initially relevant, they were still encoded (Biss, Campbell, & Hasher, 2012). To investigate this under direct recall conditions, Campbell and colleagues (2010) administered a 1-back task to both young and older adults. Two syllable nouns (e.g., mother) were superimposed on line drawings (e.g., lobster) from Snodgrass and Vanderwart (1981). These image/word combinations were shown at a rate of 1,000 ms with a 500 ms inter-trial interval (Campbell, Hasher, & Thomas, 2010). Participants were told to key-press when they saw the same line drawings shown twice in a row, while ignoring the words. After a delay, another set of line drawing/noun pair images were shown at a rate of 4,000 ms each. Participants were told to memorize the images, as they would later be asked to provide the word when shown only the image. There were two conditions in this block – a high- and low-interference group (Campbell, et al., 2010). The low-interference group saw only novel drawing/word pairs, whereas the high-interference group saw half novel pairs and half previously-presented pairs (e.g., mother/lobster). Finally, cued-recall was used by showing only the line drawing and participants were asked to supply the accompanying word (Campbell, et al., 2010).

Young adults recalled a comparable number of words across both low- and high-interference conditions. Older adults recalled fewer words under high-interference conditions than low-interference conditions (Campbell, et al., 2010). This indicates that line drawings from the first phase (e.g., line drawing of a lobster with the word ‘mother’) may have interfered with learning new associations in later phases (e.g., line drawing of a lobster with the word ‘garbage’). Older adults in the high-interference group were less likely to recall the new association (e.g., garbage) than their counterparts in the low-interference condition in which completely new associations were shown (e.g., line drawing of a chair with the word 'garbage') (Campbell et al., 2010). When distractors were not relevant to a later task, they might have still been encoded by the older participants. This finding is consistent with previous research indicating that older adults are less likely to exhibit negative priming than young adults (e.g., Hasher & Zacks, 1988). Additional studies which replicated this effect used a stimulus display time of no greater than 1,000 ms (Rowe, Valderrama, Hasher & Lenartowicz, 2006; Campbell, Zimerman, Healey, Lee, & Hasher, 2012).

To summarize, age-related deficits in performance may be mediated by poor distraction control (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008). Furthermore, this lack of control over distractors may be a function of *access*, a component of inhibition (Hasher & Zacks, 1988). A decline in inhibitory ability (e.g., poor *access, deletion,* or *restraint*) may subsequently overload working memory and reduce the processing of currently relevant information.

A large sample of young and older adults were administered the Reading with Distraction task (Darowski et al., 2008). The participants were asked to read aloud a baseline reading passage (low-interference condition), as well as a distracting passage (high-interference condition). A battery of tests included working memory span tasks (sentence, operation, and rotation span) as well as Raven's Advanced Progressive Matrices (RAPM) was administered. RAPM is a non-verbal measure of fluid intelligence. Increasingly difficult patterns were displayed and participants were asked to designate which item would come next in the given sequence.

Darowski et al. (2008) reported that performance on this battery of tests was related to performance on the Reading with Distraction task. That is, older adults who had increased reading time on the Reading with Distraction task also had slower performance on measures of working memory. Those older adults who took longer to complete the distracted reading task also demonstrated a smaller working memory capacity. This may indicate that distraction control can mediate age-related declines in performance on executive function tasks (Darowski et al., 2008).

Another potential explanation for distraction control comes from Salthouse et al.'s (2007) Generalized Slowing Hypothesis. General slowing may account for many of the observed age-related differences in performance. To examine general slowing further, Yang and Hasher (2007) statistically controlled for general slowing while using a distraction task. They displayed images from the Snodgrass and Vanderwart (1980) line drawing set (e.g., line drawing of shoes) and superimposed both related (e.g., heel) and unrelated (e.g., crib) words on them. Both young and older participants were shown the images and told to key-press if they had previously seen the word shown on the image. The irrelevant pictures in the background significantly slowed reaction time when they were related to the word shown (e.g., shoes/heel) but not when unrelated (e.g., shoes/crib). Slowest reaction times were demonstrated for those images that were shown for short durations (e.g., 50 – 1,000 ms). This interferences effect faded with longer presentation times for older adults (e.g., over 1,000 ms), suggesting that automatic activation (as little as 50 ms of exposure) may allow irrelevant information to access working memory.

This may imply that inhibitory responses require conscious processing (over the 1,000 ms threshold), and automatic processing (less than 1,000 ms) allows acknowledgement of extraneous detail. Even after statistically accounting for age related slowing, older adults showed greater distraction than young adults. Age related declines in processing speed may contribute to - but are not solely responsible for - performance deficits in older adults (Yang & Hasher, 2007).

Carstensen, Isaacowitz, and Charles (1999) Socioemotional Selectivity Theory (SET) highlights another variable which may influence cognitive performance in older adults: affect. This theory was first introduced to explain social motivations across the lifespan (Carstensen, 1991). As researchers in other disciplines (e.g., neuroscience, attention) have accrued supporting evidence for SET, it has been acknowledged as an important theory to consider in the field of cognitive aging (Grossman, 2010; Biss & Hasher, 2012; Samanez-Larkin & Carstensen, 2008; Mikels & Lockenhoff, 2010).

The Positivity Effect in Older Adults: The Role of Affect

Emotional stimuli may change how cognitive processing functions across the lifespan. In empirical studies, older adults tend to consider emotional factors more than young adults and attend to positively valenced stimuli for longer periods of time (Blanchard-Fields et al., 1995). Studies such as these shed light on how memory may be enhanced for older adults, by using emotional information (Charles et al, 2003; Mather et al., 2003, Fung & Carstensen, 2003). Positively valenced stimuli are not only recalled at a higher rate, but evidence suggests it may also be processed for longer periods of time (Mather et al., 2003, Fung & Carstensen, 2003). This paradoxical memory boost with age has led several researchers to study how emotion may impact cognition in later adulthood.

Compared to young adults, older adults report shorter and less-frequent negative emotional experiences. Older adults also redirect their attention away from negative stimuli (Carstensen, Isaacowitz, & Charles, 1999). The Socioemotional Selectivity Theory (SET) posits that these behaviors are due to an awareness of the limited nature of time (Carstensen, 1991). Young adults tend to engage in protracted tasks (e.g., building new relationships and careers) as they view time as an inexhaustible resource. Both older adults and those with terminal illness recognize that time is limited, and they spend their time on enriching and rewarding activities (e.g., spending time with family or spouse). Thus, young adults tend to prioritize tasks which gather information (e.g., networking, learning new hobbies) whereas older adults prefer fostering interpersonal relationships (e.g., visiting with a friend) (Carstensen et al., 1999).

The mechanisms behind this shift in priorities are relevant to the current study. Isaacowitz (2012) suggested that older adults may report more positive moods due to better emotion regulation. Using eye-tracking equipment, he demonstrated that older adults attended to positive images (e.g., smiling faces) more frequently than negative images (e.g., crying faces). Issacowitz (2012) hypothesized that older adults regulate, or direct energy toward, positive emotions as a way of enjoying their later years. This bias toward attending to positive information may impact other executive functions, such as decision-making. Others have suggested that a shift toward positive affect is the result of a tradeoff between cognitive and affective resources in older adults, called the Dynamic Integration of Differentiation and Optimization model (Labouvie-Vief, 2003). This model describes a reduced flexibility in decision-making as age increases. Thus, young adults can more easily switch between a variety of strategies (e.g., affective, deliberate/cognitive) whereas older adults primarily use one strategy (e.g., affective). Young adults make optimal decisions using an information-focused approach, whereas older adults make better choices when employing an emotion-focused approach (Mikels, Lockenhoff, Maglio, Carstensen, & Goldstein, 2010).

Further evidence to support a positive decision bias comes from Kim et al. (2008). In this study, both young and old participants were randomly assigned to one of two conditions – control or evaluate. Those participants in the evaluate condition were instructed to write about the positive and negative features of items presented to them (i.e., pen, mug, flashlight, whiteboard). Participants in the control group did not subjectively rate the objects. Next, both groups were instructed to select an item that they would take home with them and rated their subjective satisfaction of that object at two intervals - immediately and after two weeks.

In support of their hypothesis, older adults who were required to rate their options reported more overall satisfaction (at initial choice and after two weeks) than young adults who were in the same condition (Kim et al., 2008). Neither age group in the control condition exhibited this positivity bias. When directed to emotionally evaluate all their options (e.g., rating their satisfaction of an unexpected gift), older adults were more likely to report enduring satisfaction. Older adults who were not directed to subjectively rate an object displayed no such effect. This suggests that emotions may influence decision making in older adults (Kim et al., 2008).

Kim and colleagues (2008) work supports the theory that older adults attend to positive information more than young adults. To show a positivity bias, older adults must engage both cognitive and affective processes. The reason older adults from the control group did not show a positivity bias may in part be they did not explicitly engage cognitive processes (Kim et al., 2008). Clearly, the interaction between cognition and affect is precarious. Results from studies in this area imply that positive affect may mediate age-related declines in older adults. One area that has shown consistent sensitivity to age-related decline is inhibition. To date, few studies have examined how affect may help or hinder inhibitory performance in older adults. The goal of the current study was to further understand this relationship.

Biss, Hasher, and Thomas (2010) examined how affect may impact another attentional component; distractibility. Young adults' mood state was assessed using the Brief Mood Introspection Scale (BMIS) and participants were then exposed to a variety of distraction tasks. Similar to previous studies (e.g., Campbell et al., 2010), the Snodgrass and Vanderwart line drawings set was used as stimuli. These drawings had superimposed nouns on them (e.g., MELON). Instructions were explicitly stated to ignore the words while verbally acknowledging when the current image was identical to the previous one (i.e., 1-back task). Upon completion of this task, participants were exposed to a variety of word fragment problems (e.g., _E_ON). These problems had multiple possible solutions (e.g., MELON or LEMON), but only one was shown in the previous set of images (e.g., MELON).

Young adults who completed word stems with previous distractor words (e.g., MELON rather than LEMON) also scored high on a measure of positive mood (Brief Mood Introspection Scale). Consistent with findings from other studies, those participants who reported higher positive affect were more likely to answer with distractor words (Rowe et al., 2006). These findings may indicate that positive affect is linked to increased distractibility in young adults. To better understand this relationship, Biss and Hasher (2011) induced mood states in older participants.

Participants were randomly assigned to either the positive or neutral mood state condition (Biss & Hasher, 2011). Participants were shown images from the International Affective Picture System (IAPS) that were rated above a seven-point valence (positive) or between 4.5 and 5.5 valence (neutral) (Lang et al., 2008). The IAPS images were photographs which were normed for valence and arousal. Norms were assessed using valence, arousal, and dominance scales (Lang, Bradley, & Cuthbert, 2008). In addition to looking at images for six minutes, participants also listened to either a "jazzed-up version of Bach's *Brandenberg Concerto*" (positive) or ambient noise (neutral). After the induction phase, older adults reported their mood and arousal on a nine-point scale. Similar to the previous study, older adults participated in a 1-back task which utilized line drawings from the Snodgrass and Vanderwart set. These images had words superimposed on them (e.g., CAR), and participants were instructed to respond to the image alone by verbally indicating when the current image was the same as the previous image. In the final phase, participants completed a word fragment task (e.g., _AR) where one third of the solutions were previously shown as distractors (e.g., CAR). Those who were randomly assigned to the positive mood induction condition most frequently answered word stems with previously shown distractor words. Biss and Hasher (2011) suggested that positive affect may widen the bandwidth of attention during encoding to include distracting materials.

Summary

Several studies in the area of cognitive aging have indicated that there are age-related differences in attentional abilities. Attentional tasks which draw heavily on cognitive resources produce the greatest age-related differences (Birren et al., 2006). Both micro and macro theories have been proposed to explain this effect, but underlying mechanisms have yet to be identified (Salthouse et al., 1985; Hasher, Stoltzfus, Zacks, & Rypma, 1991). Hasher and Zacks (1998) first suggested that executive function in older adults may be reduced in part due to poor inhibitory control. Although some labs report conflicting evidence (Salthouse et al., 1989; Light, 1991), several findings are consistent with the Hasher and Zacks Inhibitory Deficit Hypothesis. Reduced inhibitory abilities may contribute to the indicators (e.g., reduced working memory capacity) noted by other researchers.

Kim, Hasher, and Zacks (2007) proposed that attentional decline in older adults may be adaptive. Empirical evidence suggests that older adults report contextual details at a higher frequency than young adults. The Hyper-Binding Theory (Campbell et al., 2010) posits that older adults 'bind' intended memories with extraneous information. In both young and older adults, memory for distractors is greatest among those who report the highest levels of positive affect. Over the last 20 years, researchers in the field of cognitive aging have increasingly acknowledged affect may impact cognition.

When making decisions in a laboratory setting, older adults tend to consider emotional factors more than young adults (Blanchard-Fields et al., 1995). The Positivity Bias, where older adults demonstrate a preference for positive information, has been confirmed in many disciplines – including neuroscience and attention (Charles et al, 2003; Mather et al., 2003, Fung & Carstensen, 2003). Consequently, older adults redirect attention away from negative stimuli. It is suggested that this may be a mechanism by which they regulate emotion (Carstensen et al., 1999).

The current study explored how affect may mediate inhibitory ability by placing emotional words (i.e., positive, neutral, and negative) within the context of real-life images from a normed image set which also varied in valence (i.e., positive, neutral, and negative). Participants were asked to complete a 1-back task by responding to stimuli with a key-press. Response instructions varied across conditions. The Adaptive condition instructed participants to attend to only the image stimuli, whereas the Nonadaptive condition instructed them to respond to both the word and image stimuli. Upon completion of the 1-back task, participants were administered the RAT. Some solutions to this task were previously shown in the 1-back task. Predictions of correct solutions varied dependent upon the condition. If the correct solution was provided, it was assumed that the presented word was not inhibited by the participant.

Hypothesis 1

A relation between age (i.e., young, old) and condition (i.e., attend to image only, attend to both image and word) on inhibitory performance as measured by correct solutions on the RAT task was expected. Consistent with the Hyper-Binding Theory, older adults were expected to bind extraneous information to target information (Campbell et al., 2010). As a result, older adults were expected to supply more RAT responses than young adults in the Adaptive condition. Young adults were expected to have superior cognitive control, and thus provide more RAT solutions than older adults in the more challenging Nonadaptive condition.

Hypothesis 2

A relation between valence (i.e., positive, negative, neutral) of the stimuli and age (i.e., young, old) was expected across conditions. Based on the Socioemotional Selectivity Theory (Carstensen, 1991), it was expected that while young adults would supply more RAT answers overall, older adults would provide more words that were positively valenced. Older adults were expected to recall fewer negatively valenced words than young adults. Consistent with the Hyper-Binding Theory (Campbell et al., 2010), young adults were expected to recall neutrally-valenced stimuli at a higher rate than older adults.

CHAPTER 3

METHOD

Participants

Participants included young (18-29 years old) and older (60-89 years old) adults recruited from a large university in the Midwest and the surrounding community. Young adult participants voluntarily participated in exchange for course credit in an Introduction to Psychology and upper level Psychology classes. Older participants were recruited from community organizations and word of mouth. Using G-Power (ANOVA: repeated measures, within factor, 2 groups, 2 measurements, $\eta 2 = .2$), an estimated total sample size of 54 was sufficient to produce the desired effect (27 in each age group). This was consistent with previous studies, which utilize a repeated measures design to examine the relations between affect, aging, and memory.

Participants aged 65 and up were administered the Saint Louis University Mental Status (SLUMS). This measure was developed to screen older adults for mild cognitive impairment (MCI) and dementia and is dependent on both education level and age (Tariq et al., 2006). In the current study, criterion recommended by Tariq et al. (2006) was utilized. The SLUMS was used as an alternative to the more traditional Mini-Mental Status Exam (MMSE), which may not detect MCI or dementia at lower thresholds (Folstein, Folstein & McHugh, 1975). Tariq et al. (2006) indicated that MCI was indicated in individuals without a high school education at a score of 23.5, with a sensitivity and specificity value of 0.92 and 0.81, respectively. For this population, the SLUMS is highly sensitive (1.0) to dementia when scoring at 19.5 or below (specificity value 0.98). For those who have completed high school, Tariq et al. (2006)

recommended using a score of 25.5, with a sensitivity of .95 and specificity value of 0.76. Again, the SLUMS is highly sensitive (.98) to dementia, indicated at a score of 21.5 for those who have completed high school.

Participants were also required to take a standard vision test (Lighthouse Near Visual Acuity Test, Second Edition – corrected vision). Those who scored below the threshold on the SLUMS or were unable to complete the vision test with a Snellen score of 20/50 or better (with corrected vision) were excluded from participating. Two older participants were excluded due to performance on the SLUMS, no participants were excluded due to vision. Solutions on the RAT task (dependent variable) are often compound words and common English phrases. Therefore, only participants who listed English as their native language participated in the current study.

Materials

Executive Function Measures

Wisconsin card sorting task, computerized (wcst-c).

The computerized WCST was used to assess global executive functioning and is a quick, efficient, and portable assessment of working memory. The standard version of the WCST was first developed by Berg and Grant to assess set switching and strategy use (Berg, 1948; Grant & Berg, 1948). Heaton et al. (1993) standardized the task and published it as a measure of executive function. The WCST is the most frequently used assessment for those presenting with executive function complaints (e.g., memory loss, short attention span, distractibility), (Rabin et al., 2005). Scoring on the standard and computerized versions of the WCST are reliable, and norms indicate that performance on this task does not decline until age 60 (Rhodes, 2004;

Fortuny & Heaton, 1996).

This task was presented on a Dell computer, running Windows 7 Enterprise operating system. The monitor was a Dell E198WFP with a 20” screen, set to factory standard 1440 x 900 resolution. Participants were asked to view the screen from 15” to 20” away. On the computerized version of the WCST, participants are presented with four cards. Each card has different colors (e.g., red, green, yellow, blue), symbols (e.g., triangles, stars, crosses, circles), and quantities (e.g., 1, 2, 3, 4). As each card is presented, the participant must indicate which of the four cards matches the current stimulus. Immediate feedback regarding accuracy is provided. After every ten card presentations, the sorting rule changes without warning. Learning this implicit rule and sorting appropriately increases the score, whereas perseverative errors result in lower scores.

Trail making test (TMT).

The TMT test consists of two parts (TMT-A, TMT-B), each with 25 numbers or letters (Reitan, 1985). The initial test (TMT-A) consists of only numbers. Participants must connect these numbers in sequence (e.g., 1, 2, 3…) as rapidly as possible. Upon completion of this trial, the second test is administered. TMT-B consists of both numbers and letters, which the participant must connect in an alternating pattern (e.g., 1, A, 2, B…) as rapidly as possible. Time-to-complete each section is measured as the dependent variable. By subtracting time-to-complete TMT-A (e.g., 20 seconds) from time-to-complete TMT-B (e.g., 50 seconds), an overall measure of performance (e.g., 30 seconds) is obtained.

Trail Making Tests (Reitan, 1985) were administered on paper in the current study. Participants were instructed to connect numbers (i.e., TMT-A) or numbers and letters (i.e., TMT-B) without lifting the pencil from the paper. Per standard administration, errors were immediately pointed out and participants were allowed to self-correct. The Trail Making Test is a reliable measure across time, with young adults scoring consistently on both TMT-B (.89) and TMT-A (.79) 11 months after initial administration (Strauss, Sherman, & Spreen, 2006). In a sample of older adults, reliability drops after one year (TMT-A, .53-.64; TMT-B, .67-.72) but is still adequate (Strauss et al., 2006).

Mood and Personality Measures

Positive and negative affect schedule (PANAS).

The PANAS is a self-report measure designed to assess mood state (Watson, Clark & Tellegen, 1988). PANAS is comprised of two mood scales (e.g., positive affect, negative affect). Participants are presented with ten positive (e.g., strong, interested) and ten negative (e.g., fearful, guilty) adjectives. They are asked to rate how often they experience each emotion (1 being “very slightly or not at all” to 5 being “extremely”). Two scale scores are obtained from each participant, one for positive and one for negative affect. Those with high-positive affect report high energy, whereas those with low-positive affect report lethargy (Watson et al., 1988). The PANAS can be used to assess moods on various time scales (e.g., today, a few days, weeks, months, a year). For the current study, participants were asked to rate their mood over the last 24 hours.

Participants in the current study were presented with stimuli which varied in both valence and arousal. The PANAS scale allowed the assessment of current mood state prior to stimuli exposure. Kercher (1992) validated the use of the PANAS in both a young and older adult population. The PANAS is highly correlated with the often-used Profile of Mood States (McNair, Lorr & Droppleman, 1971). Coefficient alphas demonstrate good internal consistency with positive (.84-.87) and negative (.86-.90) affect scales (Watson et al., 1988).

Center for epidemiological studies – Depression scale (CES-D).

The CES-D consists of 20 self-report questions and is used to evaluate one's current level of depression and frequency of depressive symptoms over the last week. Responses indicate how many days a week the participant reports affective symptoms of depression (e.g., less than 1 day, 1-2 days, 3-4 days, 5-7 days). Total scores are summed to provide an estimated degree of depression, as validated with other depression measures (e.g., Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Raskin, Schulterbrandt, Reatig, & McKeon, 1969).

The CES-D has a high degree of internal reliability among young adults (.84) and demonstrates 93% sensitivity to identifying depression. This measure also exhibits high levels of test-retest reliability (.75-.96) in a university population over short periods of time (< two weeks). Reliability on the CES-D is consistent across the lifespan, but may become invalid below a certain mental status threshold (Strauss et al., 2006). Therefore, it is recommended that older adults who perform poorly on dementia screening measures such as the MMSE and SLUMS (indicating moderate to severe dementia) should not be given the CES-D. In the proposed study, older adults who indicated MCI on the SLUMS were excluded from participating in the study. Therefore, in the current study's sample of older adults the CES-D was an appropriate measure of depressive symptoms.

Horne-östberg morningness/eveningness questionnaire (MEQ-SA).

The MEQ-SA was used to examine differences in circadian rhythms between young and older adults. This measure consists of 5 self-report questions regarding sleeping and waking habits (Horne & Östberg, 1976). Scores are based on a continuous scale from evening-type (low scoring) to morning-type (high scoring). Performance on executive function and inhibitory tasks fluctuate with circadian arousal (May & Hasher, 1998; May 1999). As these arousal patterns may influence performance on the tasks administered in the current study, Morningness/ Eveningness was considered.

The MEQ-SA demonstrates high validity when compared to peak body temperatures and heart rate, which fluctuate throughout the circadian cycle. In addition, the MEQ-SA correlates highly (.95) with other measures of Morningness/Eveningness such as the Torsvalland Akerstedt measure (Smith, Reilly, & Midkiff, 1989). The Horne-Östberg measure is the most-used measure to determine Morningness/Eveningness (Smith et al., 1989). It is both reliable and valid, but is not recommended for use with night shift workers due to the format of questions (e.g., “How do you feel after being awakened in the morning?”). This measure has been used in several aging studies and is appropriate for use with older adults (Biss & Hasher, 2012; Rowe, Valderrama, Hasher, & Lenartowicz, 2006; May & Hasher, 1998; May 1999).

Epworth sleepiness scale (ESS).

The ESS is an assessment of daytime sleepiness. Participants are asked to self-rate how likely they would be to fall asleep in eight scenarios (e.g., reading in the afternoon, stopped in traffic as a driver). Scores for each scenario are added together to quantify a ‘daytime sleepiness’ score. Lower scores (0-9) are indicative of normal function, whereas higher scores (10+) may indicate sleep disturbances. This measure is highly reliably (.82) and demonstrates high internal consistency (.82) (Johns, 1992).

Additional Measures

Wechsler adult intelligence scale vocabulary test (WAIS-V).

The WAIS is the most widely used assessment of intelligence in adulthood (Strauss et al., 2006). The WAIS-V is a subtest of the Wechsler Adult Intelligence Scale (WAIS), a general intelligence measure. The Vocabulary subtest is highly reliable and is appropriate for use across the lifespan; it is normed from age 18 to 89. WAIS-V consists of 33 words (e.g., summer) that are serially presented to the participant. Scoring is based on the definition given by the participant (e.g., a warm season after Spring and before Fall). Scores ranged from zero (no answer) to two (complete description) points per word. The WAIS-V was used to assess general vocabulary, as the current study assessed inhibition of words. By ensuring that participants had a sufficient vocabulary, we were more confident in our ability to accurately evaluate their performance on the Remote Associates Task (described below).

Remote associates task (RAT). (see Appendix A)

The Remote Associates Task (RAT) was developed as a measure of creative thinking (Mednick, 1962), but has also been used by several researchers to evaluate problem solving, affect, success/failure experiences, and implicit learning (e.g., Bowers, Regehr, Balthazard, & Parker, 1990; Dallob & Dominowski, 1993; Beeman & Bowden, 2000; Bowden & Jung-Beeman, 2003). The Remote Associates Task was designed for participants with college-level reading comprehension. It targets the *restraint* function of inhibition by requiring a variety of possible solutions to be considered. In the current study, the RAT was used as a measure of inhibitory ability.

When administering the RAT, participants are presented with three clue words (e.g., manners, round, pool). The aim is to provide a fourth word (e.g., table), which is semantically related to each clue word (e.g., table manners, round table, pool table). In the current study, twelve sets of clue words were presented per condition (i.e., Adaptive condition, Nonadaptive condition). The clue words were shown for 15 seconds, at which time the participant was prompted to provide the target word. One point was given for each correct response. Solution frequencies from Bowden and Jung-Beeman (2003) were used for selection of clue and target words. Additionally, valence and word frequencies were referenced to help with selection (Brysbaert and New, 2009).

The reliability and validity of the RAT has been investigated by many researchers. Mednick (1962) initially declared it was a valid measure of creative thinking (.81). Internal reliability (.92) and test-retest reliability (.81) are high (Dailey, 1978). Furthermore, performance on the RAT changes with age and can be manipulated by inducing positive affect (Isen, Daubman, Nowicki, 1987; Feyereisen, & Charlot, 2008; Kim et al., 2007; May, 1999).

International affective picture system (IAPS).

The IAPS images are real-life photographs that have been normed for both valence and arousal. These norms were assessed using valence, arousal, and dominance scales (Lang, Bradley, & Cuthbert, 2008). Lang, et al. (2008) displayed these images to participants at a rate of 5 seconds each. Ratings were recorded using a Self-Assessment Manikin (SAM) system. SAM allows ratings on three dimensions: 1) pleasant vs. unpleasant, 2) calm vs. excited and 3) controlled vs. in-control. These responses were averaged to obtain norms for 1) valence, 2) arousal, and 3) dominance.

Selecting appropriate images was critically important for the current study. To select only the strongest images, an arousal level of 6 or higher was set as criterion for all positive and negative images. All IAPS images which met this arousal criterion were entered into a Microsoft Excel spreadsheet and sorted by valence. The highest (6+) and lowest (<3) valence values were set to accommodate approximately 80 images. To select neutral stimuli, 80 images closest to the mean valence (4.5) and low arousal (4-5) were selected.

After setting valence and arousal criterion, 76 positive, 50 neutral, and 97 negative images remained. Of these, 32 positive images were excluded for explicit nudity and 36 negative images were excluded by a panel. Seven men and women (age range 20 to 56) viewed 185 high valence images (valence > 6.0) at a presentation rate of approximately two seconds each. Raters were asked to indicate on a sheet of paper the images they found strongly aversive, or “believed were inappropriate to show older adults.” Any images that were indicated by the majority of raters were excluded from the final sample. This procedure resulted in the exclusion of 36 items.

The remaining images were selected by a random number generator. The resulting stimuli had the following characteristics: positive (*M* valence = 6.96, *M* arousal = 6.45), neutral (*M* valence = 5.5, *M* arousal = 4.4), and negative (*M* valence = 2.37, *M* arousal = 6.46). Valence of stimuli were significantly ($p < .01$) different from one another (e.g., positive vs. neutral, neutral vs. negative, negative vs. positive) as revealed by an Analysis of Variance and post-hoc tests. Each image list was randomly sorted in Excel and combined with a similarly-random list of words (see Table 1 for complete list) from the Affective Norms for English Words set (described in the following section) to form stimuli for the 1-back task. Each pair of stimuli were matched for valence and arousal (e.g., negative image-negative word or neutral image-neutral word) (see Figure 1).

Affective norms for english words (ANEW).

The ANEW word list includes normative valence and arousal ratings for over 1,000 English words. These norms were assessed using the same procedure described for the IAPS stimuli set as described in the previous section (Lang et al., 2008).

In order to select appropriate word stimuli, several steps were taken. To select only the most arousing words, an arousal level of 6 or higher was set as criterion for all words. All ANEW words which met this arousal criterion were entered into a Microsoft Excel spreadsheet and sorted by valence. To keep stimuli consistent, valence cutoffs were used from the IAPS image set (e.g., high valence = 6+, low valence = <3). To select neutral stimuli, 40 words closest to the mean valence (4.5) were selected. Note: fewer word stimuli were needed than images, as RAT solutions were intermixed with word stimuli.

After setting valence and arousal criterion, 128 positive, 36 neutral, and 181 negative words remained. The Corpus of Contemporary American English was used to find the Word Frequency per Million Words (wf) for each stimuli word (e.g., ‘like’ wf value = 3998.9 whereas ‘exalt’ wf value = .2). This value is a standard measure which is independent of corpus size and allowed us to hold constant the frequency of word use and thus, the familiarity of each word.

Two positive words were excluded due to explicit sexual language (i.e., intercourse, orgasm) and two negative words (i.e., rape, slave) were removed at the discretion of the researcher. Any words longer than 8 letters were also excluded, due to programming requirements. The remaining words were selected by a random number generator. The resulting stimuli had the following characteristics: positive (*M* valence = 7.39, *M* arousal = 6.48, *M* wf = 77.7), neutral (*M* valence = 4.5, *M* arousal = 6.39, *M* wf = 20), and negative (*M* valence = 2.4, *M* arousal = 6.6, *M* wf = 32.5). Valence of stimuli were significantly ($p < .01$) different from one another (e.g., positive vs. neutral, neutral vs. negative, negative vs. positive) as revealed by an Analysis of Variance and post-hoc tests. These words were randomly sorted in Excel and combined with the IAPS list to form stimuli pairs for the 1-back task.

Lastly, the ANEW set of words was used to select which RAT sets to include in the study. Only RAT sets with a solution word that was rated on the ANEW set were included. This allowed us to vary the valence and arousal of the solutions as they were presented in the task. Of the 250 RAT sets, only 80 had ratings from both the ANEW and Corpus of Contemporary American English. These RAT solutions were sorted by solution rate (Bowden & Jung-Beeman, 2003). To avoid floor and ceiling effects, the middle solution rates (41-85%) were selected. These 41 RAT sets were sorted by valence. The eight with the lowest and highest valence were selected as stimuli, as well as the nine most-neutral RAT sets. The RAT sets with the highest solution rates were selected to be used for practice trials. The average solution rate of the selected RAT sets was 49.58% after 15 seconds, with an average word frequency rate of 98.98.

Procedure

After completing an Informed Consent form, participants were administered screening measures (e.g., Vision, SLUMS for older adults). Some measures were administered on paper (CES-D, PANAS, Demographics, TMT, MEQ-SA, ESS, WAIS-V), and others were administered on the computer (1-back, WCST-C). Prior to any stimulus exposure, participants were asked to complete the CES-D and PANAS. They also completed a demographic and health questionnaire (see Appendix B). After rolling a die, participants were either assigned to complete the Adaptive or Nonadaptive condition of the 1-back task. The task was administered on a computer which was programmed for presentation using E-prime software (Psychology Software Tools, Pittsburgh, PA). The remaining measures (TMT, MEQ-SA, ESS, and WAIS-V) were administered on paper, and the WCST-C was administered on the computer. The final condition of the 1-back task was administered, and then the participant was thanked for their time and effort (see Figure 2 for procedure phases). An average completion time was approximately 60 minutes. Young adults were provided with extra credit and older adults were presented with a $10 gift card to an establishment of their choosing.

Task Conditions (Adaptive, Nonadaptive)

Two conditions were presented that differed in cognitive control. The current study specifically explored inhibitory ability and affect by placing a target word (e.g., table) within the context of real-life images from a normed image set. These words and images were matched for valence, but varied from positive (e.g., ‘love’ on image of the beach) to neutral (e.g., ‘lobster’ on image of a paperclip), to negative (e.g., ‘blood’ on image of war). This study utilized a repeated measures design, with conditions being counterbalanced in presentation by roll of a die (if even, Adaptive condition first; if odd, Nonadaptive condition first). Directions varied across condition, either instructing participants to attend to the image alone, while ignoring the word (Adaptive) or to simultaneously attend to the image and word (Nonadaptive). Participants were asked to key-press when the same stimulus is shown twice in a row (1-back task). Immediately following each condition, 12 RAT problems were presented. Six of the RAT solutions were previously presented during the 1-back task, and these RAT solutions also varied in valence. Correct solutions provided on the RAT were used to evaluate if participants successfully ignored the word superimposed on the previously presented pictures.

Adaptive condition of the 1-back task.

Participants were explicitly instructed to attend only to the image while ignoring the word. A set of 20 image/word practice trials and three RAT practice problems were presented. Accuracy was verified, and corrections were made if necessary. Participants had the opportunity to ask questions or clarify instructions after completing the practice trials. The experimental condition began after all questions were answered. The initial instructions for this task indicated that participants should press the spacebar whenever the same image was repeated twice in a row. They were explicitly reminded to respond only to the image, while ignoring the word. A fixation cross appeared for 500 ms, followed by the presentation of an image/word pair for 750 ms. A series of 60 pairs were displayed, with 10 repeating (1-back task). Upon conclusion of this task, participants were administered 12 RAT problems. Six of the RAT solutions were words that were previously displayed during the 1-back task. If participants successfully ignored the presented words, correct answers on the RAT were decreased. It was expected that participants who were unable to control distraction would have fewer correct responses to the 1-back task and be more likely to supply previously shown words as correct solutions on the RAT task.

Nonadaptive condition of the 1-back task.

Participants were explicitly instructed to attend to both the image and the word. A set of 20 image/word practice trials and three RAT practice problems were presented. Accuracy was verified, and corrections were made if necessary. Participants had the opportunity to ask questions or clarify instructions after completing the practice trials. The experimental condition began after all questions were answered. The initial instructions for this task indicated that participants should press the spacebar whenever the same image/word pair was repeated twice in a row. They were explicitly reminded to respond to the combination of both image and word. A fixation cross appeared for 500 ms, followed by the presentation of an image/word pair for 750 ms. A series of 60 pairs were displayed, with 10 repeating (1-back task). Upon conclusion of this task, participants were administered 12 RAT problems. Six of the RAT solutions were words that were previously displayed during the 1-back task. If participants successfully attended to both images and words simultaneously, more correct answers were expected on the RAT. Those participants who unsuccessfully attended to both the image and word were expected to have fewer correct responses on the 1-back task and be less likely to supply accurate solutions on the RAT task.

CHAPTER 4

RESULTS

This study was designed to test age-related differences in performance on a recall task across two conditions (Adaptive, Nonadaptive). These conditions differed in directions given to the participant about what stimuli they should attend to. The Adaptive condition required attending to only one stimulus (image), whereas the Nonadaptive condition required attending to both image and word, thus requiring greater cognitive control. A series of 55 emotional image/word pairs were displayed for 1,000 ms each. In the Adaptive condition, participants were instructed to ignore the word stimulus and key-press when the same image appeared twice in a row (1-back task) In the Nonadaptive condition participants were instructed to attend to both the image and word stimuli and key-press when the same image/word pair was shown twice in a row.

Older adults were expected to be distracted by positively valenced extraneous stimuli. This distraction was measured by performance on a subsequent task, of which half of the answers were previously used as distractor stimuli. Older adults were expected to provide these positively valenced distractors at a higher rate than young adults. Consequently, it was expected that while older adults would provide some negatively valenced responses, young adults would provide these at a higher rate. Descriptive statistics were obtained to find the mean, standard deviation, and skewness for executive function and mood measures. Pearson's correlations, *T*-Tests, and a mixed-effects ANOVA were performed based on the hypotheses, the results of which are presented below.

Data Preparation

Data was collected from 42 young adults and 25 older adults. Participants aged 18 to 30 were classified as young (M_{age} = 21.68, *SD* = 2.31) while participants aged 60 to 89 were classified as older (M_{age} = 72.00, *SD* = 9.58). The sample of older adults was highly educated with an average of 4.18 years of post-secondary education (*SD* = 1.76) whereas young adults averaged significantly fewer years of education (*M* = 2.41, *SD* = .61), t (62) = -5.40, $p < .01$. In both young and older samples, more participants were female than male. The gender breakdown in young adults was 64.9% female and 35.1% male. In the sample of older adults, females represented 68.2% of participants and males represented 31.8% of the sample. According to an a priori power analysis, 28 participants per group were recommended. However, recruitment of older adults from a community sample via word of mouth and promotional materials proved more challenging than anticipated in the time allotted for data collection.

Counterbalancing across the Adaptive and Nonadaptive conditions was equivalent, with young participants being assigned the Adaptive condition first 51.7% of the time, and the Nonadaptive condition 48.3% of the time. Similarly, older participants were assigned the Adaptive condition first 45.5% of the time, and the Nonadaptive condition first 54.5%.

Exclusions and Outliers

Participants were excluded due to their extreme scores or an inability to complete at least one of the cognitive tasks or experimental conditions. Two young adults and one older adult were identified as outliers by using boxplots. These participants were subsequently excluded from the overall sample analysis. If not removed, these outliers may have impacted the group mean or skewed the normal distribution of scores. For example, one young adult was an extreme outlier for Trails B, and was subsequently a mild outlier in three of the experimental measures. One young adult was excluded due to falling asleep during the completion of the second experimental condition.

There were a total of 14 outliers across non-executive function and non-experimental measures. These outliers were identified with boxplots and excluded for only the measure on which they were an extreme score. One older adult reported being strongly evening-type, which was unusual for their age group. Two young adults were unable to complete the WAIS-V measure, resulting in extreme outlier scores.

Descriptive Statistics

All measures from the current study were sorted into four categories (executive function, mood, sleep, vocabulary). Performance and descriptives for each of these categories will be discussed in subsequent sections. Measures within the executive function category included WCST-C and Trails. The mood category was composed of both the PANAS and CES-D which assess mood state and depressive symptoms, respectively. The category of sleep included two measures; the MEQ-SA and ESS. Lastly, a vocabulary category included performance on the WAIS-V. See Table 2.1 for an overview of relevant descriptive statistics.

Executive function measures: descriptive statistics.

Raw scores on the executive function measures (e.g., WCST-C, WAIS-V, TMT) were left untransformed. Norms for these measures are adjusted for age and education (Strauss et al., 2006). The computerized WCST was administered to all participants. Young adults (*M* = 99, *SD* = 16.25) perseverated about as frequently as older adults (*M* = 94.5, *SD* = 12.44), *t* (51) = .81, *p* = .42. Similarly, young adults (*M* = 97.77, *SD* = 13.37) demonstrated similar values of consecutive correct responses as older adults (*M* = 91.18, *SD* = 16.77), *t* (51) = -1.43, *p* = .16.

As expected, the only measure of executive function related to level of education was the Trail Making Test (*r* = .31, *p* = .02). Achievement on the Trail Making Test is measured in seconds, with lower scores indicating better performance. Older adults (*M* = 21.82 s, *SD* = 11.27) and young adults (*M* = 19.92 s, *SD* = 10.39) performed comparably, *t* (51) = -1.07, *p* = .17. Older adults were expected to have significantly higher completion times than young adults, as this measure was sensitive to reaction time (Strauss et al., 2006). When performance by older adults from this sample was compared to age-appropriate norms (*M* = 39.42 s for average age 70-74, with some post-secondary education), it was evident that the current sample performed much faster than expected (Strauss et al., 2006).

Mood measures: descriptive statistics.

There was no significant difference in self-rated positive affect between young (*M* = 29.76, *SD* = 8.68) and older adults (*M* = 32.25, *SD* = 8.19), *t* (55) = -1.05, *p* = .29. However, as hypothesized, young adults self-reported stronger negative affect (*M* = 17.14, *SD* = 6.11) in the 24 hours prior to the study than older adults (*M* = 12.89, *SD* = 5.28), *t* (55) = 2.56, *p* = .01. Figure 3 shows self-rated affect for both young and older adults. Similarly, young adults self-reported significantly more depressive symptoms (*M* = 17.65, *SD* = 13.23) than older adults (*M* = 8.5, *SD* = 6.46), *t* (56) = 2.29, *p* < .01.

Sleep measures: descriptive statistics.

Sleep quality declines in older adults (May, Hasher, & Zacks, 1998; Hlaing, 2012; Winocur and Hasher, 2002). Similarly, college students experience sleep disturbances and report getting fewer hours than needed (Hlaing, 2012). Sleep problems in this sample were pervasive, with 97.3% of young and 95% of older adults meeting criterion for daytime sleepiness (score of >10). Young adults reported an average daytime sleepiness of 16.1 (*SD* = 3.26) with older adults reporting similar amounts of sleepiness on average at 15.3 (*SD* = 3.18), t (55) = .93, p = .36. MEQ-SA scores were consistent with previous research, with young adults reporting equal tendencies toward morning and evening-type (skewness = .01, *SD* = .83) and older adults skewing toward morning-type (skewness = -.42, *SD* = .89), t (57) = -3.88, p < .01 (see Figure 4) (May et al., 1998; Winocur and Hasher, 2002; Biss & Hasher, 2002). These results represent typical sleep patterns between young and older adults and were expected.

Vocabulary measure: descriptive statistics.

Older adults typically demonstrate significantly higher vocabulary scores than young adults (Ghisletta, Rabbitt, Lunn, & Lindenberger, 2012; Singer et al., 2003). Forms of crystallized intelligence, such as vocabulary, are expected to remain stable over time (Yam, Gross, Prindle & Marsiske, 2014). Older adults from the current sample performed as expected, and received significantly higher scores (*M* = 52.10, *SD* = 7.99) on the WAIS vocabulary measure than young adults (*M* = 35.65, *SD* = 8.03), t (53) = -7.39, p < .01. As discussed previously, older adults reported significantly more years of education than young adults. As expected, education was related to performance on the vocabulary measure (r = .66, p < .01).

Hypothesis-Driven Results

Hypothesis 1

A relation between age (i.e., young, old) and condition (i.e., attend to image only, attend to both image and word) on inhibitory performance as measured by correct solutions on the RAT task was expected. Consistent with the Hyper-Binding Theory, older adults were expected to bind extraneous information to target information (Campbell et al., 2010). As a result, older adults were expected to supply more RAT responses than young adults in the Adaptive condition. Young adults were expected to have superior cognitive control, and thus provide more RAT solutions than older adults in the more challenging Nonadaptive condition.

Hypothesis 2

A relation between valence (i.e., positive, negative, neutral) of the stimuli and age (i.e., young, old) was expected across conditions. Based on the Socioemotional Selectivity Theory (Carstensen, 1991), it was expected that while young adults would supply more RAT answers overall, older adults would provide more words that were positively valenced. Older adults were expected to recall fewer negatively valenced words than young adults. Consistent with the Hyper-Binding Theory (Campbell et al., 2010), young adults were expected to recall neutrally-valenced stimuli at a higher rate than older adults.

Analysis

Number of correct distractor RAT responses were entered in a mixed-effects ANOVA with valence (positive, negative, neutral) and condition (Adaptive, Nonadaptive) as within-subjects factors and age (young, older) as the between-subjects factor.

Outliers were removed prior to analysis. Mixed-effects ANOVA revealed no significant interaction between valence, condition, and age, partial $\eta2 = .07$, $F(2, 52) = 1.57$, $p = .14$. In contrast to Hypothesis 2, age group did not significantly interact with valence, partial $\eta2 = .01$, $F(2, 52) = .37$, $p = .69$. However, mixed-effects ANOVA indicated that age group did interact with condition, partial $\eta2 = .15$, $F(2, 52) = 4.52$, $p = .04$. Additionally, the valence by condition interaction was significant (see Figure 6), partial $\eta2 = .94$, $F(2, 52) = 151.01$, $p < .01$. There was no main effect of condition, partial $\eta2 = .00$, $F(2, 52) = .01$, $p = .97$, but valence by itself had an effect on number of correct RAT solutions (see Figure 7), partial $\eta2 = .12$, $F(2, 52) = 3.32$, $p = .04$.

Age group significantly interacted with condition, partial $\eta2 = .15$, $F(2, 52) = 4.52$, $p = .04$. Comparisons with a Sidak adjustment for multiple corrections showed that in the Adaptive condition, older adults ($M = 3.04$, $SD = .12$) provided significantly fewer correct RAT solutions than young adults ($M = 3.25$, $SD = .13$), $p = .04$. However, in the Nonadaptive condition, older adults ($M = 3.31$, $SD = .12$) provided significantly more correct RAT solutions than young adults ($M = 3.0$, $SD = .14$), $p = .04$.

The valence by condition interaction was observed in only the neutral and negative stimuli, partial $\eta2 = .94$, $F(2, 52) = 151.01$, $p < .01$. Participants provided similar numbers of positive RAT solutions in both the Adaptive condition ($M = 2.99$, $SE = .15$) and the Nonadaptive condition ($M = 3.16$, $SE = .14$). Number of negative RAT solutions was strongly impacted by condition, with significantly more being provided in the Adaptive condition ($M = 5.05$, $SE = .13$) relative to the Nonadaptive condition ($M = 1.62$, $SE = .09$). This effect was reversed with neutral RAT solutions, where participants provided fewer in the Adaptive condition (*M* = 1.4, *SE* = .10) and more in the Nonadaptive (*M* = 4.69, *SE* = .17) condition.

A main effect of valence was observed, partial η2 = .12*, F* (2, 52) = 3.32, *p* = .04. RAT solutions associated with negative stimuli (*M* = 3.33, *SE* = .07) were provided more frequently than those associated with positive stimuli (*M* = 3.07, *SE* = .10) or neutral stimuli (*M* = 3.04, *SE* = .11), *p* = .04. There was no significant difference in RAT solution rate between neutral and positive stimuli, *p* =.99.

Bivariate Pearson correlations were used to investigate the relations between the dependent variable (i.e., total correct RAT solutions) and implicit memory measures (e.g., word stems, image recognition) across both conditions (Adaptive, Nonadaptive). In the Adaptive condition, participants who provided more correct RAT solutions were more likely to give primed answers on the word stem task (*r* = .35, *p* = .01). Similarly, there was a positive correlation between correct RAT solutions and correct image recognition (*r* = .29, *p* = .03). Lastly, there was a positive correlation between primed answers on word stems and correct image recognition in the Adaptive task (*r* = .39, *p* = .01). On the other hand, there were no significant correlations between the measures in the Nonadaptive condition. Specifically, there was no significant relation between RAT solutions and primed answers on the word stem task (*r* = .27, *p* = .06) or correct image recognition (*r* = -.07, *p* = .65). Additionally, no relation was observed between primed answers on word stems and correct image recognition on the Adaptive task (*r* = .15, *p* = .30). Performance on the RAT task was significantly related to both education (*r* = .27, *p* = .04) and vocabulary score (*r* = 33., *p* = .01).

CHAPTER 5

DISCUSSION

This study was designed to investigate age-related differences in recall performance on a 1-back task. This task was administered, within subjects, across two conditions, which differed in instructions about what stimuli to attend to (e.g., attend to image only; attend to image/word pair). The Adaptive condition required attending to only one stimulus (image), whereas the Nonadaptive condition required attending to both image and word, thus requiring greater cognitive control.

The sample was composed of 42 young adults (Midwestern college students aged 18-30 yrs) and 25 older adults (rural community dwellers aged 60-89 yrs). Young participants were recruited from psychology courses and given extra credit for participation. Older adults were recruited via postcards, phone calls, and word-of-mouth and provided with a $10.00 gift card.

In order to assess group-based differences in performance, two hypotheses were proposed and will be discussed in subsequent sections. A significant interaction between age and condition was observed on amount of correct RAT solutions, where in the Adaptive condition, older adults provided significantly fewer correct RAT solutions than young adults. Conversely, in the Nonadaptive condition, older adults provided significantly more correct RAT solutions than young adults. Additionally, there was a significant interaction between valence and condition on average amount of RAT solutions, with significantly more negative RAT solutions provided in the Adaptive condition relative to the Nonadaptive condition. This effect was reversed with neutral RAT solutions, where participants provided fewer in the Adaptive condition relative to the Nonadaptive condition. A main effect of valence was observed, with negatively valenced RAT solutions being provided more frequently than those associated with positive or neutral stimuli.

Valence

Positively valenced distractor stimuli were expected to distract the older participants, thus decreasing recall performance of this group. Distraction was measured by correct solutions provided on the RAT task, of which half of the answers were previously used as distractor stimuli. Older adults were expected to provide positively valenced distractors at a higher rate than young adults. Young adults were expected to provide negatively valenced distractors at a higher rate than older adults. Valence was related to performance on the RAT, but age differences were not observed. Both young and older adults provided significantly more negative- than positive-valenced words, indicating that highly emotional stimuli can induce distraction. This effect was strongly influenced by condition, which is discussed in the following section.

It has been suggested that, like working memory, perceptual processing has a limited capacity and is driven by 'bottom up' processes, initiated by sensory input (Lavie, 2004). Once this perceptual capacity is reached, extraneous details are not processed (Lavie, 2004; Lavie & Tsal, 1994). High perceptual load, evident in the current study using IAPS images, may leave no spare capacity for additional processing of details such as valence (Craik & Schloerscheidt, 2011). Several studies of attention and inhibitory ability used Snodgrass and Vanderwart (1980) line drawings (Biss & Hasher, 2011; Rowe, et al., 2006; Yang & Hasher, 2007; Campbell et al., 2010). In this study, complex and real-life images were used instead of line drawings. This may have contributed to interference due to the increased cognitive processing required. In behavioral observations, several older participants commented they were unable to tell what the IAPS photos were, "because they were going too fast". IAPS photos may have increased the processing load, thereby increasing distractor interference (Lavie, 2004; Lavie & Tsal, 1994; Jiang & Chun, 2001).

In a study similar to the current study, valenced (positive, negative, neutral) photos were shown for 1000 ms (Kensinger, Garoff-Eaton, & Schacter, 2007). Findings were comparable, with both young and older adults demonstrating enhanced memory for negative stimuli. This effect may be due, in part, to positively valenced stimuli being processed for longer periods of time (Mather et al., 2003, Fung & Carstensen, 2003). This increased processing may consequently increase the perceptual load (Craik & Schloerscheidt, 2011). These results indicate that negative distractors might enhance specificity of memory for both young and older adults (Tulving and Thomson, 1973; Bahrick, 1970; Puglisi, Park, Smith & Dudley, 1988).

Another variable to consider is arousal. The IAPS and ANEW (Lang et al., 2008) are normed for both valence and arousal. Arousal was held constant across both positive and negative stimuli (>6) but was lower in neutral stimuli (<4). This may have led to stronger attention and encoding of highly arousing stimuli. This effect was strongly influenced by condition, which is discussed in the following section.

Condition

Older adults were expected to supply more RAT responses than young adults in the Adaptive (attend to image only) condition. It was expected that participants who were unable to control distraction would be more likely to encode distractors, and thus supply previously shown words as correct solutions on the RAT task. Conversely, in the Nonadaptive condition (attend to both image and word), older adults were expected to provide fewer RAT solutions than young adults. This condition required greater cognitive control because participants were required to attend to both stimuli (Kahneman, 1973). Young adults were expected to demonstrate superior cognitive control when compared to older adults.

Although there was a significant interaction between age and condition, it was contrary to Hypothesis 2. Young adults provided more RAT solutions in the Adaptive condition relative to older adults. This effect was reversed in the Nonadaptive condition, with older adults providing more correct RAT solutions than young adults. Current findings provide further support that context places a crucial role in processing, and can influence problem-solving performance (Artistico et al., 2010).

A significant interaction between condition and valence was observed. When told to ignore the word stimuli (Adaptive), participants provided significantly more negatively valenced solutions than either positive or neutral. When told to attend to both image and word stimuli (Nonadaptive), participants provided significantly more neutrally valenced stimuli than either positive or negative. These findings indicate that instructional manipulations may lead to differential processing and that the two conditions did indeed access distinct underlying cognitive mechanisms.

Kahneman (1973) proposed a ‘limited capacity’ model, in which executive functions (e.g., attention) are controlled by a finite amount of cognitive resources. As tasks are introduced and completed, resources are distributed across necessary systems (e.g., while learning new content, ‘attention’ may consume more cognitive effort than ‘problem solving’). Cognitive demand was highest in the current study during the Nonadaptive condition, where participants were asked to attend to concurrent emotional stimuli. Neutral stimuli (less arousing and less emotional) were recalled the most in the Nonadaptive condition. Perhaps while the stimuli were being presented, the necessary cognitive resources to additionally process the emotional nature of the stimuli were not available. Future studies could further investigate the cognitive demand of emotional stimuli by assessing how arousal and valence impact encoding.

Performance on cognitive tasks may be enhanced by attentional manipulations (Kim et al., 2007). If distractors are attended to, performance on some tasks may be improved (due to encoding extraneous, contextual details) (Kim et al., 2007; Campbell et al., 2010). This is consistent with findings from the current study, where more negative responses were provided when cognitive demands were manipulated to require less cognitive control (e.g., Adaptive condition).

Age-Related Differences

No age-related differences in recall based on valence of stimuli were observed. However, a significant interaction emerged between age and condition. Young adults provided more RAT solutions in the Adaptive condition, and older adults provided more RAT solutions in the Nonadaptive condition. All of these solutions were displayed as distractors, which may have facilitated performance and provides additional support for the Hyper-Binding Theory (Campbell et al., 2010). As discussed previously, there is less variability between young and older participants on focused attention tasks

(Kramer & Madden, 2008; Rogers, 2000). Additionally, the accessed sample of older adults for this study were homogeneous and lacked interindividual variability in cognitive performance.

Tasks which assess focused attention typically display a static target with distractors, which appear around the target (e.g., listening to a lecture while other students arrive late and sit down in front of you). Tasks which draw on this form of attention do not show strong age-related differences, so it would be expected that smaller age-related differences would be observed (Kramer & Madden, 2008; Rogers, 2000). Perhaps the current RAT task drew heavily on focused attention. Future studies could attempt to induce divided or selective attentional demands (which are more age-sensitive) to investigate how distraction may be influenced by valence and condition across age groups.

One way in which older adults may benefit from context is by forming associations between to-be-remembered information and extraneous contextual information (Campbell et al., 2010). The Hyper-Binding theory suggests that older adults connect or 'bind' the intended (e.g., target) information with distracting (e.g., contextual) information. In the current study, older adults provided significantly more RAT solutions in the Nonadaptive condition relative to young adults. This may provide support for the benefits of context on recall performance (Campbell et al., 2010). Older adults recalled more words that they were instructed to attend to, and fewer of those which were used as distractors. Future studies may attempt to deduce whether distractor words were properly encoded but not recalled efficiently. This may be the underlying mechanism of declining recall performance in older adults (Kim, et al., 2007).

The content of the RAT task may draw more heavily on crystallized intelligence (e.g., skill, experience, vocabulary), which increases in middle adulthood and remains stable into older adulthood (Yam et al., 2014). By drawing on crystallized intelligence, older adults may have been able to facilitate their performance on the RAT task.

Paradoxical findings where older adults recall more than young counterparts have previously been attributed to a reduction in inhibitory actions (Hartman & Hasher, 1991). Older adults may be less efficient at ignoring or forgetting distractors than young adults. Older adults typically do not inhibit distractors, which can lead to both processing and encoding of the information (Kim et al., 2010). This effect may not have been observed in the current study due to the highly-functioning sample of older adults. Alternatively, older participants may have sustained activation of distractors for longer periods of time because they did not suppress the information (Kim et al., 2010). Future studies could investigate this by assessing reaction times while controlling for generalized slowing expected in older adults (Salthouse, 2004).

It was expected that the Nonadaptive condition would require greater cognitive control. In this study, older adults provided more RAT solutions in the Nonadaptive compared to Adaptive condition. These results were contrary to expectations. Hasher and Zacks (1988) proposed that inhibitory processes draw heavily on cognitive resources. Instructions in the Adaptive condition required participants to inhibit the word stimuli, which may have resulted in a more demanding task (Hartman & Hasher, 1991). This could explain the pattern of performance observed in the current study. Future research could examine reaction times to evaluate performance on a similar 1-Back task. Those findings may reveal which condition required greater cognitive resources.

The current sample of older adults performed well above average on measures of executive function. For example, older adults demonstrated fewer perseverative errors than expected on the WCST-C (this measure targets the deletion function of inhibition), indicating they were a select group of high-functioning older adults (Strauss, Sherman, & Spreen, 2006). Conversely, young adults in this sample performed as expected (Strauss et al., 2006) on executive function measures.

Expected differences in affect, depressive symptoms, and Morningness/Eveningness were observed in the current sample of older adults and are consistent with previous literature. When compared to young adults, older adults report shorter and less frequent negative emotional experiences (Carstensen et al., 1999). Young adults reported more frequent negative affect than older adults in the current sample. As expected, young and older adults did not differ in positive affect (Carstensen et al., 1999; Labouvie-Vief, 2003; Rowe et al., 2006).

Limitations

Several steps were taken to carefully design the current study with a great deal of methodological control. Using a repeated measures design reduced interindividual differences and variability. Additionally, this design allowed for a highly efficient study, which required a smaller sample of participants. Although repeated measures designs are susceptible to mean regression and order effects, proper counterbalancing was utilized to address these concerns. The results supported the strengths of the design, in that measures were correlated where expected (e.g., in the Adaptive condition, performance on the RAT was correlated with implicit memory measures). Another factor that contributed to the validity of this study was the use of normed images.

This study sought to replicate real-life instances of distraction. Several previous studies of attention and distraction relied on the Snodgrass and Vanderwart (1980) set of line drawings (Biss & Hasher, 2011; Rowe, et al., 2006; Yang & Hasher, 2007; Campbell et al., 2010). While valid, these images do not replicate the visual processing experienced outside the laboratory. By utilizing IAPS images, the current study ensured that target stimuli offered a more realistic portrayal of the processing demands that older adults encounter in daily activities (Lang et al., 2008). The 1-back task in this study required integrating several components of the stimuli (e.g., image details, valence of image, word stimuli, valence of word, etc.), which may be more similar to real-life processing (e.g., during a conversation the recipient may process the surrounding sights and sounds, as well as the meaning of words, facial expressions, body language, etc). Utilizing this method increased the external validity of the current study.

Future studies may examine the validity of IAPS norms for older adults. Behavioral observation indicated that several older adults felt the negatively valenced images "stood out". Some participants also commented that the negatively valenced images were "more negative" and the positively valenced images were "less positive". For example, one participant stated that when they thought of positive images, they pictured "babies and puppies", but the positive images in the current study were things they didn't associate with a positive mind set, such as roller coasters and skydiving. This effect is likely due to the high arousal (>6) of both positive and negative images (Lang et al., 2008).

Although the results provide intriguing evidence regarding influence of distractor valence on recall performance, there are several limitations to be considered. Foremost, a cross-sectional design was implemented which does not allow conclusions to be drawn about age related change, only age differences. The effects observed may be in part due to cohort or generational differences, rather than age alone. Additionally, due to the quasi-experimental nature of age as an independent variable, no causal conclusions can be drawn from the results. Due to the aforementioned factors, generalizability of the study is limited.

The target population for this study was average American older adults. The selected sample of older adults, by design, did not exhibit strong variability in cognitive abilities. Additionally, 96% of the selected older adults were Caucasian. The majority of older adults in this sample lived alone, representative of approximately 46% of American older adults (AOA, 2012). No participants in this sample came from hard-to-access settings such as institutional living, where approximately 6.3% of the population resides (AOA, 2012). Lastly, comorbidities and health issues are pervasive in the American population, with 56% of older adults reporting health problems (AOA, 2012). Only 14% of older participants from the current study responded similarly.

As a result of these limitations, the findings apply to a very select sample of highly functioning and healthy older adults. Overall, this sample performed well above expected for their age group. The current sample of older adults was not representative of those in the general population for this age group. The selected sample of older adults who participated were likely more focused and motivated than their peers from the general population (Salthouse, 2010).

An additional factor that may have led to biased sampling is incentives. Incentives such as extra credit and gift cards were provided. Behavioral observation suggested that social interaction may have also acted as an incentive for both the young and older participants. More than half of older adults stayed longer than the 60-minute research time to visit with the researcher. Several commented that it was nice to have company and to have someone show interest in their stories. These incentives may bias the participant pool by motivating a select group of young and older adults.

Throughout the testing process, some young adults used cell phones, or were interrupted by noise from either adjacent rooms or personal electronics. Several measures that were administered in this study drew upon attentional resources, which may be impacted by both external and internal distractors. However, steps were taken to ensure a reliable testing environment. Participants were reminded to turn off their cell phones and electronics prior to participating. Additionally, signage outside the laboratory indicated when testing was ongoing. These precautions limited the number of interruptions and unintended distractions.

Another factor which may have hindered performance was sleepiness. Daytime sleepiness (as assessed by the Epworth Sleepiness Scale) was reported by the majority of both young and old participants, but was most behaviorally evident in young adults. For example, one young participant fell asleep during the computerized tasks and two had to be reminded about staying alert. Many of the young participants also verbally reported being tired. Although Morningness/Eveningness orientation was self-reported via assessment with the MEQ, it was not possible to accommodate preferences of all participants when scheduling testing times. Older adults self-selected their testing time, whereas young adults had pre-selected times to choose from. Future research may explore how circadian rhythms and synchrony impact distractability. Participants could be scheduled at synchronous (e.g., morning-type person at 9am) and non-synchronous (e.g., evening-type person at 9am) times to see how Morningness/Eveningness orientation may influence attention and inhibition. Distraction by affect (e.g., positive, negative stimuli) could similarly be explored. While young adults may have struggled with staying alert, some older adults experienced frustration with performance on executive function tasks.

Older adults appeared to struggle on select tasks. Behavioral observation suggested that tasks such as TMT and WCST-C contributed to performance anxiety especially for the older participants. Older adults tended to be invested in their own performance, so tasks which provided immediate feedback allowed them to instantaneously self-gauge performance. Based on their perception of performance, some older adults demonstrated occasional agitation. For example, one participant verbally acknowledged their frustration when answering incorrectly on the WCST-C. This agitation led to delayed responding on subsequent questions, when it appeared they could not ‘get past’ performance on previous trials. This arousal may have negatively affected performance when it became too stimulating (Diamond, Campbell, Park, Halonen & Zoladz, 2007).

Another task that many participants were frustrated by was the RAT. Based on behavioral observation, the majority of participants disliked the RAT. To reduce frustration and resignation, most participants required verbal encouragement. The average solution rate was between 40% and 60%, so there were no floor or ceiling effects. However, completing 24 RAT problems in less than an hour with an average solution rate of 50% is discouraging. Many young adults confided that they "felt stupid" or "didn't realize they were so bad at word problems". This subjectively negative experience may have contributed to poor performance or led to heightened attention toward negative stimuli. Future studies may consider selecting RAT tasks which have a higher average solution rate, or may reduce the number of RAT problems given.

Implications

As demonstrated in the current study, valence and condition instructions may strongly influence recall on implicit memory tasks. Many daily activities, or Instrumental Activities of Daily Living (IADL), require efficient attentional abilities (e.g., managing money, transportation, and medication) (Vaughan & Giovanello, 2010). Situations may turn hazardous if the person becomes distracted, such as starting fires while cooking or becoming inattentive during driving. Results from the current study may provide a basis for training studies. Cognitive training has been proposed as a possible mechanism maintain independent living for older adults (Ball, et al., 2002; Willis, et al., 2006; Karbach & Kray, 2009). Results from the current study could be used when designing a cognitive training regimen. By using negatively valenced stimuli as distractors, researchers may increase recall of training materials.

Forgetting medication (or re-dosing) and injurious falls are potential byproducts of distraction, and are the target of several intervention studies (Roaldsen, Halvarsson, Sahlström, & Ståhle, 2014; Parry et al., 2014; Michael et al., 2010). For instance, one study implemented clinical education and behavioral counseling as a method of reducing risk and rate of falls in older adults. Participants participated in weekly group sessions led by an occupational therapist for seven weeks (Michael et al., 2010). Researchers may be able to improve recall on these intervention tasks by manipulating the valence of stimuli (e.g., positively framing stimuli "likelihood of preventing a fall", instead of negatively framing stimuli "likelihood that a fall is injurious").

Many older adults could benefit from clinical or behavioral training from physical/occupational therapists. Seventy three percent of Americans aged 65+ report some type of activity limitation (e.g., difficulty in sensory processing, cognition, self-care, movement, or independent living) (AOA, 2012). Those with restrictions often seek occupational or physical therapy in order to improve or regain skills (Vaughan & Giovanello, 2010). Understanding distraction and attention in older adults may influence retention and recall of concepts and training tasks. For example, this study demonstrated increased recall of negatively valenced distractors. Negative distractors in the learning/training environment may lead to increased distraction. Therefore, steps should be made to eliminate negatively valenced extraneous information (e.g., posters, flyers) in the training environment.

Another area impacted by distraction is goal-oriented behavior. Both learning and achieving goals (short- and long-term) require prioritization of thoughts and behavior (Hasher, 2007). Prioritization takes place on two levels; what should be attended to and what irrelevant stimuli to block out. Healthy inhibitory control assists in this process by down-regulating activation and supporting organization (Hasher, 2007). Inhibitory control is utilized during speech/language production, memory, and social interaction (May & Hasher, 1998). If, as suggested by the current study, inhibitory control is decreased by negative distractors, then cognitive tasks such as learning and memory may be impacted by extraneous information.

Both young and older adults should recognize that negatively valenced information may reduce cognitive efficiency. If inhibition is disrupted, irrelevant information may reduce the capacity of working memory, slowing the processing of relevant information (May & Hasher, 1998). Reduction of inhibitory capability is evident in older adults, and can be exacerbated by common conditions such as mood disorders and degenerative diseases (Hasher, 2007). Future research may incorporate findings from the current study into interventions for mood and degenerative disorders. In addition, young adults may benefit from reducing negative distractors in their learning environment. For instance, young adults should limit negative (e.g., stressful, sad) stimuli while completing tasks which draw heavily on attentional abilities (e.g., learning new material or studying for tests).

CHAPTER 6

CONCLUSION

This goal of this study was to investigate age-related differences in performance when valence and condition instructions were manipulated. There was a significant effect of age on amount of correct RAT solutions, with young participants providing significantly fewer solutions than older participants. There was also a significant interaction between valence and condition on number of correct RAT solutions, where more negative-valenced solutions were provided in the Adaptive condition. In the Nonadaptive condition, more neutral-valenced solutions were provided than either positive- or negative- valence. Age group differences were not observed based on valence or condition, only on total correct responses. The RAT task may draw heavily on crystallized intelligence, a kind of aptitude which increases in later adulthood. The current sample of older adults performed well above average on measures of executive function, but young adults performed as expected.

The association between affect and inhibitory processes (including both the benefits and disadvantages of distractibility) was the focus of the current project. One implication of this research is the development of interventions and programs designed to maintain or improve activities of daily living such as driving ability, reading comprehension, and social interactions. While older adults do exhibit a reduction of inhibitory capability (May & Hasher, 1998; Hasher, 2007) which may lead to distractibility, distraction may, at times, be adaptive for older adults (Kim, et al., 2007; Healey et al., 2008) and allow older adults to encode contextual details that would otherwise be ignored. This study supports the view that aging leads to both losses and gains in function.

Beyond understanding how attention functions, researchers in developmental psychology are interested in how attention fluctuates across the lifespan. Utilizing cross-sectional designs, cognitive aging researchers have documented how types of attention differ between young and older adults. While cognitive processes may be impacted by attentional decline, not all processes are *negatively* impacted. The Benefits of Distractibility Theory (Kim et al., 2007) serves as a framework for how distraction may, at times, be adaptive for older adults and allow older adults to encode contextual details that would otherwise be ignored.

Table 1

Stimuli pairs for both Adaptive and Nonadaptive conditions

Adaptive (ANEW)	Adaptive (IAPS)		NonAdaptive (ANEW)	NonAdaptive (IAPS)
bomb	IAPS\2811.jpg		killer	IAPS\9183.jpg
enjoy	IAPS\8163.jpg		cure	IAPS\5626.jpg
enjoy	IAPS\8163.jpg		abuse	IAPS\9635.1.jpg
soap	IAPS\7010.jpg		despise	IAPS\9635.1.jpg
suffer	IAPS\3059.jpg		red	IAPS\7050.jpg
fail	IAPS\9921.jpg		laugh	IAPS\4660.jpg
bankrupt	IAPS\6821.jpg		cash	IAPS\8490.jpg
anxious	IAPS\6821.jpg		graduate	IAPS\4689.jpg
chaos	IAPS\7025.jpg		loved	IAPS\8492.jpg
pistol	IAPS\7058.jpg		happy	IAPS\8492.jpg
laughter	IAPS\4643.jpg		win	IAPS\8470.jpg
laughter	IAPS\4643.jpg		blood	IAPS\9908.jpg
trick	IAPS\7161.jpg		joke	IAPS\8400.jpg
miracle	IAPS\8186.jpg		award	IAPS\4608.jpg
murderer	IAPS\6520.jpg		shock	IAPS\7032.jpg
murderer	IAPS\6520.jpg		assume	IAPS\9940.jpg
crocodile	IAPS\7003.jpg		assume	IAPS\9940.jpg
blade	IAPS\7165.jpg		frenzy	IAPS\7021.jpg
race	IAPS\7055.jpg		bribe	IAPS\7000.jpg
afraid	IAPS\9325.jpg		disaster	IAPS\9902.jpg
python	IAPS\7001.jpg		mutilate	IAPS\9163.jpg
victory	IAPS\8190.jpg		betray	IAPS\6315.jpg
cheerful	IAPS\8190.jpg		betray	IAPS\6315.jpg
thrill	IAPS\5470.jpg		winner	IAPS\8158.jpg
romantic	IAPS\5629.jpg		loud	IAPS\7012.jpg
engaged	IAPS\8501.jpg		loving	IAPS\8034.jpg
sun	IAPS\8030.jpg		gift	IAPS\8034.jpg
revolt	IAPS\7009.jpg		cheese	IAPS\7211.jpg
revolt	IAPS\7009.jpg		bonus	IAPS\8170.jpg
vampire	IAPS\7026.jpg		bonus	IAPS\8170.jpg
startled	IAPS\7042.jpg		poison	IAPS\3103.jpg
passion	IAPS\5621.jpg		police	IAPS\7057.jpg
wolf	IAPS\7045.jpg		rejected	IAPS\7057.jpg
tragedy	IAPS\6563.jpg		dog	IAPS\7052.jpg
war	IAPS\9414.jpg		volcano	IAPS\7019.jpg
shotgun	IAPS\9414.jpg		drown	IAPS\3100.jpg
gold	IAPS\8499.jpg		girl	IAPS\8300.jpg

Table 1 (continued)

Adaptive (ANEW)	Adaptive (IAPS)		NonAdaptive (ANEW)	NonAdaptive (IAPS)
joy	IAPS\8540.jpg		nerves	IAPS\7018.jpg
stun	IAPS\7017.jpg		court	IAPS\9810.jpg
torture	IAPS\9570.jpg		treasure	IAPS\4676.jpg
torture	IAPS\9570.jpg		treasure	IAPS\4676.jpg
lucky	IAPS\8193.jpg		disloyal	IAPS\6350.jpg
terrible	IAPS\9412.jpg		funny	IAPS\8200.jpg
ecstatic	IAPS\8370.jpg		terrific	IAPS\8251.jpg
success	IAPS\8370.jpg		terrific	IAPS\8251.jpg
hatred	IAPS\2352.2.jpg		squeal	IAPS\7081.jpg
pin	IAPS\7030.jpg		ghost	IAPS\7150.jpg
toxic	IAPS\9300.jpg		trauma	IAPS\6230.jpg
sexy	IAPS\8185.jpg		bear	IAPS\7041.jpg
pollute	IAPS\3500.jpg		bear	IAPS\7041.jpg
kiss	IAPS\8180.jpg		cancer	IAPS\9187.jpg
kiss	IAPS\8180.jpg		risk	IAPS\7036.jpg
accident	IAPS\6540.jpg		leprosy	IAPS\9254.jpg
stress	IAPS\9075.jpg		defiant	IAPS\7130.jpg

Note. These pairs were shown in sequential order. Repeating stimuli (e.g., ‘enjoy’ in second row) were part of the 1-Back task.

Table 2

Descriptive statistics by age, for all four categories (executive function, mood, sleep, vocabulary)

	Young Mean *(SD)*	Older Mean *(SD)*	*t*	*p*
Executive Function				
WCST-C Perseveration	99.0 (*16.25*)	94.5 (*12.44*)	.81	.42
WCST-C Conceptual Responses	97.77 (*13.37*)	91.18 (*16.77*)	1.43	.16
Trails	19.92 s (*10.39*)	21.82 s (*11.27*)	-1.07	.17
Mood				
PANAS Positive	29.76 (*8.68*)	32.25 (*8.19*)	1.05	.29
PANAS Negative	17.14 (*6.11*)	12.89 (*5.28*)	2.56	.01*
CES-D	17.65 (*13.23*)	8.5 *(6.46*)	2.29	.001*
Sleep				
MEQ-SA	2.41	3.36	-3.88	.001*
ESS	16.13 (*3.26*)	15.3 *(3.18*)	.93	.36
Vocabulary				
WAIS-V	35.65 (*8.03*)	52.10 (*7.99*)	-7.39	.001*

Note. Means and standard deviations for both young and older participants. Independent samples *t*-tests were conducted to reveal significant differences. *T*-values and significance values are provided above.

Figure 1. Sample Stimuli Pair

Figure 1. Sample of IAPS/ANEW stimuli used in 1-back task. The value valence and arousal of each image and word varied, but were matched for type (e.g., positive-positive or neutral-neutral).

Figure 2. Phases Of Current Study

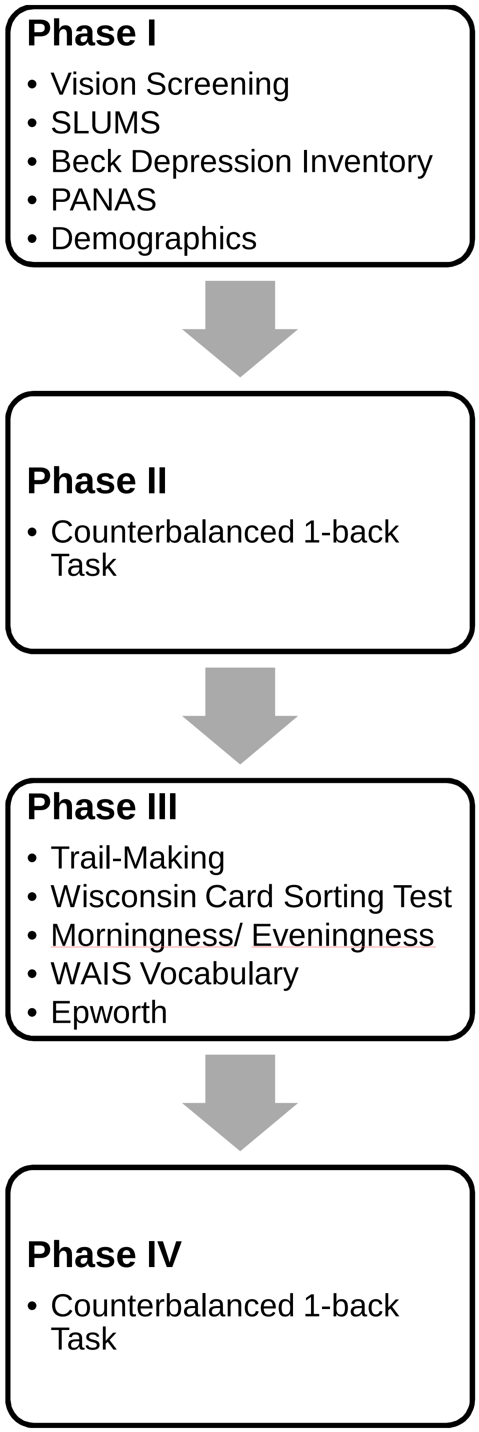

Figure 2. Stages of the current study, in sequential order. Phase II and Phase IV were counterbalanced in presentation by roll of a die.

Figure 3. Interaction Between Affect And Age

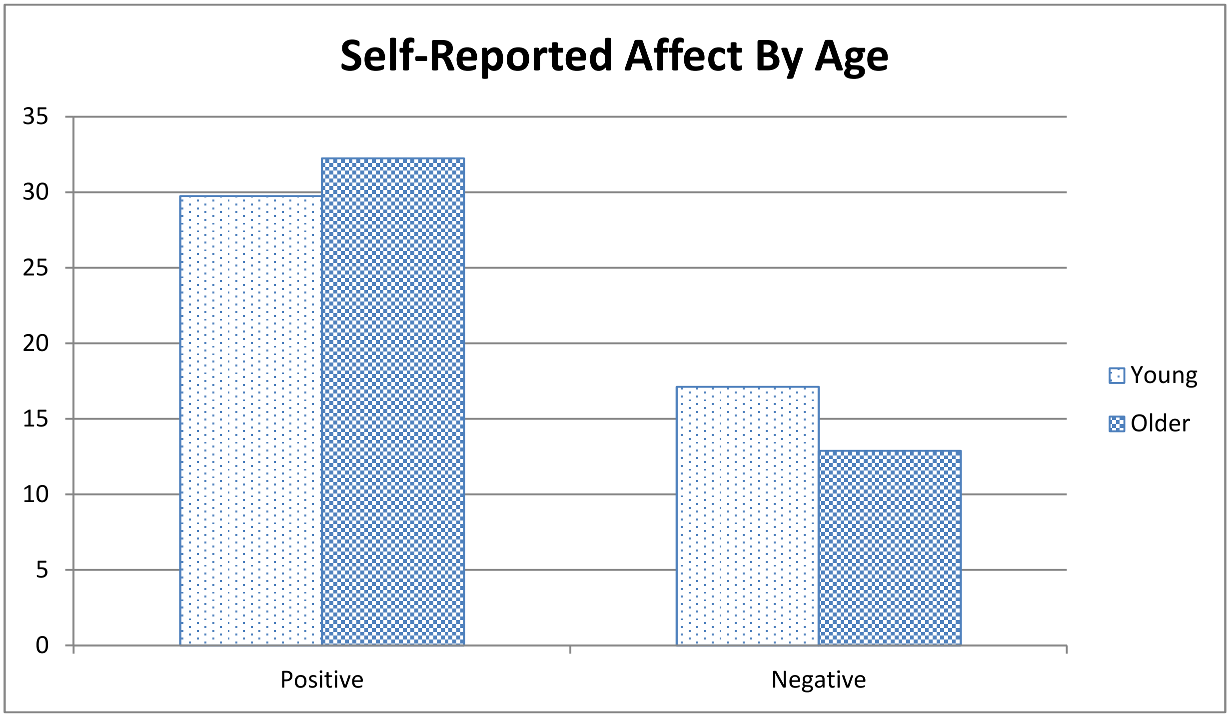

Figure 3. Scores on the PANAS scale by age, using self-reported data for the past 24 hours. There was no significant difference between age groups for positive affect, but young adults reported significantly more negative affect than older adults.

Figure 4.Morningness-Eveningness Scores For Young And Older Adults

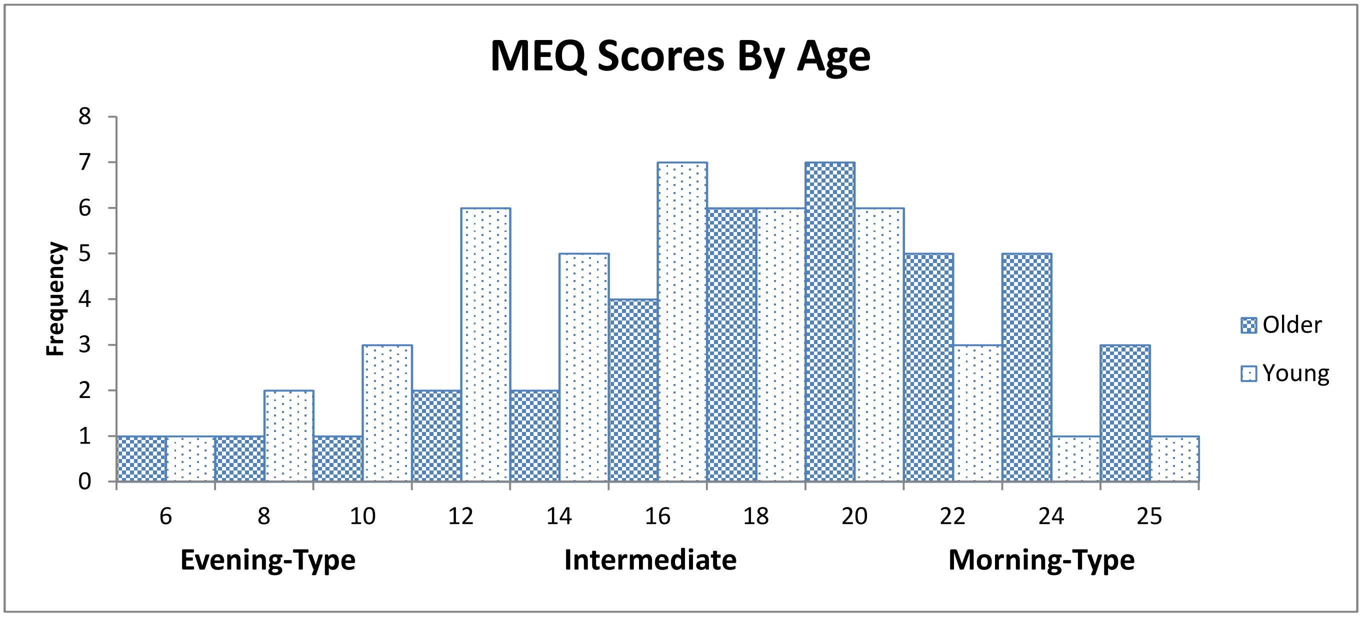

Figure 4. Scores on the MEQ scale by age, using self-reported data. On average, young adults reported being equally Evening- and Morning-Type, with most young adults reporting an Intermediate-Type. Conversely, older adults most frequently reported being Morning-Type.

Figure 5. Interaction Between Age And Condition On Correct Solutions

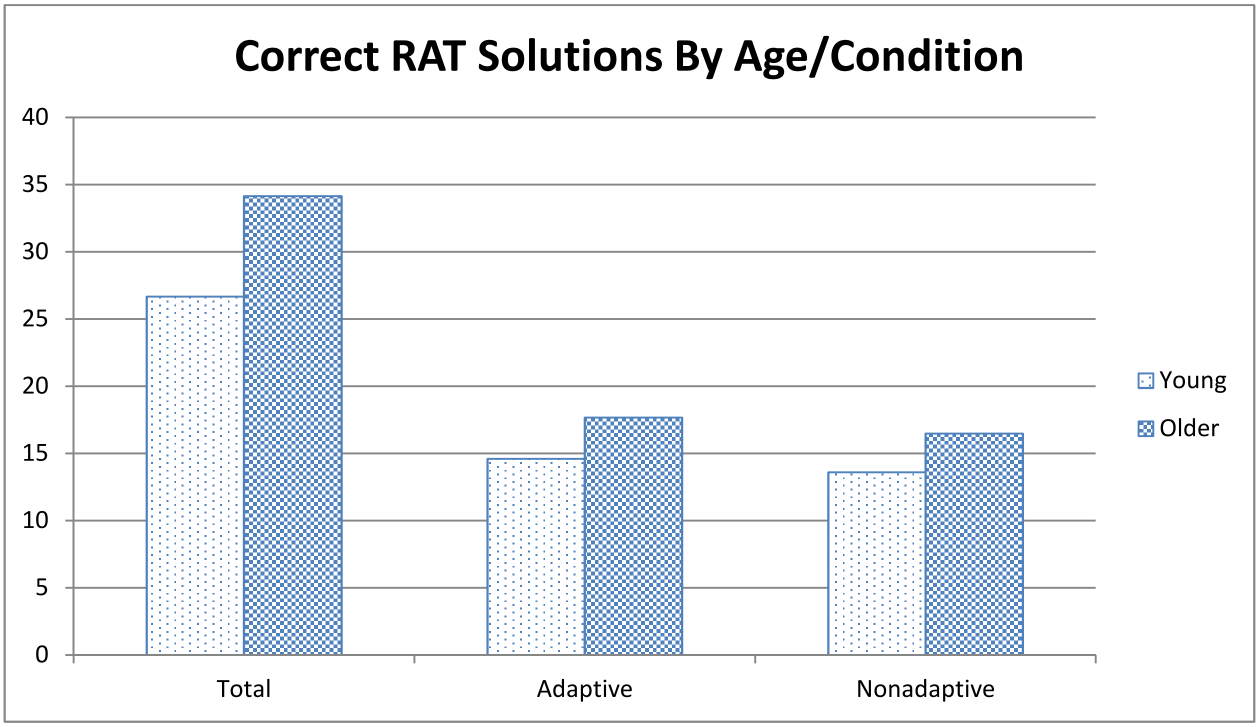

Figure 5. Correct RAT solutions by age and condition. Older adults provided significantly more total correct solutions, but did not display a significant advantage in either the Adaptive or Nonadaptive conditions.

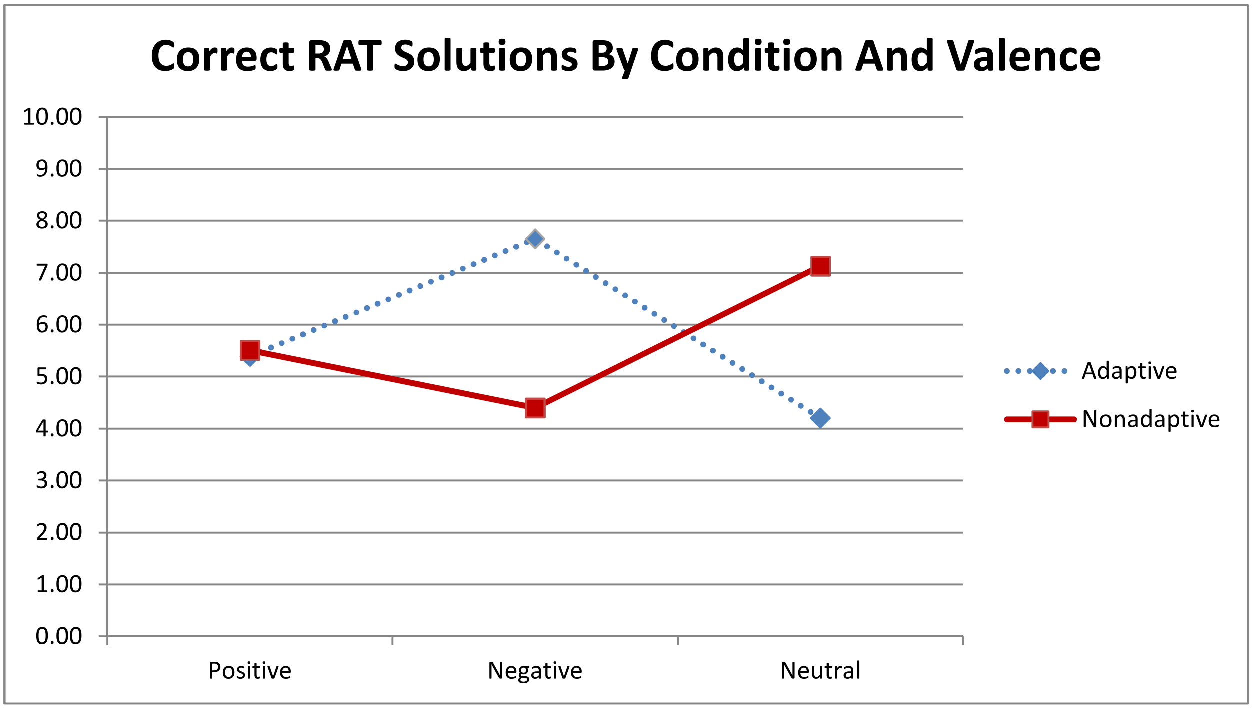

Figure 6. Interaction Between Valence And Condition On Correct Solutions

Figure 6. Number of correct RAT solutions by condition (Adaptive, Nonadaptive) and valence (positive, negative, neutral). A significant interaction emerged, with negative solutions being recalled significantly more in the Adaptive than Nonadaptive condition. Conversely, neutral stimuli were recalled significantly more in the Nonadaptive than Adaptive condition.

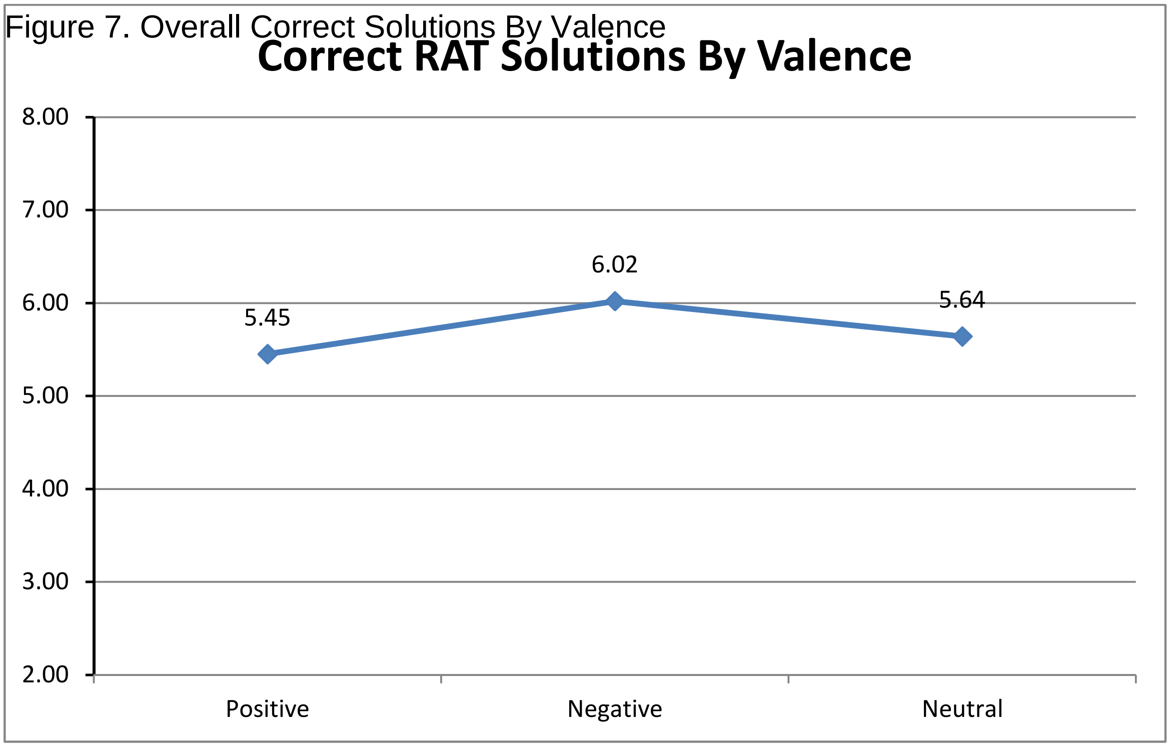

Figure 7. Number of correct RAT solutions by valence (positive, negative, neutral). These values are collapsed across age and condition, but were significant with negative being recalled significantly more than positive or neutral.

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APPENDICES

Appendix A

Remote Associates Test

Remote Associates Test

Each of the ten problems below consists of three “clue” words. For each problem, please think of a fourth word that relates to each of the other three “clue” words. Write your response on the line alongside each problem.

Example: Elephant–Lapse–Vivid

Answer: Memory

1. Athletes–Web–Rabbit _______________
2. Shelf–Read–End _______________
3. Sea–Home–Stomach _______________
4. Car–Swimming–Cue _______________
5. Board–Magic–Death _______________
6. Walker–Main–Sweeper _______________
7. Cookies–Sixteen–Heart _______________
8. Chocolate–Fortune–Tin _______________
9. Lounge–Hour–Drink _______________
10. Keel–Show–Row _______________

Appendix B

Demographic and Health Questionnaire

What year were you born? _______

Sex:
Female____ Male ____

Marital Status:
Divorced _____
Married _____
Single _____
Widowed _____

Ethnicity:
African American _____
Asian _____
Latino _____
White/Caucasian _____
Other, describe: ___________________

Do you speak more than one language?
Yes _____ No _____
If yes, list languages in the order you learned them (native language first):
1._____________ 2.______________ 3. ________________

Highest Education Level Completed:
Some High School _____
High School Degree _____
Associates Degree _____
Bachelor's Degree _____
Master's Degree _____
M.D./PhD Degree _____
If you are still a student, what is your overall GPA? ______

Do you nap regularly?
Yes ____ No ____
If yes, how often do you nap per week? __________
How long is an average nap? __________

Do you exercise regularly?
Yes ____ No ____
If yes, how often do you exercise per week? __________
On average, how long do you exercise? __________

Occupation before retirement:____________________________________
In the last month, how would you rate your stress on a scale of 1 to 7?
_______ (1= no stress 4= moderate stress 7= unmanageable stress)

Indicate if you play any of the following:

	Never	Occasionally	Monthly	Weekly	Daily
Sudoku	____	________	____	____	____
Crosswords	____	________	____	____	____
Board games	____	________	____	____	____
Trivia games	____	________	____	____	____

How often do you have a drink containing alcohol?

Never	____
Monthly	____
Twice a month	____
1 - 3 times/week	____
4+ times/week	____

In general, would you say your physical health is:

Poor Fair Good Very Good Excellent

Compared to one year ago, how would you rate your physical health now?

Much Worse	____
Somewhat Worse	____
Same or Similar	____
Somewhat Better	____
Much Better	____

Have you ever had any of the following?

Heart Surgery	Yes____	No____
Stroke	Yes____	No____
Head Injury	Yes____	No____

If yes, were you unconscious longer than 2 minutes?
Yes____ No____

Indicate if you have any of the following medical conditions:

	Yes	No		Yes	No
ADHD	Yes____	No____	If yes, are you on medication?	Yes____	No____
Depression	____	____	If yes, are you on medication?	____	____
Diabetes	____	____	If yes, are you on medication?	____	____
COPD	____	____	If yes, are you on medication?	____	____
High blood pressure	____	____	If yes, are you on medication?	____	____
Arthritis	____	____	If yes, are you on medication?	____	____
Parkinson's	____	____	If yes, are you on medication?	____	____
Heart conditions	____	____	If yes, are you on medication?	____	____

Appendix C

Review of Literature Related to Inhibition and Cognition

Authors and Reference	**Participants**	**Materials Used**	**Design, Covariates**	**Major Results**
Biss, R. K., Hasher, L., & Thomas, R. C. (2010). Positive mood is associated with the implicit use of distraction	36college students (9 males, 27 females) *M* age = 19.7	Snodgrass and Vanderwart line drawings Brief Mood Introspection Scale (BMIS) Shipley vocabulary scale	ANOVA, Correlation between mood and performance	Correlations between mood rating and use of distracting information were significant. Mood was unrelated to spatial working memory and vocabulary. Implicit memory for distracting materials was related to valence but not arousal.
Biss, R. K., & Hasher, L. (2011). Delighted and distracted: Positive affect increases priming for irrelevant information	64 college students (21 male, 43 female) *M* age = 19.4	IAPS Mood pleasantness and arousal scale adapted from Rowe et al. (2007) Snodgrass and Vanderwart line drawings	ANOVA, mood as between-subjects and rating as within-subjects	Positive mood reports were significantly related to recall of novel stimuli. Main effect of rating, ceiling effects or the 1-back task were demonstrated.

Biss, R., Weeks, J., & Hasher, L. (2012). Happily distracted: mood and a benefit of attention dysregulation in older adults	60 older adults *M* age = 67.9	IAPS Mood pleasantness and arousal scale adapted from Rowe et al. (2007) Snodgrass and Vanderwart line drawings	ANOVA, mood as between-subjects and rating as within-subjects	Interaction between mood group (positive, negative) and rating time. Arousal ratings were not significant. No difference in accuracy on the 1-back task across mood groups.
Biss, R. K., & Hasher, L. (2012). Happy as a lark: Morning-type young and older adults are higher in positive affect	435 college students (153 male, 282 female) *M* age = 19.7 297 older adults (125 male, 172 female) *M* age = 67.8	Morningness-Eveningness Questionnaire Brief Mood Introspection Scale (BMIS) Self-reported health status	Correlation, mediation model, Sobel test of mediation Covariates: time of measurement	Correlations between age and reported mood type were significant, with older adults reporting more positive moods. Interaction mood and day-type was significant, with morning-type responding more positive.
Bowden, E., & Jung-Beeman, M. (2003). Normative data for 144 compound remote associate problems	289 college students	Remote Associates Task (RAT)	Correlation	After 30 seconds, both homogenous and heterogeneous problem types had similar solution rates.

Campbell, K. L., Hasher, L., & Thomas, R. C. (2010). Hyper-Binding: A Unique Age Effect	24 college students (3 male, 21 female) *M* age = 19 24 older adults (7 male, 17 female) *M* age = 66.6	Snodgrass and Vanderwart line drawings	ANOVA, age as between-subjects and pair-type as within-subjects	Older adults demonstrated decreased accuracy and slower response time.
Charles, S., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults	Young (age 18-29) Middle (age 41-53) Older (age 65-85)	International Affective Picture System	ANOVA, age by image type	The discrepancy between positive and negative recalled images increased proportionally with age. Older recalled more positive than negative, young recalled equal amounts positive and negative.
Craik, F. M., & Schloerscheidt, A. M. (2011). Age-related differences in recognition memory: Effects of materials and context change, Experiment 1A	24 young adults (7 male, 18 female) *M* age = 19.6 25 older adults (7 male, 18 female) *M* age = 67.7	120 Common Object names 20 color photographs from the internet	ANOVA, group by context	Interaction between age and context was significant, with older adults having greater effects on recognition for older but not young adults.

Craik, F. M., & Schloerscheidt, A. M. (2011). Age-related differences in recognition memory: Effects of materials and context change, Experiment 1B	32 young adults (7 male, 25 female) *M* age = 20.8 32 older adults (7 male, 25 female) *M* age = 67	120 Common Object names 20 color photographs from the internet	ANOVA, group by context	Context but not age was significant. Items presented in original context were better recognized by older when compared to young adults.
Craik, F. M., & Schloerscheidt, A. M. (2011). Age-related differences in recognition memory: Effects of materials and context change, Experiment 2	16 young adults (5 male, 11 female) *M* age = 23.3 16 older adults (9 male, 7 female) *M* age = 69.9	120 Common Object names 20 color photographs from the internet	2x2 mixed design ANOVA, age x recognition type	Age differences in recall were significant, with older adults recalling half the amount of items provided by young adults. False alarm rates were higher for older rather than young.
Feyereisen, P., & Charlot, V. (2008). Are There Uniform Age-Related Changes Across Tasks Involving Inhibitory Control Through Access, Deletion, and Restraint Functions? A Preliminary Investigation	30 young adults (10 male, 20 female) *M* age = 25 34 older adults (18 male, 16 female) *M* age = 72	Remote Associates Task (RAT) Reading with Distraction Directed Forgetting Listening Span Hayling Task Manual Stroop-like Task	ANOVA, age as between-subjects and condition as within-subjects	Larger interference effects were not specifically observed in older adults, as hypothesized by the Inhibitory Deficit Hypothesis. Limited support was found to arbitrarily group inhibitory functions into three categories.

Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Rypma, B. (1991). Age and inhibition, Experiment 1	30 young adults *M* age = 19.4 30 older adults *M* age = 67.9	Letter strings	ANOVA, age as between-subjects and trial as within-subjects	Older adults were slower overall than young adults. Interaction between age and trial was significant. No detectable 'suppression effects' observed for older adults, although they were found in young adults.
Hasher, L., Stoltzfus, E. R., Zacks, R. T., & Rypma, B. (1991). Age and inhibition, Experiment 2	30 young adults *M* age = 18.7 30 older adults *M* age = 69	Letter strings	ANOVA, age as between-subjects and trial as within-subjects	Older adults showed reduced inhibition for selective-attention tasks when compared to young adults.
Kim, S., Hasher, L., & Zacks, R. T. (2007). Aging and a benefit of distractibility	26 young adults *M* age = 20 26 older adults *M* age = 68.5	Reading passages from Connelly et al. (1991) Remote Associates Task (RAT)	Correlation ANOVA, age as between-subjects and item-type as within-subjects	Significant difference in target RAT responses between young and older adults, with older adults providing more than young. No significant findings on reading completion time.

Rowe, G., Valderrama, S., Hasher, L., & Lenartowicz, A. (2006). Attentional disregulation: A benefit for implicit memory	28 evening-type young adults Range (18-30 years) 32 morning-type older adults Range (60-75 years)	Morningness-Eveningness Questionnaire Snodgrass and Vanderwart line drawings Corsi Block Test Shipley Vocabulary Test	ANOVA, age and synchrony as between-subjects and condition as within-subjects	Significantly older adults were morning-types than young adults. Interaction between performance and time-of-testing was significant. Older adults supplied significantly more distractor words than young adults.
Salthouse, T. A., & Babcock, R.L. (1991). Decomposing Adult Age Differences in Working Memory	233 adults, age 18-82, 139 women, 94 men	Digit Span Computation Span Letter Comparison Pattern Comparison	Correlation	Working memory task performance was significantly associated with increased age. Reductions in processing efficiency were also related to declines in working memory and increased age.
Yang, L., & Hasher, L. (2007). The Enhanced Effects of Pictorial Distraction in Older Adults	47 young adults *M* age = 20 45 older adults *M* age = 69	Snodgrass and Vanderwart line drawings	2x2x2 ANOVA, age, ISI, distraction	Significant for age, ISI, and interaction. Older adults demonstrated a reduced distractibility with increased delay.

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