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Effects of goal maintenance training on executive control in older adults

Jessica Paxton
Washington University in St. Louis

WASHINGTON UNIVERSITY

Department of Psychology

Dissertation Examination Committee:

Deanna Barch, Co-Chairperson
Todd Braver, Co-Chairperson
Lisa Connor
Mark McDaniel
Susan Stark
Martha Storandt

EFFECTS OF GOAL MAINTENANCE TRAINING ON EXECUTIVE CONTROL IN OLDER ADULTS

by

Jessica Paxton

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ABSTRACT OF THE DISSERTATION

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Jessica Paxton

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Professor Deanna Barch, Co-Chairperson

Professor Todd Braver, Co-Chairperson

Due to the fact that executive control abilities are necessary for successful execution of many cognitive and real-world tasks, interest has arisen in determining how these abilities can be improved. A previous study demonstrated that both practice and strategy training improved performance in older adults on an executive control task requiring goal maintenance abilities (Paxton et al., 2006), but no previous research has investigated the amount of exposure to this executive control task during training. Thus, questions remained about whether amount of exposure (e.g., extended experience with one task or limited experience with multiple tasks) or type of intervention (e.g., training or practice) improve performance through different cognitive mechanisms. In order to address these questions, this dissertation study sought to determine whether practice and training interventions varying in amount of exposure to the trained task lead to improvement on the tasks trained and/or untrained transfer tasks. Results demonstrated that, regardless of intervention condition, older adult participants become more accurate and efficient on the training task. The strategy training intervention was only found to improve performance on the training task when analyses were conducted to evaluate

whether two primary trial types changed in divergent directions. The lack of significant differences between training and practice interventions in raw scores on the training task replicates our previous study (Paxton et. al, 2006). The training and practice interventions did not produce significantly different results for the near transfer tasks, and therefore, conclusions could not be drawn about whether training and practice improve performance using different cognitive mechanisms. Also, compared with interventions involving limited experience with multiple goal maintenance tasks, interventions involving greater exposure to one goal maintenance task only led to a significant improvement in performance on the near transfer task when analyses were conducted to evaluate whether two primary trial types changed in divergent directions, and may have been influenced by pretest differences across training conditions. No differences were found among the interventions in terms of facilitation of far transfer.

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CHAPTER 1: OVERVIEW

Consistent with the frontal theory of aging, previous studies have demonstrated that, relative to younger adults, older adults show impairment on various executive control tasks. Successful execution of many experimental and real-world executive tasks require goal maintenance or the ability to use goal relevant information in order to prepare for and execute a goal. One way of using goal relevant information to reach a goal is to activate, integrate, and maintain goal relevant information. Older adults have been shown to show deficiencies in these goal maintenance abilities.

Due to the fact that executive control abilities are necessary for successful execution of many cognitive and real-life tasks, interest has arisen in determining how these abilities can be improved. Although studies have assessed the effects of various practice and training interventions on cognitive abilities such as memory and/or fluid intelligence, few studies have assessed the effectiveness of interventions on executive control abilities. A previous study demonstrated that both practice and strategy training produced improved performance in older adults on an executive control task requiring that one activate, integrate, and maintain goal relevant information (Paxton et al., 2006). Still, questions remain about whether different intervention procedures such as training and practice improve performance through different cognitive mechanisms, which can be measured by ability to transfer improvement to untrained tasks.

Thus, this dissertation study compared performance in intervention and transfer tasks between conditions involving (a) simple practice on one task requiring goal maintenance ability, (b) simple practice on multiple tasks requiring goal maintenance ability, (c) strategy training on one task involving goal maintenance abilities, and (d) multi task strategy training designed to improve the ability to apply goal maintenance strategies flexibly. An additional component of this study that was not included in our previous study was the implementation of an approach to strategy training that encourages generalization by applying the strategy across multiple tasks that all share a common goal structure in the multi task intervention condition. It was predicted that no differences would be uncovered between the strategy training and practice conditions on the task used in both interventions, which was predicted by the results of our previous study. It was hypothesized that, compared with both practice and single task training conditions, the multi task strategy training condition would lead to greater improvements on the transfer tasks that were not involved in any of the interventions.

Determining whether practice or strategy training differ in effectiveness in improving goal maintenance abilities has important implications for scientific theory and clinical practice. First, determining the effectiveness of interventions could guide future research and clinical applications for improving executive control and other abilities in healthy individuals as well as those with a variety of psychiatric or neurological deficits. Furthermore, learning more about the effectiveness of these interventions and whether they lead to transfer to other tasks provides insight about the cognitive processes involved in the executive control tasks. Additionally, we can gain insight about how cognitive processes are altered with practice and training interventions. Thus, if different interventions have different influences on cognitive mechanisms, then it may be possible to design interventions specific to the cognitive process that is disordered in clinical populations.

CHAPTER 2: LITERATURE REVIEW

The first section of this chapter contains an overview of the literature on age-related deficits in executive control and goal maintenance. The second section includes a review of the literature on studies assessing the effectiveness of various interventions in improving cognitive performance in older adults. The third section reviews questions that remain and motivate research on interventions aimed to improve executive control in older adults.

Executive Control

Overview of Executive Control

Cognitive control has been defined as "the ability to orchestrate thought and action in accord with internal goals" (Miller & Cohen, 2001, p. 167). Executive control includes complex behavioral output requiring planning and sequencing, attending to multiple tasks or switching among tasks, the ability to inhibit inappropriate responses, abstract reasoning ability, the ability to generate hypotheses, and concentration (Mesulam, 2002; Smith & Jonides, 1999; Miyake et al., 2000). Conceptualization of executive control has arisen from neuropsychological studies of patients with frontal lobe damage, which has guided the selection of neuropsychological tests for assessment of frontal impairment (Stuss & Levine, 2002).

Defining the concept of executive control has been challenging (Miyake et al., 2000) and complicated by the fact that the relationship between executive control deficits and frontal lobe damage is not definite in every case and there are discrepancies about which cognitive processes are executive (Baddeley, 2002). Furthermore, attention has been focused both on determining whether there are different executive abilities that can be dissociated and on deriving a sensible way of taxonomizing. This work has resulted in one such theory proposing that executive abilities can be dissociated into updating, shifting, and inhibition abilities (Miyake et al., 2000). Furthermore, it has been asserted that abilities such as selective attention, inhibition, switching attention, goal planning, updating working memory, and managing information in working memory are executive control abilities (Smith & Jonides, 1999).

For instance, working memory has been regarded as an important aspect of executive functioning and is required for successful completion of many cognitive and functional tasks. Following an influential theory asserting that executive processes are involved in the way that information is stored in short term memory (Atkinson & Shiffrin, 1971). Baddeley (1986) developed a widely used explanation for working memory. Baddeley's model describes a short-term storage system for visual and verbal information with the "central executive" where executive processes occur with information held in the verbal and visual stores. Studies have supported the importance of updating or monitoring the contents of a working memory storage system so that new information can be stored by extinguishing the processing of old information (Miyake et al., 2000). Furthermore, the concept of "controlled attention" is proposed to represent maintenance and inhibition of information in working memory, which is used during a variety of executive control tasks such as those requiring that goals are maintained or that decisions are made despite conflicting information (Engle et al., 1999).

Other important executive abilities are focused attention and inhibition, which are necessary in a variety of situations such as when two goals are in conflict (Smith & Jonides, 1999). The Stroop task (Stroop, 1935) is a commonly used test that assesses selective attention and ability to inhibit irrelevant stimuli. In this task, participants are shown stimuli consisting of color names in different color ink. They are instructed to either read the color name or report the color of the ink. Because word reading occurs more automatically and faster than color naming, the ability to name the ink color is facilitated by a matching color name and interference occurs when the color name does not agree. Thus, the ability to successfully identify the color requires that one attend to the goal and the stimuli while inhibiting the word name. Another task assessing ability to inhibit information within a working memory store is a variant of the Sternberg task. When individuals are required to differentiate between items shown in a current memory set and items shown in a very recent memory set, neuroimaging research has suggested that successful performance requires that the relevant stimuli is held in working memory while the irrelevant stimuli is inhibited (Jonides et al., 2002).

Age-related Deficits in Executive Control

Examination of cognitive change with age has been an area of intense study with results showing that age-related cognitive decline is most notably evidenced by impairment in memory and executive functioning (Buckner, 2004). For example, older adults have shown impaired performance in comparison with young adults on neuropsychological tests regarded to assess executive functioning. For instance, the Wisconsin Card Sorting Test (WCST) was developed with the purpose of assessing frontal functions (Milner, 1963) thought to represent shifting abilities (Miyake et al., 2000). Older adults have demonstrated impaired performance relative to young adults on the WCST (Kramer, Humphrey, Larish, Logan, & Strayer, 1994; Rhodes, 2004). Similarly, several studies show impaired performance in older adults compared with young adults on the Stroop task (Spieler, Balota, & Faust, 1996; Rush, Barch, & Braver, 2006; West & Baylis, 1998), which assesses effectiveness of attention (Lezak, 2004) and ability to inhibit responding based on the more automatic color naming ability.

Studies using more experimental cognitive tasks have provided additional evidence of executive control deficits with age. This work has revealed deficits in a number of domains, including coordinating multiple task sets in working memory (Kray & Lindenberger, 2000; Verhaeghen et al., 2005), inhibiting a response based on misleading information (Jacoby, Bishara, Hessels, & Toth, 2005), anticipating a target in an antisaccade task (Nieuwenhuis et al., 2004), completing a complex working memory span task (Myerson, Emery, White, & Hale, 2003), rejecting familiar but incorrect items on a working memory recognition task (Oberauer, 2001, 2005), updating previously viewed information (Johnson, Mitchell, Raye, & Greene, 2004; Johnson, Reeder, Raye, & Mitchell, 2002), performing an event-based prospective memory task with cues unrelated to ongoing activity (Einstein & McDaniel, 2005), and working memory impairment due to a deficit in inhibitory control (Hasher & Zacks, 1988). It has been shown that as the executive control demands of a task increase, older adults' pattern of performance becomes more divergent from young adults (e.g., Verhaeghen, Cerella, Bopp, & Basak, 2005). Further evidence of executive control deficits has been derived from studies using summary or factor scores representing executive control abilities. Thus, in a study of older adults attempting to replicate the executive functioning factors identified in young adults (Miyake et al., 2000), significant age-related deficits were uncovered for factors representing updating, inhibition, and shifting factors, but the access factor did not show age-related deficits (Fisk & Sharp, 2004).

Furthermore, executive control abilities in older adults have been investigated using more ecologically valid tasks such as a task requiring that older adults plan and execute steps in a simulated cooking breakfast task. Older adults showed significant deficits in working and prospective memory in this task (Craik & Bialystok, 2006). In addition, researchers have found that the "real-life" ability to follow through in taking medication was predicted by performance on tests of working memory and executive control in older adults (Insel, Morrow, Brewer, & Figueredo, 2006). In summary, age-related executive control impairment has been shown in a variety of tasks and recent evidence suggests that these deficits likely influence everyday functioning.

Prefrontal Cortex and Executive Control

Evidence that the prefrontal cortex mediates executive control ability has been provided by studies demonstrating that damage to the prefrontal cortex results in impaired performance on tasks assessing these abilities. For example, such evidence is provided by studies demonstrating working memory impairment in primates with prefrontal cortex lesions (Goldman & Rosvold, 1970), difficulty on inhibition tasks in humans with prefrontal cortex tumors (Leimkuhler & Mesulam, 1985), and impairment in making decisions and being cognitively flexible in novel situations in patients with prefrontal damage (Godefroy & Rousseaux, 1997). Furthermore, neuroimaging techniques such as functional magnetic resonance imaging (fMRI) have demonstrated increased activation in prefrontal cortex regions when individuals perform executive control tasks (see Braver & Ruge, 2006, for a review)

Research studies assessing cognitive change with age also show that executive or cognitive control tasks are mediated by the prefrontal cortex in that performance on executive control tasks has been shown to correlate with neuroanatomical changes in the prefrontal cortex with age. For example, decline on a scale of executive control deriving items from tests assessing initiation, fluency, digit span, and visual span was correlated with longitudinal decline in cortical gray matter and an increase in white matter hyperintensities (Kramer et al., 2007). Furthermore, structural MRI studies have demonstrated that performance on the Wisconsin Card Sorting Test is correlated with the volume of the prefrontal cortex (Gunning-Dixon & Raz, 2003).

Frontal Theory of Aging

Several theories have been put forth in attempt to explain the cognitive changes that occur with healthy aging such as reduced processing resources (Craik & Byrd, 1982), reduced ability to maintain and manipulate information in working memory (see Light, 1991, for a review), reduced speed of processing (Cerella, 1985; Salthouse, 1996), and an inability to inhibit irrelevant stimuli (Hasher & Zacks, 1998). The frontal theory of aging (West, 1996) postulates that the prefrontal cortex is among the brain areas most strongly affected by increasing age. Furthermore, the cognitive abilities mediated by the prefrontal cortex decline earlier than other cognitive abilities (Dempster, 1992; West, 1996), which has been supported by the observation that cognitive deficits in older adults resemble deficits observed in patients with frontal lobe damage (Moscovitch & Wincour, 1995). Furthermore, age-related decline has been observed in executive control abilities shown to be mediated by the prefrontal cortex.

Additionally, the frontal theory of aging is supported by neurobiological evidence of age-related deficits in the prefrontal cortex (Arnsten, Cai, Steere, & Goldman-Rakic, 1995; Cabeza, 2001; Peters, Sethares, & Moss, 1998; Raz et al., 1997; Tisserand &

Jolles, 2003; Volkow et al., 1998). It has been proposed that the neurotransmitter dopamine modulates lateral prefrontal cortex function and that dopamine projections to the dorsolateral prefrontal cortex are disrupted in older adults, leading to difficulties in executive control tasks (Braver & Barch, 2002). Longitudinal studies measuring the volume of gray matter using magnetic resonance imaging (MRI) have provided evidence that the prefrontal cortex showed the greatest decline in brain volume with increasing age (see Raz, 2005, for a review). Evidence from studies using fMRI suggest that older adults show either increased or reduced activation in comparison with young adults in the PFC. Thus, there are several studies showing increased activation with age (Cabeza et al., 2002; Cabeza et al., 2004; Colcombe, Kramer, Erickson, & Scalf, 2005; Grady et al., 1998; Haut, Kuwabara, Leach, & Callahan, 2000; Langenecker & Nielson, 2003; Langenecker, Nielson, & Roa, 2004; Logan et al., 2002; Persson et al., 2004; Rosen et al., 2002; Rypma & D'Esposito, 2000; Townsend, Adamo, & Haist, 2006). Enhanced activity in lateral PFC regions has been interpreted as reflecting either compensatory activation in response to reduced efficiency/integrity of activation (Buckner, 2005; Cabeza et al., 2004; Cabeza et al., 2002; Cabeza et al., 1997; Grady, 2000; Mattay et al., 2006; Park et al., 2004; Rosen et al., 2002) or non-selective recruitment of task regions not necessarily helpful for task performance (Li, Lindenberger, & Sikstrom, 2001; Li & Lindenberger, 1999; Logan et al., 2002; Tisserand & Jolles, 2003).

Given the substantial evidence reviewed about neural degradation with age, it is encouraging that research has shown that older adults can compensate for less efficient neural processing by activating different regions or the same regions at a greater magnitude. Research providing evidence of compensation suggests that more effective performance and processing can occur despite age-related neural changes.

Goal Maintenance

Much experimental research aimed to better understand cognitive functioning in experimental tasks, in neuropsychological tests used for diagnosis, and in daily activities require executive control abilities. Successful execution of many executive control tasks requires goal maintenance, which is conceptualized here as the ability to use goal relevant information effectively to complete a task goal. There are different ways that one can use goal relevant information to achieve a goal. One way is to use goal relevant information in order to prepare in advance by activating, integrating, and maintaining this information before responding. It may be that use of goal relevant information in this way could compensate for age-related decline in executive control abilities such as working memory. Specifically, one must activate the goal by attending to relevant information and ignoring irrelevant information presented in the environment. Then, one must integrate this relevant goal-related information with the goal of the task in order to translate it into an action plan. Finally, one must maintain this action plan until a response is required. This approach to using goal relevant information is synonymous with using what is termed a *proactive* cognitive control strategy (Braver, Gray, & Burgess, 2007).

Conversely, another strategy would be to exert minimal attention to the goal relevant information when it is first presented. Specifically, using this alternative approach would entail activating the goal-related information and translating it into an action plan at the time when a response is required. This approach does not require that the action plan be maintained and is referred to as *reactive control* (Braver et al., 2007). It has been proposed that optimal performance across varying tasks and responsibilities require a combination of reactive and proactive approaches (Braver et al., 2007). For instance, preparing in advance for a response is more effective in situations where one must override a tendency to make an automatic, but inaccurate response. Even though preparing in advance with a proactive strategy requires that one exert more neural resources across time, this approach will lead to better accuracy. Alternatively, a reactive approach where one waits to integrate goal-related information with the goal of the task is likely a better approach when confronting a task with a very lengthy delay between the presentation of goal-related information and response.

Examples of Tasks Requiring Goal Maintenance Abilities

Examples of tasks requiring goal maintenance abilities will be described for further elucidation. The classic AX-Continuous Performance Test (AX-CPT; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956) involves the presentation of consecutive pairs of letters that appear on a computer screen individually. The first letter of each pair is called the cue; the second letter is the probe. Participants are told to make a target response for an X (probe) that follows an A (cue) and to make nontarget responses for any other cue-probe combination. Because target (AX) trials occur with high frequency (70%), two types of biases are present that influence context goal maintenance in different ways. First, use of goal relevant information is critical for inhibiting a target response bias that occurs when an X probe follows a non-A cue (BX trials). Second, use of goal relevant information enables the target expectancy bias that can impair performance when an A cue is followed by a non-X probe (AY trials). Thus, intact representation and use of goal relevant information should lead to impaired AY performance but enhanced BX performance. Conversely, individuals with impairments in goal maintenance should show poorer performance on BX compared with AY trials.

Examination of approaches that individuals use on the AX-CPT has been useful in explaining differences in goal maintenance ability. Proactive control on the AX-CPT task involves activating and using goal relevant information provided by the cue to prepare to respond to the upcoming probe in advance of its onset (i.e., when the cue letter is A, expect X and prepare to make target response), which leads to increased AY errors but decreased BX errors. In contrast, reactive control on the AX-CPT task involves minimal activation of the cue information at the time of cue presentation (i.e., expectancies for an X target are not developed following an A cue) but requires reactivation of the cue information when the probe appears and a target or nontarget response must be made (i.e., if the probe is X, recall if the cue was an A), which causes one to be less likely to make AY errors with an increase in BX interference (Braver, Gray, & Burgess, 2007).

Furthermore, a more practical example of a task requiring goal maintenance abilities is a prospective memory task where one must remember to execute a particular action at a particular time. For instance, trying to remember to take a certain medication after lunch would require goal maintenance. For example, the goal to take medicine could be activated when you see a note posted in the kitchen causing you to attend to the goal of taking medicine after lunch. Next, this goal relevant information must be translated into an action plan that involves planning to locate the medicine to take after lunch. Last, you must maintain this action plan until you have finished your lunch and have taken the medication.

Age-related change in goal maintenance ability

Evidence of difficulty in goal maintenance abilities is provided by research using the AX-CPT task. In previous studies using the AX-CPT task older adults made fewer errors than young adults on AY trials, suggesting that the identity of the cue letter resulted in a stronger bias for young adults compared with older adults. Further, older adults had longer reaction times than young adults on BX trials, suggesting that they experienced interference from the X probe letter on these trials (Braver et al., 2001; Braver et al., 2005). One interpretation of this pattern of performance in older adults is that older adults are more likely to use a reactive approach to the AX-CPT task, whereas young adults use a more proactive approach. Thus, older adults were not as adept in goal maintenance abilities requiring that they attend to the cue, integrate this with the goal of the task to form an action plan (i.e., after seeing an A cue, plan to make a target response if X follows A), and maintain the action plan. Older adults' pattern of performance demonstrated that they were less likely to activate the cue information and translate it into a plan to bias processing in advance, which may be due to difficulty at any step in the goal maintenance process. A study that investigated the effects of manipulations on the length of cue presentation demonstrated that the different pattern of performance found in older adults is not due exclusively to a failure to maintain the identity of goal relevant information in the form of the cue on this task. Thus, we proposed that another aspect of goal maintenance is responsible for age-related performance deficits (Paxton, Barch, Storandt, & Braver, 2006). In a recent study comparing young and older adults in patterns of brain activation while completing the AX-CPT task, older adults showed significantly greater activation in prefrontal regions at the time of the probe, whereas young adults showed significantly greater activation at the time of the cue. Increased activation at the time of the probe in comparison with the cue provides additional support that older adults use a reactive approach in exerting neural resources at the time when a response is required instead of at the time of the cue (Paxton, Barch, Racine, & Braver, 2008).

Cognitive Interventions

Overview

Goal maintenance abilities are necessary for many cognitive and executive control tasks that older adults often confront. For instance, one must remember important goals that directly affect their own health and wellbeing (e.g., taking medication, following medical advice, exercising, cooking, paying bills), the well-being of their family (e.g., transporting and/or caring for health needs of friends and family), and responsibilities as members of society (e.g., safe driving, following through with responsibilities associated with employment or volunteer work). As such, it would be beneficial to improve performance in these goal maintenance abilities in older adults. Further, research aimed to identify means of improving goal maintenance abilities in older adults has the potential to be beneficial in providing insight about how older adults could be better able to function with many real-life executive control responsibilities.

Research has been completed assessing different types of interventions (e.g., practice, strategy training) seeking to improve different abilities (e.g., memory, speed) in different populations (e.g., older adults, brain-injured patients). In an attempt to examine this literature in a coherent way, I will outline the methods and results of studies seeking to improve abilities in various populations according to the type of intervention used. Four different general classes of intervention methods will be presented ranging from the simplest with no change to the task (i.e., practice) to more complicated interventions involving many manipulations (i.e., explicit strategy training).

Interventions Involving Practice

When simple practice is used, it is assumed that the participant generates the approach or strategy used and that any improvement is due to the person's intrinsic capacity to derive an effective means of improving. Several studies have demonstrated that simple practice is effective in improving performance in older adults. For example, older adults perform better on a similar fluid intelligence task after practicing a type of fluid intelligence ability consisting of figural relations problems (Baltes, Sowarka, & Kliegl, 1989; Blackburn, Papalia-Finlay, Foye, & Serlin, 1988). Additionally, studies have shown that older adults benefit from practice to the same degree as young adults on a task- switching task (Kramer, Hahn, & Gopher, 1999) and the Stroop task (Davidson, Zacks, & Williams, 2003; Dulaney & Rogers, 1994). Practice on the AX-CPT task resulted in older adults performing more like young adults with an effect that did not significantly differ from the effect of strategy training (Paxton et al., 2006). Still, Jennings and colleagues (2005) found that practice with feedback on a recognition task did not improve accuracy but led to faster reaction times, whereas a more complicated training procedure improved both accuracy and showed transfer effects.

Additionally, studies have examined the effect of practice with young adults using neuroimaging techniques. For instance, young adults who practiced a visuospatial working memory task for 5 weeks showed decreased reaction times and transfer of improvement in reaction times on a Stroop task (Oleson, Westerberg, & Klingberg, 2004). This study also found that activation in prefrontal and parietal areas increased after practice (Oleson et al., 2004). Finding increased activation after practice in the same areas activated before practice is suggestive that the same strategy was used before and after the practice intervention with greater proficiency indicated after the intervention (Jonides, 2004). These results of increased activation after practice contrast with studies showing decreased prefrontal activity after practice generating a verb when presented with a noun (Raichle et al., 1994). Thus, these results suggest that practice leads to a decline in neural activation in regions including the prefrontal cortex when the task becomes automatic with practice, but practice results in increases in neural activation when the task is novel or demanding of attention or working memory capabilities (Oleson et al., 2003). Another study with young adults provided evidence that an intervention of simple practice brought about increases in grey matter in the temporal and parietal regions after spending 3 months learning to juggle (Draganski et al., 2004). Thus, functional and structural brain changes after practice suggest that the brain is malleable and that plasticity is possible due to simple practice, though a question remains about whether this is also true in older adults.

It is encouraging to find that practice interventions lead to performance improvements and neural changes. Thus, simple practice results in changes in a variety of abilities including fluid intelligence, executive control, and motor learning. Practice effects could also influence results of investigations that use cognitive tests repeatedly over time. Thus, it is important to study and understand the influence of simple practice on performance and patterns of brain activation. Although the studies reviewed provide evidence that simple practice is as effective as other interventions in improving performance on the task practiced, there is little evidence that simple practice leads to a transfer of benefit to novel or different tasks than those practiced for older adults. Thus, it is of interest to determine whether the cognitive process that leads to improvement on a task with practice is the same process that leads to improvement with more involved and complicated intervention procedures.

Interventions Involving Practice with Constraints

Studies assessing the effectiveness of intervention involving practice with some aspect of the task being manipulated or constrained will be discussed next. These interventions are more complicated because the way that the stimuli are presented is changed in some way so that the task demands different skills than the same task without the manipulation. Still, these studies do not explicitly instruct participants to change the way that they confront the task even though the manipulations usually require that one change the approach used. For instance, using a different condition than simple practice mentioned in the previous section, Jennings and colleagues (2005) used an intervention including practice with feedback and an incremental increase in the delay in which words were presented. Results demonstrated that accuracy and reaction times improved on a recognition memory test after training, suggesting that these incremental increases in delay and the requirement that one recollect the stimuli aided in the ability to expand the amount of time that the individual could store the information (Jennings et al., 2005).

A speed of processing intervention involved a discussion about the importance of speeded processing in many tasks followed by computerized practice with speeded tasks wherein the difficulty increased incrementally. This training led to improved performance on a test of visual-processing speed (Edwards et al., 2005; Vance et al., 2007), which was maintained for 2 years (Vance et al., 2007). Improved performance was also found in instrumental activities of daily living (Edwards et al., 2005), but no transfer to neuropsychological tests in other cognitive domains such as memory, executive functioning, or visuospatial skills were uncovered (Edwards et al., 2005; Vance et al., 2007).

While assessing dual task performance, Kramer and colleagues (1995) compared a variable priority condition where the priority placed on each condition varied within each task block and a fixed priority condition where the priority did not vary. They found that both young and older adults in the variable priority condition showed improved performance on the trained test as well as a novel dual task test. This observed ability to transfer benefit suggested that this variable training improved the ability to process the stimuli in such a way that it became automatic and allowed participants to gain generalizable skills in coordinating the components involved in a dual task activity (Kramer, Larish, & Strayer, 1995). In a subsequent study, however, Bherer et al. (2005) used a paradigm where both tasks required the same motor response and found that both variable and fixed priority training led to improvements in performance with no significant difference in type of training. Furthermore, it was determined that both older and young adults improved on a dual task ability when an individualized limits-testing training approach was used, suggesting that older adults possess reserved capacity for improvement (Bherer et al., 2006). Another study assessing practice with a constrained task found that older adults performed like young adults on a measure of switch costs when working memory demands were decreased. Thus, when a task is structured or cues are used in a way that does not require that one keep track of switch trials, older adults perform like young adults, but they do not show as significant improvement when they must keep track of when a switch trial will occur without cues (Kramer et al., 1999). Furthermore, in a study assessing the effects of practice with a deadline procedure requiring that individuals increase their speed of response as they completed the task, older adults improved to a greater degree than young adults in reaction time on a working memory task (Baron & Mattila, 1989).

In summary, improved performance in older adults has been demonstrated with several intervention methods where the task is constrained with incremental increases in delay or difficulty, decreases in time given to respond, use of cues, or practice varying the degree of effort exerted on different aspects of a task. Thus, benefits in performance can be obtained with tasks structured in a way that makes it consistently challenging and/or requires adoption of a flexible approach to the task. The benefits of these interventions were maintained across time when maintenance was assessed. Transfer of benefit was found for cognitive tasks that were very similar in demands and structure to those practiced. Also the speed of processing intervention produced transfer of benefit to daily living skills.

Plasticity Interventions

Another set of intervention methods involves what will be referred to as plasticity training, which is motivated by the theory that age-related decline is reversible and deficits are due to impoverished environments (Baltes & Schaie, 1976). Thus, this leads to the hypothesis that cognitive resources should be stimulated or exercised in a variety of domains in order to promote more efficient teaching of new skills or general cognitive processing. The plasticity interventions described in this section differ from simple practice in that they involve practice on multiple tasks instead of just one. Practice on multiple tasks is what is hypothesized to lead to stimulation or exercise of cognitive functions.

Mahncke and colleagues (2006) conducted a series of studies using a training intervention designed to stimulate and exercise language systems. The goal of this intervention was to compensate for reduced use of neural resources and increased noise thought to interfere with effective processing in older adults. The language-training protocol increased in difficulty according to criterion achieved and resulted in improved performance in comparison with a control group. Additionally, transfer of improved performance was found on neuropsychological measures.

It has been hypothesized that interventions will be beneficial if they lead to and increase neural activity. Thus, a study compared training in theatre skills with visual arts training. The theatre-training group was found to be superior to a control group on word recall performance and superior to a visual arts training group in problem solving ability. It was proposed that theatre training successfully improved cognitive performance because actors must multitask and the training stimulated effort on a novel set of tasks that involved multiple modalities (Noice, Noice, & Staines, 2004).

Other studies have examined attention process training, (Sohlberg, McLaughlin, Pavese, Heidrich, & Posner, 2000, p. 656), which involves practice with a variety of auditory and visual attention tasks that increase in difficulty with experience. This procedure is effective in training specific strategies or skills instead of improving previously utilized skills or general attention abilities in patients with traumatic brain injury (e.g., Park, Proulx, & Towers, 1999). For instance, attention process training led to greater improvement than an education intervention in performance on neuropsychological tests of executive control and working memory not used during training in brain-injured patients (Sohlberg et al., 2000).

Another study assessed the effect of an intervention involving practice on tasks requiring skills in several cognitive domains (e.g., attention, memory, nonverbal intelligence) with patients with Alzheimer's disease and mild cognitive impairment. The results demonstrated improvement on the tasks used in the intervention as well as transfer to multiple neuropsychological tests in those with Alzheimer's disease. Individuals with mild cognitive impairment showed improvement that transferred to one neuropsychological test. These results suggest that the intervention is effective in improving performance on the task trained and on some transfer tasks but suggests that training differentially affects different clinical populations (Cipriani, Bianchetti, & Trabucchi, 2006).

In summary, these plasticity interventions involving multi task practice in a variety of domains including language, attention, dual task processing, memory, and reasoning has resulted in successful transfer of improvement to neuropsychological tests assessing more global cognitive skills. These results suggest that efforts to stimulate cognitive resources through plasticity training produce an improvement in cognitive processing across domains.

Interventions Involving Explicit Training

Another type of intervention aiming to improve performance on cognitive tests and abilities will be referred to as explicit training. These interventions are characterized by explicitly instructing participants about how to approach tasks or use a strategy to improve performance. For instance, Ball and colleagues (2002) completed a multi-site study that involved specific training in either verbal episodic memory, inductive reasoning ability to solve problems involving serial patterns, or speeded processing in visual search problems. Training involved instructions about new strategies and practice with these strategies. All groups showed significant improvement in the ability trained, although the effects of training did not transfer to cognitive domains that were not trained (Ball et al., 2002). The benefits in performance specific to the ability trained were maintained for 5 years and led to an improvement in functional measures of speeded processing at 11 and 35 months after initial training on speeded processing abilities (Willis et al., 2006).

Numerous intervention studies have been pursued with aims to improve fluid intelligence abilities. Many of these studies sought to train and improve figural relations abilities wherein participants studied rules used on figural relations problems that were similar in general structure to those used in the test. It has been demonstrated that this training intervention results in improvements in performance (e.g., Plemons, Willis, & Baltes, 1978). Figural relations training procedures produced stronger improvement effects in tasks most similar in structure and content to those trained (Willis, Blieszner, & Baltes, 1981). These fluid intelligence training interventions have been criticized with assertions that they train skills specific to the task used during training instead of the processes involved, which might result in the tasks becoming more like crystallized intelligence measures instead of fluid intelligence measures (Schaie, Willis, Hertzog, & Schulenbert, 1987).

When three phases of training were investigated over a 7-year period, the greatest degree of improvement in fluid intelligence occurred after the initial phase of training. Still, plasticity occurred even at the time in the study when participants were oldest (Willis & Nesselroade, 1990). A recent study examined longitudinal data to determine if the magnitude of training effects was associated with subsequent mental status changes. They found that, compared with nondemented individuals, demented individuals showed smaller training gains in reasoning ability compared 7 years prior (Boron, Willis, & Schaie, 2007).

Encouraging results have been derived as a result of strategic memory training in older adults (Scogin et al., 1985; Verhaeghen et al., 1992). Studies have demonstrated that individuals undergoing memory training maintain the benefits of this intervention over time (Sheikh et al., 1986; Neely & Backman, 1993). One of the most popular memory-training techniques is the method of loci where each word to be remembered is associated with a particular location in a sequence. Older adults improved significantly in number of words recalled after training (Kliegl, Smith, & Baltes, 1990), but an older group of older adults above age 75 improved to a lesser degree (Singer, Lindenberger, & Baltes, 2003). When these effects were investigated using neuroimaging techniques, however, young adults benefited more than older adults from the memory training, and only young adults showed an increase in activation in the left dorsolateral prefrontal cortex. Thus, it has been suggested that older adults may not show the same pattern of neural activation because of reduction in resources such as speeded processing (Nyberg et al., 2003).

Although there is significant evidence of age-related changes in executive control abilities, few studies have specifically investigated interventions seeking to improve executive control abilities such as goal maintenance. Still, goal management training, which involved explicit instructions and practice with real-life examples in exerting control over behavior by pausing to plan how to approach sub goals, was shown to result in improvements in simulated tasks representing real-life scenarios as well as self-rated executive abilities in older adults (Levine, et al., 2007). A study investigating logical reasoning ability in young adults demonstrated that an intervention with inhibition training involving warnings was successful in changing patterns of activation from posterior to anterior regions, but logical training and practice were not effective (Houde et al., 2000). Thus, the specific type of explicit training used interacts with the type of executive control task being trained.

A strategy training procedure aimed to improve goal maintenance abilities in older adults was assessed with the AX-CPT task. The strategy training first involved explicit instructions and practice identifying the cue and deriving an action plan for the response. Specifically, participants first practiced verbally identifying whether the cue was A or not A and then practiced planning for their response by stating "if X, then red" when the cue was A or "yellow" when the cue was not A. This strategy training intervention was effective in improving goal maintenance abilities on the AX-CPT task in older adults (Paxton et al., 2006). Similar to the training with the AX-CPT involving the translation of contingency information from the cue into an action plan, Gollwitzer and

Brandstatter, (1997) used implementation intentions whereby one plans to take a certain action in the future when a specific event is encountered. For instance, an implementation intention could be "I intend to do Y, when situation X is encountered" (Gollwistzer & Brandstatter, 1997, p. 187). These researchers found that completion of a writing task was improved when participants planned when and where they would begin the task. Thus, the process of using implementation intentions is like the strategy training on the AX-CPT in that the action is determined (e.g., press target button or begin writing paper) but is contingent on a particular event (e.g., if the probe is an X or if it is Wednesday morning). Thus even though contingency planning on the AX-CPT and the implementation intentions were used with different types of tasks and populations, both techniques proved to be beneficial in improving the ability to follow through with goal directed behavior.

Studies investigating the effects of interventions involving explicit instructions have demonstrated encouraging results in terms of improving the abilities trained and leading to maintenance of these improvements over time. Most studies assessing explicit training protocols have targeted fluid intelligence and memory abilities with very few studies seeking to improve executive control abilities. When the ability to transfer improvement to novel tasks was assessed, results were not encouraging, which has resulted in concerns that procedures may train abilities specific to the test used.

Questions Remaining about Cognitive Interventions

Overview

The investigation of interventions aimed to improve cognition has become an important area of inquiry in older adults and other individuals. Nevertheless, drawing conclusions from the multiple studies in this area has been complicated by inconsistent results found across studies. Burgess and Robertson (2002) pointed out several explanations to account for ambiguities in intervention studies across various populations. These researchers attribute these inconsistencies to (a) the lack of agreement about the definition of the construct being evaluated, (b) differences in outcome measures across studies where some studies seek to improve very specific abilities and others aim to improve global intellectual ability, (c) differences in the populations of participants, and (d) differences in the methodologies used to assess outcomes (e.g., fMRI vs. paper test). Although it is encouraging to find that many studies have shown improvement in cognitive performance as a result of interventions, there are several questions that remain. The questions and topics described in this section focus on the aim to improve goal maintenance and executive control abilities because deficits in these areas are a significant concern for older adults.

Training Goal Maintenance

Can the strategy training procedure used in previous studies be applied to executive control tasks requiring goal maintenance abilities? Although much has been learned about the effects of explicit training interventions in improving fluid intelligence abilities and memory, very few studies have used explicit training to improve or evaluate executive control abilities. An explicit training study of fluid intelligence abilities demonstrated that higher scores on measures of strategy use were found to be associated with increased gains from pretest to posttest in a group receiving inductive reasoning strategy training. Thus, it has been suggested that strategy use may be a mechanism by which explicit training is effective (Saczynski, Willis, & Schaie, 2002). Evidence that older adults do not spontaneously derive effective strategies (Hybertson, Perdue, & Hybertson, 1982; Touron & Hertzog, 2004) motivates research with strategy training. Previous studies using strategy training have documented improvement in the domains of memory and reasoning in older adults. Therefore, it is hypothesized that strategy training would assist with executive functioning abilities. Previous results (e.g., with the AX-CPT) reviewed above demonstrated that improved executive control abilities were observed after strategy training. Thus, we ask whether the strategy training procedures used previously on the AX-CPT (Paxton et al., 2006) or in studies training memory or fluid intelligence would lead to improved performance on other tasks assessing goal maintenance or executive control abilities?

Explicit Training versus Practice

As reviewed in the previous sections, several different types of interventions have been studied and have shown some promise of improving cognitive performance in older adults. Still, very few studies directly compare the effectiveness of different interventions. One aim in comparing interventions is to determine which intervention is most effective. Our ability to make conclusions about the mechanisms that are leading to improvement is aided by demonstration that one intervention in more effective than another on improving specific outcomes. Identification of such mechanisms, however, has been clouded when two different interventions show very similar effects. For instance, no significant differences were found between an explicit training intervention and simple practice in a study using a figural relations tasks (Baltes, Sowarka, & Kliegl, 1989) and the AX-CPT task (Paxton et al., 2006). Thus, if explicit training and practice result in the same degree of change in performance on the task, then it would be sensible to promote the use of simple practice because it is the most efficient intervention. Nonetheless, another study demonstrated that specific mnemonic training is more effective than practice with self-generated strategies when a memory test is administered without support in the form of cues on a memory test (Derwinger Neely, Persson, Hill, & Backman, 2003).

Even if explicit strategy training and practice both improve performance, it is possible that they do so through different mechanisms. For instance, Schmidt and Bjork (1992) suggested that interventions that maximize performance during training do not lead to improvements in performance over time, whereas manipulations that hurt performance during training lead to better maintenance. Thus, the mechanism leading to benefit from training versus practice is complicated and likely to be influenced by several factors. Additionally, it is assumed that when simple practice interventions are used, participants will generate their own strategy, which may or may not be effective. Thus, if the strategy generated by a participant in the practice condition is effective, then practice may be beneficial in leading this strategy to become more automatic. Alternatively, if a participant in the practice condition is not able to generate an effective strategy, then practice may not be helpful as additional experience with an ineffective approach does not make it effective. Despite the importance of these questions in determining the cognitive mechanisms involved as a result of strategy training and practice interventions, it is often not possible to observe the strategy that one spontaneously derives and how strategy use changes over time with and without direct intervention.

Transfer

It may be possible to differentiate between mechanisms leading to performance improvements via practice versus explicit training by looking at more diverse sets of measures. Hence, one way of determining whether the cognitive process occurring as a result of an explicit training intervention differs from the process resulting from a practice intervention is to assess ability to transfer improvement to a task not used during the intervention. The ability to transfer benefit suggests that a "generalizable task coordination or management skill" (Kramer et al., 1995, p. 69) or an effective way of approaching multiple tasks was gained during the intervention.

Based on the review of the studies using interventions aiming to improve performance, it can be concluded that virtually any intervention will lead to an improvement in older adults on the task used. Transfer of improvement to novel tasks is more challenging to achieve (Edwards et al., 2005; Kramer & Willis, 2002). Thus, transfer effects are very desirable; such results suggest that a change has occurred in the way that the participant confronts the task or that the cognitive processing has been altered. Also, any intervention would be most efficient if it not only improved performance on the trained task but others as well.

In the previous review of studies using an intervention to improve cognitive performance in older adults, only a portion showed successful transfer. Of those studies showing transfer, significant improvement was only obtained on a very similar transfer task. Examination of studies producing effective transfer effects leads to two hypotheses about how transfer effects might be facilitated. First, studies using simple practice of working memory ability in young adults (Oleson et al., 2004), task constraints requiring the adjustment of one's approach to a task as it becomes more demanding (Jennings & Jacoby, 2003; Kramer, Larish, & Strayer, 1995), and multitask practice aimed to stimulate cognitive resources (Cipriani, Bianchetti, & Trabucchi, 2006; Mahncke et al., 2006; Noice, Noice, & Staines, 2004; Sohlberg et al., 2000) have demonstrated successful transfer of benefit to untrained tasks. The authors of these studies have argued that, in order to achieve transfer, it appears to be required that a processing skill is trained instead of training skills needed for a specific task used during training. It is notable that interventions using multi task exercise aimed to stimulate neural resources led to transfer of benefit to novel neuropsychological tests in several studies. Thus, these results suggest that successful transfer is facilitated when one learns to be flexible in the way that he or she approaches tasks (Kramer et al., 2005) or when one learns to be flexible in improving skills on multiple tasks (Cipriani, Bianchetti, & Trabucchi, 2006; Mahncke et al., 2006; Noice, Noice, & Staines, 2004; Sohlberg et al., 2000). Thus, this leads to the hypothesis that interventions that train processing skills and flexibility will result in better transfer of benefits.

The second hypothesis pertains to training effects and stems from an area of cognitive theory that has been examined in order to better understand memory functioning. Transfer appropriate processing refers to the finding that memory performance is enhanced when the type of information emphasized by encoding is similar to the type of information required at the time of the memory test (Morris et al., 1977). McDaniel and Schlager (1990) proposed that this principle applies to learning and found that practice discovering strategies transfers to other problem-solving tasks requiring development of new strategy. These results raise a question of whether practicing the cognitive *process* of transferring skills learned to novel tasks would lead to better ability to transfer at a later time. Furthermore, questions remain about whether the ability to observe and map analogies in the structure between different tasks that are similar in structure, referred to as relational reasoning (Hummel & Holyoak, 2005) could be trained with practice using the same strategy instructions on different tasks with similar general demands. Thus, previous studies suggest that transfer is facilitated by practicing the process of applying a general strategy to multiple tasks, which is the process that is required for successful transfer of improvement to untrained tasks. Additionally, several previous studies have asserted that ability to show benefits of skill learning training on a retention test depends on the degree to which the "learning procedures are reinstated at test" (Healy, Fendrich, & Proctor, 1990, pp. 280).

One of the primary goals of the current study was to evaluate whether strategy training and/or practice interventions facilitate transfer to untrained tasks. In developing the interventions used in this study, I assumed that the development of appropriate strategies is necessary to perform well on goal maintenance tasks and that an appropriate strategy would need to be developed for the untrained transfer tasks in order for benefits of training to transfer. Therefore, as described in detail in the future chapters, an intervention condition was developed that sought to train participants to apply a general strategy adaptively to new tasks. Failure of this intervention to facilitate transfer could mean that strategies are not necessary for successful performance on novel untrained tasks or that the intervention did not effectively train the ability to flexibly adapt strategies.

Summary of questions motivating current study.

In summary, several questions have been presented inquiring about the effectiveness of strategy training and practice interventions that motivated the development of the current study. Is strategy training more effective than practice in improving performance on executive control tasks? Do strategy training and practice interventions improve performance with different cognitive mechanisms? Will strategy training and practice show differences in ability to transfer improvement to an untrained task, suggesting differences in the cognitive process used?

Theoretical motivation for study design

Most generally, the questions that motivated the current study centered on determination of the best intervention for improving goal maintenance abilities in older adults. The discussion of interventions to improve cognitive functioning has focused on highly controlled laboratory interventions studies. Before proceeding into the design for the current study, it is important to consider the advantages and disadvantages of the type of intervention used in the current study.

One type of intervention is what I refer to as *direct practical interventions* or when clinicians intervene with persons suffering from brain injury seek to directly improve daily living skills through instructing persons about how to perform them, providing compensatory strategies, and/or allowing practice with the skills. In such real-world interventions, both the training and outcome measures involve competing real-life daily living challenges. As such, this type of intervention is highly relevant, and if effective, immediately affects some aspect of one's daily life. When a daily living skill is trained, then it is simple to determine whether the training of the particular skill was effective in terms of immediate performance of the desired skill and performance over time. Still, if multiple skills or areas of cognition were targeted at once, then it may be difficult to determine what aspect of the training was effective.

Another type of intervention is referred to as *holistic practical interventions* or when many different training components (e.g., social interaction, exercise, community work, problem solving, cognitive training) are combined in one training procedure. In this type of intervention, training occurs through a combination of real-life and/or cognitive tests and outcome is evaluated with cognitive tests. For instance, a holistic intervention involving weekly social meetings where a group of older adults worked together to solve problems resulted in those trained showing significantly greater improvements in speed, inductive reasoning, and divergent thinking (Stine-Morrow, Parisi, Morrow, & Park, 2008). In another study, older adults with executive control deficits who regularly assisted elementary school students with reading showed an improvement on an executive control and memory task whereas the scores of those without the intervention declined over time (Carlson et al., 2008). These holistic studies show promising results with methods that engage older adults in their community in ways that are likely to be enjoyable, increase feelings of self-efficacy, and may benefit the community. Still, given that many factors were included in the intervention, it is not possible to know whether one particular aspect of the training procedure or the combination of all aspects of the procedure caused the improvement in performance.

Most of the studies reviewed in Chapter 2 are what I refer to as *controlled experimental studies* where the interventions involve a single manipulations that is highly controlled such that the exact cause and underlying cognitive mechanisms of any performance change as a result of training can be identified. These controlled interventions involve cognitive tests for training and outcome. Although I assert that the ultimate goal of cognitive interventions is to improve real-life performance in daily living skills, the reliance on experimental cognitive tests causes this type of intervention to be far removed from real-life stimuli or experiences. Nevertheless, I have chosen to use this type of intervention in the current study due to my goal to focus on one aspect of executive control abilities, goal maintenance, and gain knowledge about whether a particular intervention improves performance. It may be more likely that an intervention with real-life stimuli would improve real-life performance or an intervention with multiple components would show greater benefits in performance. Still, in the current study, I am interested in gaining more precise information about specific strategy training and practice intervention to determine if these types of interventions should be included in future studies with more real-life implications. Furthermore, focusing on the effectiveness of highly controlled interventions that target only goal maintenance abilities can provide more conclusive insight about what aspects of intervention procedures are or are not effective and provide information about the specific cognitive processes involved in the executive control tasks.

CHAPTER THREE: PURPOSE, RESEARCH DESIGN, AND HYPOTHESES

Purpose

Consistent with the frontal theory of aging, previous studies have demonstrated that older adults show impairment on various executive control tasks requiring that they activate and maintain goal relevant information. Even though research has demonstrated that various forms of practice or training lead to improved performance on abilities such as memory and reasoning in older adults, few studies have been specifically aimed at improving executive control abilities such as goal maintenance. A previous study demonstrated that both practice and strategy training produced improved performance in older adults on an executive control task requiring the activation, maintenance and updating of goal relevant information (Paxton et al., 2006), but this study did not assess ability to transfer improvement to other tasks or to maintain improvements over time. Thus, questions remain about whether practice and strategy training led to improvements on the task through the same mechanisms or through different mechanisms. For example, it is possible that both practice and strategy training altered a general cognitive process (e.g., ability to use a strategy for improved goal maintenance ability across tasks) or improved the learning of associations among the specific task stimuli. Alternatively, practice may improve the learning of task specific associations, while strategy use may improve a more general cognitive ability that would transfer to novel task situations. As such, evaluating and attempting to facilitate the ability to transfer improvements to other tasks can help us to understand what types of strategic change occur when performance is improved through practice and training interventions. Also, through evaluating transfer, we can determine the most effective rehabilitation techniques for improving age-related cognitive changes. Therefore, in this dissertation study four interventions were compared for effectiveness in improving performance, transfer of improvement to other tasks, and maintenance of improvement. The interventions were (a) simple practice on one task requiring goal maintenance ability, (b) simple practice on three tasks requiring goal maintenance ability, (c) strategy training on one task requiring goal maintenance ability, and (d) multi task strategy training designed to improve the ability to apply goal maintenance strategies flexibly. Performance was first evaluated on the task used during all the training and practice interventions. Additionally, performance was evaluated on untrained transfer tasks in order to investigate differences in the cognitive processes that occur after strategy training or practice.

As reviewed, previous studies have suggested that transfer of benefits will be enhanced when interventions train processing skills, flexibility, and the ability to apply general strategies to new tasks. In order to explore this prediction, we expanded the strategy training procedure used in our previous study (Paxton et al., 2006) to train flexibility and transfer skills. Thus, in one condition of the proposed study, participants practiced applying a general goal maintenance strategy to three different tasks requiring goal maintenance abilities. This multi task strategy training involves implementing an approach to strategy training that encourages generalizations through application of the strategy in multiple tasks that all share common features. Specifically, all of the trained tasks were assumed to be facilitated by applying a proactive strategy of preparing in advance for the appropriate task response based on contextual cue or goal information. As this ability to apply learned material to new tasks is assumed to be required for successful transfer, it was hypothesized that participants in the multi task training condition would be better able to transfer benefit to the untrained tasks than participants in the single task training condition or either of the practice conditions.

Research Design

Participants were healthy older adults ranging in age from 65 through 80 who were randomly assigned to one of four groups (single task training, multi task training, single task practice, multi task practice). Participants in all groups underwent four testing sessions.

All five cognitive tasks used in this study assessed executive control abilities. Furthermore, in all tasks used, theory predicts that performance improves when applying an approach of attending to and processing goal-related information in order to prepare in advance for a response. First, the AX-CPT, described earlier, evaluates the ability to use goal-related information in the form of a cue in order to prepare in advance to make a probe response. The Dot-CPT task is analogous to the AX-CPT task in structure but uses visual dot patterns instead of well-learned letters.

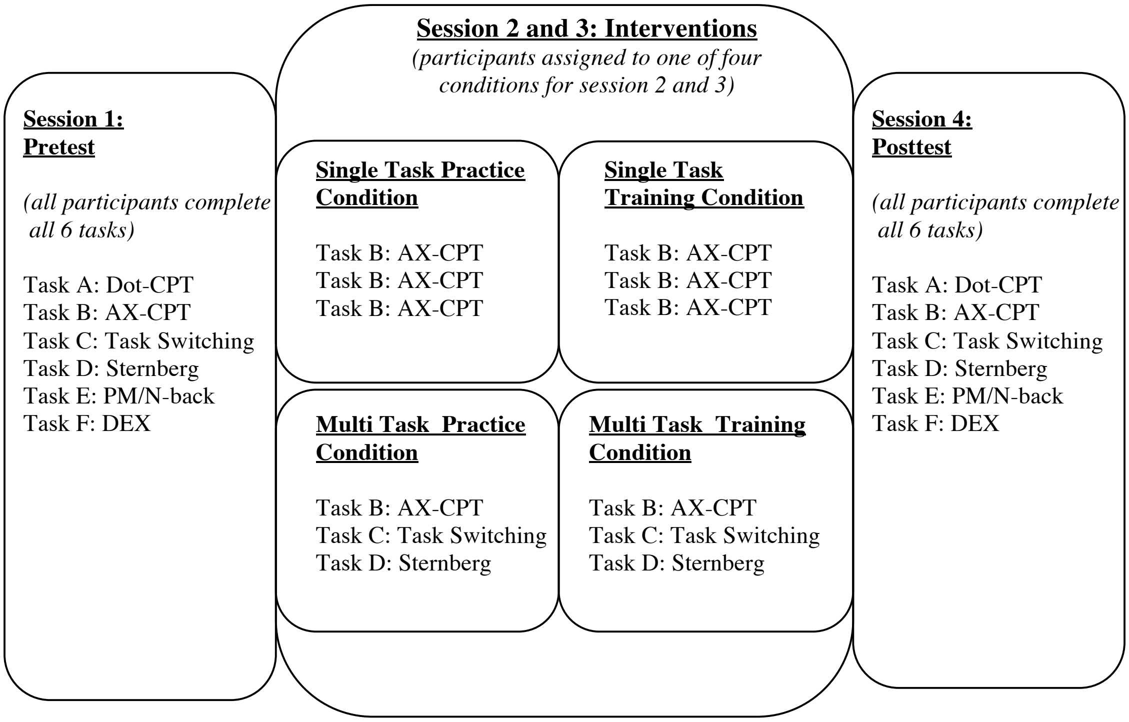
The letter-number task switching test is a version of a category of tasks that assess the ability to coordinate and alternate between different goals. Success on this task switching test requires that one attend to a cue designating whether to pay attention and make a judgment about the letter (and determine whether it is a consonant or vowel) or number (and determine whether it is odd or even). Hence, goal maintenance abilities could be used to attend to the cue information and use the identity of the cue to prepare in advance for either the number or letter.

The modified Sternberg test requires that participants decide whether a probe word was one of the four words previously presented in a memory set. Numerous incorrect probe stimuli are words that were presented in the memory set previously; therefore, this task assesses the ability to inhibit answers based on familiarity. On the modified Sternberg task goal maintenance abilities could be used to attend closely to the memory set and prepare to look for only the words that were in the previously presented memory set at the time of the probe.

The prospective memory/N-back (PM/N-back) test involves two N-back tasks assessing working memory (WM) ability as well as a prospective memory (PM) task. The prospective memory task requires that participants make an explicit response when the stimulus appears in a specified color while simultaneously performing the N-back task. It has been asserted that assessing prospective memory combined with an ongoing task determines whether one continuously monitors in an effort to detect the prospective event or devotes attention to the ongoing task with intentions to detect the prospective memory event when it occurs (McDaniel & Einstein, 2007). Prospective memory tasks that require more active strategic monitoring demand executive control abilities more than tasks where one retrieves the prospective memory goal only when the prospective event occurs. The PM task used required goal maintenance abilities because the ongoing N-back task is challenging enough to demand significant cognitive resources. Furthermore, determining whether the stimuli appear in a particular color is also challenging because all words appear in different colors and one cannot assume that the designated target color will be obvious without strategic monitoring. Thus, this PM task requires that one actively maintain and monitor for the occurrence of the designated color prospective event, which requires goal maintenance abilities.

During Session 1 (pretest), executive control ability was assessed with five cognitive measures of executive control ability (AX-CPT, letter-number task switching, modified Sternberg, Dot-CPT, and PM/N-back) and one self-report measure (Dysexecutive Questionnaire; DEX) to establish pretest level of performance. In Sessions 2 and 3 (each lasting 1 to 2 hours) participants in the multi task training condition underwent focused strategy training with the AX-CPT, task switching, and modified Sternberg tasks. Participants in the single task training condition underwent the same focused strategy training with only the AX-CPT during Sessions 2 and 3. Participants in the multi task practice condition practiced with the AX-CPT, task switching, and modified Sternberg tasks during Sessions 2 and 3. Participants in the single task practice condition practiced with the only the AX-CPT task during Sessions 2 and 3. In Session 4 (posttest) all participants repeated the five cognitive measures and one self-report measure to assess for change from pretest performance. These cognitive tasks included the three that were trained or practiced in Sessions 2 and 3 (AX-CPT, letter-number task switching, and modified Sternberg). The transfer tasks were administered at Session 1 (pretest) and Session 4 (posttest), but were not presented during intervention sessions 2 and 3. The task resembling the AX-CPT with nonverbal stimuli, the Dot-CPT task, was included to assess near transfer, and the executive control task that does not resemble the trained or practiced tasks in structure, the PM/N-back task, was included to assess far transfer. Please see Figure 1 for a description of the study design.

Figure 1



Study Design for participants at pretest, intervention sessions, and posttest.

Overview of Hypotheses

First, it was expected that all participants would improve, at least slightly, from pretest to posttest due to simple exposure to the tasks. Thus, it was expected that, regardless of condition, improvement would be observed from pretest to posttest (main effect of session).

The effect of the training and practice interventions were first compared on the task that was included in all intervention conditions, the AX-CPT. Because a previous study demonstrated that practice and training interventions are effective in modifying performance, no difference between strategy training and practice interventions was hypothesized. Still, it is important to note that the conditions differ in amount of practice on the AX-CPT task in each session. The single task practice condition involves 300 trials of practice on the AX-CPT task, the multi task practice condition involves 100 trials of practice on the AX-CPT task, the single task training condition involves 360 trials of practice on the AX-CPT task incorporated in training procedure, and the multi task training condition involves 120 trials of practice on the AX-CPT in the course of the strategy training procedure. Thus, participants in the single task practice and single task training conditions were exposed to a greater number of AX-CPT trials in both Session 2 and 3 than the participants in the multi task training and multi task practice conditions. Hence, if it is assumed that the strategy training and practice interventions produce approximately equal effects when amount of practice is comparable, then it could be that the more substantial practice for single task conditions would produce a larger effect than the shorter practice in the multi task conditions. Therefore, it was hypothesized that participants in the single task training condition would perform better than participants in the multi task training condition due to extended practice with the AX-CPT. Likewise, it was hypothesized that participants in the single task practice condition on the AX-CPT would perform better than those the multi task practice condition on the AX-CPT due to extended exposure. No significant differences in AX-CPT performance were predicted between both strategy training and both practice conditions due to results of our previous study showing a lack of significant differences between training and practice interventions.

We were also interested in comparing strategy training and practice in order to determine whether these interventions led to improvements in performance through similar or different cognitive mechanisms. This question was explored by assessing ability to transfer improvement to tasks not used during the intervention. The strategy training condition involved learning a goal maintenance strategy to be applied to multiple tasks and gaining practice in applying the general strategy in a flexible manner across tasks. It was hypothesized that the multi task strategy training intervention would improve ability to use an effective goal maintenance strategy and/or improve "processing skills" on the three tasks used. Therefore, it was hypothesized that the multi task training condition would lead to improvement in the ability to use a strategy in a flexible and adaptable way on different untrained tasks. Thus, based on these predictions and in comparison to the single task training condition and both practice interventions, the multi task training intervention was hypothesized to lead to better transfer to the two tasks not included in training, the Dot-CPT task and PM/N-back.

Hypotheses

<u>*Hypothesis 1: Performance at Pretest*</u>

Hypothesis 1. It was hypothesized that, at pretest, performance on the five executive control tasks would correlate positively with one another in all participants. It was predicted that the task identified to measure near transfer, the Dot -CPT, would show stronger correlations with letter AX-CPT than other tasks, including the far transfer measure, the PM/N-back. Also, scores on the DEX Questionnaire indicating self-reported executive complaints were predicted to correlate negatively with performance on executive control tasks at pretest.

<u>*Hypothesis 2: Performance on the AX-CPT*</u>

Hypothesis 2a. It was predicted that all participants would show improvement on the AX-CPT task from pretest to posttest due to the benefit of practice with the task at pretest and during the intervention sessions.

Hypothesis 2a predicts that a main effect of session would be uncovered for the proactive error and RT index scores. It was predicted that this main effect would be qualified by an interaction described in Hypothesis 2b.

Hypothesis 2b. It was predicted that participants in the single task conditions would show significantly improved performance on the AX-CPT at posttest compared with pretest above and beyond improvement shown by participants in the multi task conditions. Furthermore, it was predicted that participants in the single task practice condition would show a larger increase in proactive performance from pretest to posttest *compared with those in the multi task practice condition. It was also hypothesized that participants in the single task training condition would show a greater increase in proactive performance than participants in the multi task training condition.*

Hypothesis 2b predicted an exposure condition by session interaction for AX-CPT proactive error and RT index scores. It was predicted that the single task conditions would show greater increase in proactive index scores compared with the multi task conditions. It was predicted that participants in the single task training condition would show larger increases in proactive error and RT index scores from pretest to posttest compared with participants in the multi task training condition. It was predicted that participants in the single task practice condition would show larger increases in proactive error and RT index scores from pretest to posttest compared with participants in the multi task practice condition.

Hypothesis 2c. It was hypothesized that the degree of improvement in goal maintenance abilities from pretest to posttest on the AX-CPT would not be significantly different for the practice and training groups, which was predicted by results of the previous study (Paxton et al., 2006).

A session by training intervention interaction was not predicted for the proactive error and RT index scores. It was predicted that proactive index scores would increase for participants in the practice and training conditions, but there would be no significant differences between the training and practice conditions.

Hypothesis 3: Performance on the task switching and modified Sternberg tests

Hypothesis 3a. For the task switching test, it was hypothesized that all participants would show worse performance in accuracy and RTs in mixed block repeat trials compared with pure block trials. Likewise, it is expected that all participants would show worse performance in accuracy and RTs in mixed block switch trials compared with mixed block repeat trials on the task switching test. Also, it was predicted that all participants would show worse accuracy and RT performance in recent negative trials compared with novel negative trials on the modified Sternberg.

On the task switching test, it was predicted that a main effect of mixing cost (mixed block repeat trials vs. pure block trials) would be uncovered and follow-up analyses would demonstrate that number of errors and RTs would be higher for the mixed block repeat trials compared with the pure block trials. Also, a main effect of switching cost was predicted (mixed block switch trials vs. mixed block repeat trials), and it was predicted that follow-up analyses would show that the number of errors and RTs would be greater for the mixed block switch trials compared with mixed block repeat trials.

On the modified Sternberg task, a main effect of trial type (recent negative vs. novel negative) was expected, and it was predicted that follow-up analyses would show that participants produced greater errors and RTs on the recent negative trials compared with the novel negative trials.

Hypothesis 3b. It was predicted that all participants would show improvement on the task switching and modified Sternberg tests from pretest to posttest due to the benefit from exposure to these tests at pretest in all conditions.

A main effect of session was predicted for all task switching and modified Sternberg scores showing that performance improved from pretest to posttest.

Hypothesis 3c. Participants in the multi task conditions gained experience with the task switching and modified Sternberg tasks during the interventions sessions, whereas participants in the single task conditions only gained experience with these tasks during the pretest session. Because those in the multi task conditions gained more experience with these two tasks during the two intervention sessions, it was hypothesized that the multi task groups would show a significantly greater improvement in performance from pretest to posttest than those in the single task conditions on the task switching and modified Sternberg.

A session by exposure condition (multi task vs. single task) interaction was expected. It was predicted that multi task conditions would show greater change in scores from pretest to posttest compared with the single task conditions.

Hypothesis 3d. It was predicted that participants in the multi task training condition would show a significantly greater improvement in performance than participants in the multi task practice condition on the task switching and modified Sternberg tests at posttest compared with pretest.

It was expected that a session by exposure condition (multi task vs. single task) by training condition (training vs. practice) interaction would be found. It was also predicted that multi task training condition would show greater change in scores from pretest to posttest than any of the other three training/exposure condition combinations (single task training, multi task practice, or multi task training).

Hypothesis 4: Performance on the near transfer task: Dot-CPT

Hypothesis 4a. It was hypothesized that all participants would show improvement on the Dot-CPT task from pretest to posttest due to simple exposure to the task at pretest.

It was predicted that a main effect of session would be uncovered showing a significant increase in proactive error and RT index scores from pretest to posttest.

Hypothesis 4b. It was hypothesized that participants in the multi task training condition would show a significantly greater improvement in performance on the near transfer task, the Dot-CPT, from pretest to posttest compared with participants in the single task training, multi task practice, or single task practice conditions.

A session by exposure condition (single vs. multi task) by training condition (training vs. practice) interaction was expected. Separate analyses for each exposure/training condition combination were predicted to show that multi task training condition produces the greatest increase in proactive error and RT index scores. There were no predictions about differences among the single task training, multi task practice, and single task practice conditions on the Dot-CPT.

Hypothesis 5: Performance on the far transfer task: WM N-back and PM

Hypothesis 5a. It was predicted that all participants would show improvement on the WM N-back and PM tasks from pretest to posttest due to simple exposure effects.

A main effect of session was expected for each WM or PM variable evaluated, showing that participants produced better accuracy and faster RTs at posttest compared with pretest.

Hypothesis 5b. It was predicted that all participants would show worse performance in terms of accuracy and RTs in the 2-back condition compared with the 1-back condition, indicating effects of increased working memory load. Likewise, it was hypothesized that participants would show worse performance on the 1-PM-back condition compared with the 1-back condition due to greater prospective memory demands.

A main effect of working memory load (1 back vs. 2 back) was predicted to show that participants would be significantly less accurate and produce significantly slower RTs in the 2-back conditions in comparison with the 1-back condition. Also, a main effect of prospective memory load (1-back vs. 1-PM-back) was predicted wherein it was expected that participants would be less accurate and produce slower RTs in the 1-PM-back condition compared with the 1-back condition.

Hypothesis 5c. It was predicted that all participants would show more improvement in accuracy and RTs from pretest to posttest on the 2-back condition compared with the 1-back condition indicated through WM cost scores. Also, it was predicted that all participants would show more improvement on the 1-PM-back condition compared with the 1-back condition indicated through PM cost scores.

A main effect of session was expected for WM and PM cost scores, which was predicted to show a change in WM cost scores demonstrating that 2-back scores improve more than 1-back scores from pretest to posttest. Also, a main effect of session was expected for PM cost scores, demonstrating a significant change in PM cost scores wherein 1-PM-back scores improve more than 1-back scores from pretest to posttest.

Hypothesis 5d. It was hypothesized that the multi task training condition would show a greater increase in d' and greater decrease in RTs from pretest to posttest on the far transfer test, the WM N-back and PM tasks, compared with the single task training, multi task practice, and single task practice conditions.

A session by exposure condition (multi task vs. single task) by training condition (training vs. practice) interaction was predicted for WM and PM cost scores. Separate analyses for each exposure/training condition combination were predicted to demonstrate that a more significant change occurs for the multi task training condition in comparison with the single task training, single task practice, and multi task practice conditions.

Hypothesis 6: Performance on the DEX

Hypothesis 6a. Given recent evidence that explicit training aimed to improve goal maintenance abilities in real-life situations improved DEX scores (Levine et al., 2007), it was hypothesized that DEX total scores would decline from pretest to posttest.

A main effect of session was expected demonstrating that DEX total scores declined significantly from pretest to posttest.

Hypothesis 6b. It was hypothesized that a quantitative measure of improvement in goal maintenance ability from pretest to posttest would show a positive relationship with a quantitative measure of decline in self-rating scores of daily executive control dysfunction on the DEX.

It was expected that residual scores for cognitive test performance representing change from pretest to posttest would correlate positively with the DEX residual score representing change from pretest to posttest.

CHAPTER FOUR: METHOD

Participants

Ninety four older adults were recruited from the Washington University Aging and Development volunteer pool. After agreeing to undergo screening, all participants were administered the Short Blessed Orientation and Memory Scale (Katzman et al., 1983) as a screening for possible dementia. No participants were excluded due to a Blessed score of six or greater. One participant was excluded from the study due to scoring above 6 on the 15-item Geriatric Depression Scale (GDS; Yesavage & Brink, 1983). Three participants were excluded due to failing to understand and complete the tasks at the pretest session and one participant was excluded because data for the AX-CPT was not recorded due to computer malfunction. Three participants did not return after the first session. After these participants were excluded, data for eighty-six participants was analyzed.

Table 1 shows demographic information for the participants who completed the study. Participants randomly assigned to one of the four training and exposure condition combinations (i.e., single task practice, single task training, multi task practice, multi task training) did not differ in age, F (3, 82) = .07, p = .98, years of education, F (3, 82) = .82, p = .49, Short Blessed scores, F (3.82) = 1.88, p = .14, or Geriatric Depression Scale scores, F (1, 82) = .33, p = .80. All participants were Caucasian except for one person of unknown race in the multi task training condition.

One participant in the multi task practice condition and two participants in the single task practice condition made 100% errors on the BX trials on the AX-CPT task during the pretest session. One participant in each of the single task practice, single task training, and multi task training conditions made 100% errors on BX trials on the Dot-CPT task during the pretest session. Because RTs were calculated for only correct trials, these participants did not have RTs for BX trials. In order to calculate the proactive context processing RT index score (AY-BX) for these individuals, the mean RT for the participants in the same condition (e.g., single task practice) was used.

Similarly, one participant in the multi task training condition made 100% target errors on the 2-back task at pretest. One participant in the single task practice condition and two participants in the multi task practice condition made 100% PM errors on the 1-PM-back task at pretest. One participant in the multi task practice condition made 100% target errors on the 1-back task at posttest. One participant in the multi task practice condition made 100% target errors on the 2-back task at posttest. One participant in the single task practice condition and two participants in the multi task practice condition made 100% target errors on the 1-PM-back task at posttest. Lastly, three participants in the multi task practice condition made 100% PM errors on the 1-PM-back task at posttest. As with the AX-CPT, RTs were only calculated for correct trials, and therefore, these participants with 100% errors in the various PM/N-back tasks did not have RT scores. Thus, in order to derive RT cost scores, the mean RT for the participants in the same condition (e.g., multi task practice) was used.

Some participants were missing data on various tasks (e.g., one participant did not complete 1-back condition of PM/N-back measure), and therefore, analyses assessing differences between pretest and posttest sessions only include participants with data for both sessions for the measure of interest. In all tables showing mean performance at pretest and posttest, the number of participants included in the analyses is indicated.

Table 1

Demographic Data for All Participants Included in Analyses.

	Condition			
Demographic	SP	ST	MP	MT
Age (years)	72.35 (5.38)	72.57 (5.29)	73.00 (4.22)	72.76 (4.96)
Sex (% male)	26	23	33	33
Education (years)	15.17 (2.78)	14.43 (2.29)	15.62 (2.36)	14.76 (2.93)
Screening				
GDS	.52 (.73)	.81 (1.40)	.71 (1.19)	.86 (1.46)
Blessed	.52 (1.08)	1.14 (1.62)	1.33 (1.93)	.48 (1.08)

Entries are means; standard deviations are in parentheses unless otherwise noted.

SP: Single Task Practice, ST: Single Task Training, MP: Multi task Practice, MP: Multi task Training

GDS: Geriatric Depression Scale, Blessed: Short Blessed test

Materials

AX-CPT

In the AX-CPT task (Braver et al., 2001; 2005; Paxton et al., 2006) participants were presented with 100 cue-probe pairs to which they responded by pushing the target button when an X probe appears after an A cue. Participants were instructed to push the nontarget button for all other letters (e.g., all cues and probes that are not Xs that follow an A). The nontarget cue and probe letters were all other letters of the alphabet except K and Y, which were excluded because of their visual similarity to X. Target trials (AX) occurred 70% of the time, and the three nontarget trial types (AY, BX, and BY) each appeared 10% of the time. The standard version of the AX-CPT with the long delay was used; participants viewed a cue letter for 750 ms followed by an unfilled delay of 5,000 ms and then saw the probe letter for 750 ms. The intertrial interval was 1,000 ms for all 100 trials. The cue and probe were presented in white letters on a black screen in bold size 48 Helvetica font. The response buttons were referred to as *red* for the target button and *yellow* for the nontarget button, which corresponded to their color. The dependent variables of interest were median RTs and proportion of errors on AY and BX trials. The proportion of errors was calculated based on the total number of trials completed (of the 10 total trials) for each of the AY and BX trial types.

Letter-Number Task Switching

A letter-number task-switching task was used wherein participants were presented with a cue (i.e., either a letter or number). This cue indicated whether the letter should be classified as a consonant or a vowel or whether the number should be classified as odd or even when a letter-number pair appeared. The cue appeared for 1,000 ms followed by a

5,000 ms delay and then the letter-number pair for 3,000 ms. The intertrial interval was 1,000 ms. The cue was presented in white letters on a black screen with size 36 Times New Roman font. The letter-number pair was presented in white on a black screen with size 38 Times New Roman font. Participants were instructed to push the red button if a target appeared and the yellow button if a nontarget appeared. Furthermore, a paper reminding participants of the conditions that warrant a target response (e.g., consonant and even) was in view when the instructions were given and while the participant completed the task. There were four possible response combinations for target responses (consonant and even, consonant and odd, vowel and even, vowel and odd) that were randomly assigned to participants.

This task included two pure blocks (one of letters and one of numbers) of 24 trials each wherein the judgment to be made was the same for all trials in the entire block. Thus, in these pure blocks the cue could be ignored. Two mixed blocks of 24 trials each were also included wherein the judgment to be made varied from trial to trial based on the cue. The order of administration of the four blocks was randomly assigned. The dependent measures were the average of the median RTs and proportion of errors on each of the pure blocks as well as median RTs and proportion of errors on each of two categories of trials in the mixed blocks, averaged across the two mixed blocks. One category of trials in the mixed blocks included trials that required the same response as on the previous trial; these are called *task-repeat* trials. The other category included trials for which the response was different from that required on the previous one; these are called *task-switch* trials. Mixing costs were defined as RTs and accuracy for task-repeat trials within the mixed blocks compared with trials in the pure-task block. Switching costs were defined as RTs and errors for task-switch trials within the mixed block compared with task-repeat trials within the mixed blocks.

Modified Sternberg

A modified Sternberg task was used wherein participants studied a four-word memory set followed by a delay period and then one probe word. They were instructed to determine whether the probe word was one of the four words. Target responses entailed pushing the red button and nontarget responses entailed pushing the yellow button. The word set appeared for 3,000 ms followed by a delay of 5,000 ms and the probe word for 1,000 ms. Participants had 1,500 ms to respond with a 1,000 ms intertrial interval. The words were presented in black on a white screen in lowercase size 18 Chicago font. Fifty percent of the trials consisted of positive probes, which were words that were in the current trial memory set presented immediately before the delay. In order to increase difficulty of the task by making invalid probes more familiar and difficult to inhibit, 80% of the negative probes (i.e., words that were not part of the current trial memory set) were recent (i.e., in the word set just prior to the current set). Only 20% of the positive probes (i.e., words in the current memory set presented immediately before the delay) were recent (i.e., in the word set just prior to the current set). Additionally, on every trial, two of the four words presented in the memory set were the same as those presented in the previous trial.

The 480 stimulus words were one syllable nouns ranging in length from four to six letters and ranging in word frequency from 8 to 12 (M = 9.34, SD = 0.98) from the English Lexicon Project (http://elexicon.wustl.edu/). Words used in the Prospective memory/N-back task described later were excluded. Words were randomly assigned to four different word lists constructed for counterbalancing purposes. Two word lists were used to produce two blocks of 60 trials each and were randomly assigned to participants for use at either pretest or posttest. Each participant completed the task with different words list at pretest or posttest. The other two words lists were each divided into six 5-trial blocks and two 15-trial blocks, which were randomly ordered and assigned to participants in the training condition. Each participant in the training condition completed training with one word list at Session 2 and another word list at Session 3. The determination of positive, negative, novel (i.e., not presented in the word set just prior to the current set) and recent trials was randomized. Then a randomly ordered list of words was used to assign words in slots designated for positive, negative, novel, and recent words.

The modified Sternberg task assessed the ability to inhibit answers based on familiarity. Therefore, the dependent variables were the errors and median RT on the recent negative trials where the correct response is a nontarget response but the tendency to make a target response required inhibition abilities because of familiarity. These recent negative error and RT scores were compared with the median RT on novel negative trials, which required a nontarget response to an unfamiliar word. RTs were computed for correct trials only.

Dot-CPT

A variant of the AX-CPT task, the 100-trial Dot-CPT (MacDonald et al., 2005), involves dot patterns that represent the Braille letters excluding *b, k, v, w*, and *x*. Participants were instructed to make a target response when a Braille *h* immediately follows a Braille *l*. This task used the same frequency of target and nontarget trial types as in the AX-CPT task.

Consistent with the AX-CPT task, the long delay condition was used. Participants viewed a cue letter for 750 ms followed by an unfilled delay of 5,000 ms; then they saw the probe letter for 750 ms. The intertrial interval was 1,000 ms. Participants were instructed to respond with the red button for target responses and the yellow button for nontarget responses. The Braille patterns were presented in white on a black screen in bold size 48 Helvetica font. The Dot-CPT has convergent validity with the letter AX-CPT task (MacDonald et al., 2005). Therefore, median RTs and proportion of errors from the trials from the Dot-CPT task analogous to the AY and BX trials on the AX-CPT were used as dependent variables. That is, trials wherein any Braille letter other than *h* following a Braille *l* were comparable to AY trials on the AX-CPT, and trials where the Braille letter *h* followed any other letter than a Braille *l* were comparable to BX trials on the AX-CPT.

Prospective Memory/N-back

A combined working memory and prospective memory task was performed. The WM task was a version of an N-back task in which participants match the current word with the word presented N trials previously. Two separate conditions were performed, which manipulate working memory load. In the 1-back condition, participants specified whether the word matches the one immediately before it. In the 2-back condition, participants specified whether the word matches the one presented two trials before. Participants were instructed to press the red button for a target response and the yellow button for a nontarget response.

A third condition, called the 1-PM-back condition, assessed prospective memory by requiring that participants monitor for events requiring completion of a prospective goal within the context of performing the 1-back task. The prospective task required that one make a distinct response (i.e., press the green button) to any word appearing in a specified ink color (indicated at the beginning of each block with an example of the specified color). These trials were termed prospective memory (PM) trials. On trials in which the prospective memory cue did not appear, participants performed the 1-back task identically to the 1-back condition described in the previous paragraph. That is, they pressed the red button if the word is the same as in the previous trial and the yellow button if it is not. If, however, the word appears in the specified color, they pressed the green button instead. Word stimuli in all three task conditions varied randomly in ink color (white, aqua, blue, purple) across trials, but this feature was only be relevant in the prospective memory condition

Before performing the PM/N-back task, each participant viewed each of the colors used in this task (white, aqua, blue, purple) and then were asked to verbally identify the colors on the computer screen to ensure that he or she can discriminate between color. Each participant performed 72 trials each of the 1-back, 2-back, and 1-PM-back conditions. Five participants assigned to each intervention condition were randomly assigned to one of six possible orderings of the three conditions (1-back, 2-back, 1-PM-back). The same order was used in Sessions 1 and 4.

Each of the three conditions contained 22 targets, split evenly between the first and second halves of the trials. In the PM condition, there were four PM trials, which were always nontarget trials, again split evenly between the first and second halves of the trials. Each word appeared for 2,500 ms followed by an intertrial interval with fixation in the center of the screen for 1,000 msec. The words were presented in white, aqua, blue, or purple on a black screen in size 48 Geneva font.

There were three word lists for use in the 2-back condition. Five of the 30 participants in each intervention condition were randomly assigned to one of the six possible ordered combinations of 2-back word lists for Sessions 1 and 2. There were four word lists for use in the 1-back and 1-PM-back conditions. One participant in each group was randomly assigned to one of the 24 possible ordered combinations designating the order that each list was assigned for the two tasks (1-back and 1-PM-back) in Sessions 1 and 4. Six of the possible ordered combinations of word lists were chosen at random for the remaining participants in each of the three groups.

The PM/ N-back task assessed working memory and prospective memory abilities. The hit score (i.e., proportion of correct target responses) and false alarm scores (i.e., proportion of incorrect target responses to nontarget stimuli) for each condition (1-back, 2-back, 1-PM-back) were converted to the z scores in a normal distribution. Then, d' was calculated as the z score for hits minus the z score for false alarms. In the 1-PM-back condition, d' scores were derived for the target trials and percentage of errors were used as a dependent measure for the prospective memory trials. The error scores for PM trials were reported as proportion of errors. Adjustments were applied when the hit rate is 100% ($2^{-1/n}$), or the false alarm rate is 0% ($1-2^{-1/n}$) where n represents the number of possible hits or false alarms. This d' measure allows for consideration of different patterns of responding on target and nontarget trials instead of simply examining target trials.

Working memory abilities were evaluated by comparing the 1-back and 2-back conditions as it is expected that the 2- back condition places more demands on working memory ability. Prospective memory ability was assessed by comparing the 1-back task with the 1-PM-back task as both these tasks have identical working memory demands, but the 1-PM-back also assessed prospective memory.

Dysexecutive Questionnaire.

Participants were given standard instructions and completed a computerized version of the self-rating Dysexecutive Questionnaire (DEX; Burgess, Alderman, Evans, Emslie, & Wilson, 1998). This scale consists of 20 statements about executive control that are rated on a 5-point scale with scale labels 0 (never), 1 (occasionally), 2 (sometimes), 3 (fairly often), and 4 (very often). Responses from each item were summed so that scores can range from 0 to 80 with a high scoring indicating frequent difficulty.

Assessment of reliability of DEX scores has not been reported (Malloy & Grace, 2005). Factor analytic methods have been used to investigate validity of the DEX as a measure of executive ability. When examining a neurological population, three out of five derived factors correlated well with measures of executive ability (Burgess et al., 1998). A subsequent study identified five factors in neurologically healthy population but did not find that the DEX scores correlated with scores on tests assessing executive abilities (Chan, 2001). Five factors were derived for a sample of older adults ($N = 20$), and these factor scores demonstrated correlations with executive abilities. For instance, a factor representing inhibition abilities correlated with errors on the Stroop ($r = -.51$, $p = 0.02$) and the score on a single trial of a verbal recall test ($r = -.61$, $p = .004$; Amieva, Phillips, & Della Sala, 2003). As previous studies have suggested that DEX performance is best represented with multiple factors, it is important to determine valid factors to use in the current study. Previous studies deriving factor scores have either used neurological populations (Burgess et al., 1998; Chan, 2001) or a small sample size (Amieva, Phillips, & Della Sala, 2003), and therefore, the DEX scores from the proposed were factor analyzed to derive factors. As discussed in the results section, the factor analysis was inconclusive and therefore the sum of all 20 items was used as a dependent variable as recommended by a recent study (Gerstorf, Siedlecki, Tucker-Drob, & Salthouse, 2008).

Procedure

The study involved four sessions lasting about 1.5 to 2 hours each for all participants. Session 2 usually occurred within a week of Session 1. Session 3 usually occurred within two weeks of Session 2. Session 4 usually occurred within a week of Session 3.

Session 1 (Pretest)

All participants performed the same six tasks in Session 1 (pretest) and Session 4 (posttest). After obtaining informed consent, all participants received standard instructions and completed the following tasks: AX-CPT, Dot-CPT, letter-number task switching, modified Sternberg, PM/ N-back, and DEX. Participants were randomly assigned to one of the seven hundred twenty possible orderings of these six tasks. Accuracy and RTs were measured. They completed each of the first five tasks by responding with button presses on a button box. They responded with numbers on a keyboard for the DEX questionnaire.

All participants underwent the same protocol for pretest and posttest. The instructions for the AX-CPT were given while visible examples of the trial types and responses were presented. Participants practiced with AX-CPT trials until it was apparent to the experimenter that he or she understood the directions. Then participants completed one block of 100 trials. On the Dot-CPT, participants were given instructions while a paper with the trial types and responses was shown. Then participants practiced with the Dot-CPT, which was followed by one 100 trial block.

On the task switching measure, participants observed a paper with example number or letter cues and example number/letter pairs while the examiner explained the basic instructions for the task. Then, participants were instructed to complete a pure number task and the correct response combinations (e.g., even = red) were shown on a paper. The participant practiced a pure number task until he or she demonstrated an understanding of the directions. Then the pure letter task was described with a similar stimulus sheet followed by practice until the participant appeared to understand the task. Then the instructions for the mixed task were described followed by practice until the participant demonstrated an understanding. After practicing enough to demonstrate comprehension of instructions, participants completed (a) one 24-trial pure block of number, (b) two 24-trial mixed blocks, and c) one 24-trial pure block of letter task in random order.

The instructions for the modified Sternberg measure were presented with a paper available outlining the structure of the task. Participants practiced until comprehension of instructions was demonstrated. Then participants completed one 60-trial block of the modified Sternberg task after completing a series of practice trials demonstrating understanding of the directions.

On the PM/N-back, participants were presented with a visual example of the 1-back task while the experimenter provided instructions. The participants practiced the 1-back task until an understanding of the directions was demonstrated. Then a paper with a visual example of the 2-back task was presented while the participant was instructed about the 2-back task. The participants then practiced the 2-back task until it was apparent that he or she understood the directions. Next the instructions for the 1-PM-back were given with a visual example provided and then the participants practiced until it was clear that the directions were understood. During pretest and posttest sessions, one block of 72 trials for the 1-back, 2-back, and 1-PM-back tasks were completed.

Sessions 2 and 3

Multi Task Training Condition. Participants were instructed that they would be learning strategies that were thought to assist in their ability to perform many tasks. Then, participants were told that performance may be improved on tasks presented in the first session by learning to identify initial information presented (often in the form of a cue), determine how it influences the goal of the task, and keep this goal in mind by verbally or silently rehearsing it over a delay.

Participants were reminded of standard instructions for the AX-CPT task and allowed to practice until it was apparent to the examiner that they understand the task. Then, participants were explicitly told that 70% of the trials in the task were an A cue followed by an X probe and would require a red response. They were also told that the investigators were interested in whether people perform differently if given instructions about strategies to use in the task. Then they were told to first pay attention to the cue letter and decide if it was an A or not. If it was an A, they were encouraged to prepare to see an X and push the red button. If the letter was not A, they were encouraged to prepare to push the yellow button regardless of what letter appeared as the probe. They were trained to verbally categorize (i.e., say A or not A) and attend to the cue at the time that it appeared in three blocks of 10 training trials. The experimenter verbally categorized the cue letters on the first of these three blocks; the participant categorized the cues on the second block while the experimenter completed the task; then the participant categorized the cues while completing the task on the third block.

Then participants were trained to use the cue to influence how they prepare for the probe. They were reminded that when the cue was an A it was very likely that an X will follow; therefore, they should begin to prepare for a red response. Participants were told to say "if X, red" when they see an A as the cue and "yellow" when they see a cue that was not an A. The experimenter said these phrases for 10 trials while the person completed the task; then the participant said the phrases while the experimenter completed the task for 10 trials. Finally, the participant completed one 10-trial block followed by one 30-trial block saying these phrases aloud while completing the task. If the participant did not say the phrase out loud on a trial, the examiner did. Then participants completed one 30-trial block where they said the phrases silently while completing the task.

Next, participants were reminded of the standard instructions for the task switching test and practiced separately with each of the pure letter and number conditions as well as the mixed condition until it was apparent to the examiner that the participant understood the task. Then, participants were reminded that on the previous task (AX-CPT), they learned to identify information presented in the cue, determined how it corresponds to a goal for the task, and kept this goal in mind by verbally or silently rehearsing it over a delay. They were told that they would learn to apply the same approach to the current task.

Strategy training on the task-switching task involved learning to apply the strategy separately for the pure number task, pure letter task, and mixed task. They were instructed to approach the task by first identifying the goal stated by the cue (i.e., number or letter) and then to allow the identity of the cue to influence how they approach the stimuli (i.e., if odd, then red). They were trained to verbally categorize (i.e., say letter or number) and attend to the cue at the time that it appeared in three blocks of three training trials. The experimenter verbally categorized the cue words on the first of these three blocks; the participant categorized the cues on the second block while the experimenter completed the task; then the participant categorized the cues while completing the task on the third block.

Then participants were trained to use the cue to influence how they prepared for the letter/number pair that followed. They were reminded that when the cue was the word *letter*, they should prepare to determine if the letter that appeared is a consonant, and therefore, they prepared by saying "if consonant, then red." If the cue was the word *number*, they were instructed to prepare to determine whether the number was even, and say "if even, then red." The experimenter said these phrases for three trials while the person completed the task; then the participant said the phrases while the experimenter completed the task for three trials. Finally, the participant completed one 3-trial block followed by one 9-trial block saying these phrases aloud while completing the task. If the participant did not say the phrase out loud on a trial, the examiner would. Then participants completed one 9-trial block where they say the phrases silently while completing the task.

Next, participants were reminded of the standard instructions for the modified Sternberg task and allowed to practice with the task until it is apparent to the examiner that they understood the task. Then, participants were reminded that on the previous tasks they learned to identify information presented in the cue, determined how it corresponds to a goal for the task, and kept this goal in mind by verbally or silently rehearsing it over a delay. They were told that they would learn to apply the same approach to the current task. Specifically, participants were instructed to approach the task by first identifying the stimuli presented (i.e., word 1, word 2, word 3, word 4) and then allowing the words to influence how they approach the probe (i.e., if word 1, word 2, word 3, or word 4, then press red). They were trained to verbally rehearse (i.e., say word 1, word 2, word 3 word 4) and attend to the word set at the time that it appeared in three blocks of three training trials. The experimenter verbally recited the words presented on the first of these three blocks; the participant verbally recited the words on the second block while the experimenter completed the task; then the participant verbally recited the words while completing the task on the third block.

Then participants were trained to recite the word set in order to prepare to respond to the single word that follows. They were instructed to say "If word 1, word 2, word 3, word 4, then red" to prepare to respond with a target response if the single word is one of those in the memory set. The experimenter recited the four words in this phrase for five trials while the person completes the task; then the participant said the phrases while the experimenter completed the task for five trials. Finally, the participant completed one 5-trial block followed by one 15-trial block saying these phrases aloud while completing the task. If the participant did not say the phrase out loud on a trial, the examiner did. Then participants completed one 15-trial block where they said the phrases silently while completing the task.

Single Task Training Condition

Participants were instructed that they were learning strategies that are thought to assist in their ability to perform one of the tasks they completed in Session 1. Participants were reminded of standard instructions for the AX-CPT task and allowed to practice until it was apparent to the examiner that they understood the task. Then, participants were explicitly told that 70% of the trials in the task were an A cue followed by an X probe and would require a red response. They were also told that the investigators were interested in whether people perform differently if given instructions about strategies to use in the task. Then they were told to first pay attention to the cue letter and decide if it was an A or not. If it was an A, they were encouraged to prepare to see an X and push the red button. If the letter was not A, they were encouraged to prepare to push the yellow button regardless of what letter appeared as the probe. They were trained to verbally categorize (i.e., say A or not A) and attend to the cue at the time that it appeared in three blocks of 10 training trials. The experimenter verbally categorized the cue letters on the first of these three blocks; the participant categorized the cues on the second block while the experimenter completed the task; then the participant categorized the cues while completing the task on the third block.

Then participants were trained to use the cue to influence how they prepared for the probe. They were reminded that when the cue was an A it was very likely that an X would follow; therefore, they should begin to prepare for a red response. Participants were told to say "if X, red" when they saw an A cue and "yellow" when they saw a cue that was not an A. The experimenter said these phrases for 10 trials while the participant completed the task; then the participant said the phrases while the experimenter completed the task for 10 trials. Finally, the participant completed one 10-trial block followed by one 30-trial block saying these phrases aloud while completing the task. If the participant did not say the phrase out loud on a trial, the examiner did. Then participants completed one 30-trial block where they said the phrases silently while completing the task. This procedure was repeated three times in both Session 2 and 3.

Multi task Practice Condition.

Participants were reminded of standard instructions for the AX-CPT task and allowed to practice with the task until it was apparent to the examiner that he or she understood the task. Then, participants completed one block of 100 trials. Participants were then reminded of the standard instructions for the task switching test and were allowed to practice until it was apparent to the examiner that he or she understood the task. Then, participants completed one 24 trial block of the letter task, one 24 trial block of the number task, and two 24 trial blocks of the mixed task in the same order as Session 1. Then, participants were reminded of the standard instructions for the modified Sternberg task and were allowed to practice until it was apparent to the examiner that he or she understood the task. Participants then completed one 60 trial block.

Single Task Practice Condition.

Participants were reminded of standard instructions for the AX-CPT task and allowed to practice with the task until it was apparent to the examiner that he or she understood the task. Then, participants completed three blocks of 100 trials each.

Statistical Analyses

Median reaction time (RT) scores and proportion of errors were derived for all dependent measures. Even though there are many potential dependent variables in each task, the analyses focused only on those that are thought to be the strongest indices of different aspects of executive control targeted by the interventions. The dependent variables are listed in Table 2. The variables bolded in Table 2 were used in primary analyses.

AX-CPT and Dot-CPT. In the primary analyses evaluating the AX-CPT and Dot-CPT, a composite measure of the strength of *proactive context processing* was used. This measure combines the two trial types (AY, BX) that have been found to be the most salient measures of different aspects of context processing ability in previous studies (Braver et al., 2005; Paxton et al., 2006). Specifically, the context processing index is computed as: (AY-BX)/(AY+BX) wherein a higher score indicates more proactive performance. Separate index values were computed for errors and RT. For errors, a correction factor was used in the case of zero errors in one or more trial types: (0.5)/(frequency of trials +1). The *proactive context processing index* was used for simplicity of analyses and to examine the degree to which AY and BX scores changed in divergent directions from pretest to posttest. Results based on analyses that separated AY and BX errors and RTs will be reviewed at the end of the Hypothesis 2 section for the

AX-CPT and Hypothesis 4 for the Dot-CPT. The differences in results and conclusions when the proactive index scores were analyzed instead of the raw AY and BX error and RT scores will be described in the Hypothesis 2 and 4 results description and summary.

Task Switching. In the primary analyses for the task switching measure, switching and mixing cost index scores were used in order to assess the cost on performance of conditions with more executive demands compared with conditions that were less demanding. Mixing cost was calculated separately for errors and RTs as: (task-repeat trials from mixed blocks – all trials in pure blocks). Switching cost was calculated separately for errors and RTs as: (task-switch trials from mixed block – task-repeat trials from mixed block). Results did not differ in a conclusive manner when individual pure trial, mixed repeat trial, and mixed switch trial scores were used as dependent variables in analyses.

Modified Sternberg. In the primary analyses for the modified Sternberg, a recency interference index was used to measure the cost on performance due to the more challenging recent negative trials compared with the easier novel negative trials. The recency interference index was computed separately for errors and RTs as: (recent negative trials – novel negative trials). Results did not differ in a conclusive manner when recent negative and novel negative trial scores were used as dependent variables in analyses.

PM/N-back. The PM/N-back test involved three tasks or conditions: the working memory (WM) 1-back condition, the WM 2-back condition, and the prospective memory (PM) 1-PM-back condition. In the sections that follow the conditions were presented individually to ensure that it is clear to the reader which condition is being discussed.

There are many potential dependent variables for the PM/N-back test, but the cost scores chosen and used in most analyses were thought to be the strongest indices of working memory and prospective memory abilities. Conclusions did not differ significantly when analyses were conducted with d' and RT raw scores.

PM/N-back Accuracy Scores. Accuracy performance on the PM/N-back was investigated using d' scores evaluating hits versus false alarms for the 1-back, 2-back, and 1-PM-back tasks. Prospective memory cue errors on the 1-PM-back task were also evaluated because this error score was not included in the d' calculation. Three cost index scores were used in as dependent variables for errors. First, the working memory d' cost index, (WM d' Cost: 1-back d' – 2-back d'), evaluated the cost or effect on accuracy of the added working memory demands of difficult 2-back task compared with the 1-back task. Because higher d' scores indicate better performance, the WM cost score was calculated with 2-back performance subtracted from 1-back performance in order to provide an index where a higher score is indicative of a greater WM cost and would be consistent with the direction of RT measures. Additionally, the prospective memory d' cost index (PM d' Cost: 1-back d' – 1-PM-back d'), measures the cost of the more challenging PM demands on performance and, similar to the WM d' score, was scaled so that a higher score is indicative of a greater PM cost. Lastly, the PM cue trials within the 1-PM-back condition (PM error cost: PM cue errors – 1-back matched low-frequency nontarget errors) measured the cost of detecting PM cues during the PM task compared with matched low-frequency trials occurring during the 1-back task. For clarification, the 1-back trials that were used as a comparison for calculating the PM cost scores were 1-back nontarget trials that occurred with the same frequency as the PM trials in the 1-PM-back condition.

PM/N-back RT Scores. In evaluating RT performance, both target and nontarget trials were considered separately and therefore, 5 cost indices were calculated and used in analyses. First, the WM Target RT cost index (2-back Target RT – 1-back Target RT) evaluated the cost of the more WM demanding 2-back condition compared with the 1-back condition on target RT trials. Similarly, the WM nontarget RT cost index, (2-back nontarget RT – 1-back nontarget RT), evaluated the same WM demands on nontarget trials. The PM target RT cost index (1-PM-back target RT – 1-back target RT) evaluated the cost on performance of the PM demands on the 1-PM-back compared with the 1-back that does not entail a PM component. Thus, the PM nontarget RT cost (1-PM-back nontarget RT – 1-back nontarget RT) evaluated PM cost on nontarget trials. Finally, the PM cue RT cost index (1-PM-back PM Cue RT – 1-back PM Cue RT) evaluated the added difficulty of PM trials within the PM condition compared with 1-back trials that matched the PM trials within the PM task in frequency. A higher score on all RT index scores is indicative of a greater RT cost.

To evaluate hypotheses 2 – 6, performance was examined on the AX-CPT, Task Switching, Modified Sternberg, Dot-CPT, PM/N-back, and DEX with separate mixed model ANOVAs for errors and RTs. Most analyses were conducted with one within-subject factor, session (pretest vs. posttest), and two factorial between-subjects factors: training condition (training vs. practice) and exposure condition (single task versus multi task).

Table 2

Test Scores used as Dependent Variables

Task	Dependent Variables		
	Errors	Reaction Time	Composite Scores
AX-CPT	AY Errors	AY RTs	
	BX Errors	BX RTs	
	Proactive error index	**Proactive RT index**	Proactive sum
Dot AX-CPT	AY Errors	AY RTs	
	BX Errors	BX RTs	
	Proactive error index	**Proactive RT index**	Proactive sum
Task Switching	**Mixing Error Cost**	**Mixing RT Cost**	
	Switching Error Cost	**Switching RT Cost**	
	Pure block Errors	Pure block RTs	
	Mixed block: Repeat Errors	Mixed block: Repeat RTs	
	Mixed block: Switch Errors	Mixed block: Switch RTs	
Modified Sternberg	**Recency Error Interference**	**Recency RT Interference**	
	Recent Negative Errors	Recent Negative RTs	
	Novel Negative Errors	Novel Negative RTs	
PM/N-back	**WM D' Error Cost**	**WM Target RT Cost**	
	PM D' Error Cost	**WM Nontarget RT Cost**	
	PM Cue Error Cost	**PM Target RT Cost**	
	1-back D'	**PM Nontarget RT cost**	
	2-back D'	**PM Cue RT Cost**	
	1-PM-back D'	1-back Target RT	
	1-PM-back PM Errors	1-back Nontarget RT	
		2-back Target RT	
		2-back Nontarget RT	
		1-PM-back Target RT	
		1-PM-back Nontarget RT	
		1-PM-back PM RT	
DEX	**DEX Total Score**		

Note. Bolded tasks were used as dependent variables in primary analyses.

CHAPTER FIVE: RESULTS

Hypothesis 1: Pretest Performance

Hypothesis 1 focuses on task performance during the pretest session only. In line with the aim to evaluate the effects of interventions on performance from pretest to posttest, an important issue is whether participants in each of the between-subjects intervention groups differed significantly in performance at pretest. The analysis of group effects at pretest served two purposes: 1) to determine whether there are group differences at pretest that might confound interpretation of differences between training and exposure conditions at posttest; and 2) to determine whether the pretest data from the four groups can be combined to test hypotheses about the interrelationships among performance on the different tasks.

Separate ANOVAs were conducted with pretest scores for each dependent variable listed in Table 2 with training condition (training vs. practice) and exposure condition (multi task vs. single task) as between-subjects variables. Two significant differences were uncovered at pretest. First, the proactive RT index score on the AX-CPT task, $F\ (1, 84) = 3.83$, $p = .05$, partial $\square^2 = .04$, showed higher scores in the multi task conditions than the single task conditions. Second, Dot-CPT AY RT in the multi task conditions was significantly greater than the single task conditions, $F\ (1, 84) = 5.80$, $p < .05$, partial $\square^2 = .07$

Hypothesis 1. It was hypothesized that, at pretest, performance on the five executive control tasks would correlate positively with one another in all participants. It was predicted that the task identified to measure near transfer, the Dot-CPT, would show *stronger correlations with the letter AX-CPT than other tasks, including the far transfer task, the PM/N-back. Also, scores on the DEX indicating self-reported executive problems were predicted to correlate negatively with performance on executive control tasks at pretest.*

Given the large number of tasks used in this study, and because of our primary focus on the AX-CPT, examination of the relationship between dependent variables focused on comparing the relationship between the AX-CPT with each of the other tasks. These relationships were examined with Pearson product-moment correlations. Only the correlations that were found to be statistically significant are described in the text.

Relationship between AX-CPT and Dot-CPT. First, the relationship between scores on the AX-CPT and Dot-CPT were compared to confirm that the Dot-CPT represents a near transfer task that assesses similar abilities. The relationships that were theoretically predicted to be most important are bolded in Tables 3a and 3b, but all correlations between AX-CPT and Dot-CPT variables are shown for completeness. As shown in Table 3a shows that, although there was no significant relationship uncovered between AX-CPT AY errors and Dot-CPT AY errors, AX-CPT BX errors showed a positive and significant relationship with Dot-CPT BX errors and AX-CPT proactive error index showed a positive and significant relationship with Dot-CPT proactive error index. Likewise, Table 3b shows that AX-CPT AY RTs showed a positive significant relationship with Dot-CPT AY RTS, AX-CPT BX RTs showed a positive significant relationship with Dot-CPT BX RTs, and AX-CPT proactive RT index showed a positive significant relationship with Dot-CPT proactive RT index. In summary, the AX-CPT and Dot-CPT measures show a significant relationship in the direction indicating that more proactive performance on one task relates to more proactive performance on the other task.

Table 3a
Correlations between AX-CPT Scores and Dot AX-CPT Scores for All Participants at Pretest

	AY Errors	BX Errors	Proactive Error Index
Dot AY Errors	**.13**	.05	.00
Dot BX Errors	.04	**.39*** **	-.27*
Dot Proactive Error Index	.09	-.26*	**.24***

Note. Greater AY errors, fewer BX errors, greater proactive error index scores are indicative of more proactive patterns of performance. *p < .05, **p < .01,***p < .001

Table 3b
Correlations between AX-CPT Scores and Dot AX-CPT Scores for All Participants at Pretest

	AY RT	BX RT	Proactive RT Index
Dot AY RT	**.65*** **	.17	.10
Dot BX RT	.19	**.41*** **	-.41***
Dot Proactive RT Index	.13	-.34**	**.47*** **

Note. Greater AY RTs, lower BX RTs, and greater proactive RT index scores are indicative of more proactive patterns of performance. *p < .05, **p < .01, ***p < .001

Relationship between AX-CPT and PM/N-back. Next, the relationship between scores on the AX-CPT and PM/N-back were examined to confirm that the PM/N-back task represents a far transfer test that assesses similar abilities. As shown in Table 3c, AX-CPT AY errors showed a significant positive relationship with WM d' cost on the N-back. As discussed earlier, the d' cost index scores were scaled so that a higher score indicates less accurate performance on the more difficult PM/N-back condition. Thus, this correlation between AY errors and WM d' cost index scores suggested that more proactive AX-CPT performance (indicated through increased AY errors) is related to stronger cost of WM load on performance (i.e., a larger decrement in performance on 2-back vs. 1-back). This relationship is difficult to interpret given the theoretical assumption that proactive performance on AY trials involves working memory in order to maintain the identity of the A cue over the delay. Thus, the correlation between the WM d' cost index and AY errors might reflect WM abilities under low-load conditions (since AY trials also reflect a fairly low WM load). There were no other significant correlations between accuracy on the AX-CPT and PM/N-back tasks. It is especially important to note that there were no significant correlations between PM/N-back errors and the proactive error index for the AX-CPT, suggesting that more proactive error performance on the AX-CPT was not related to error performance on the PM/N-back tasks.

For RTs, Table 3d shows that AX-CPT AY RTs showed a significant positive relationship with the PM RT cost (on nontarget trials), suggesting that increased AY RTs, indicating more proactive performance, corresponded to greater effects of the PM load on on-going performance. Such effects might reflect expectancy or monitoring demands, because in both the PM task and AY trials, participants maintain expectancies about upcoming events based on goals or context (upcoming PM cues in the PM task, upcoming target probes on AY trials). Also there was a significant negative relationship between BX RTs and WM nontarget RT cost, suggesting that those showing reactive performance through increased BX RTs are not as likely to show an increase in RTs on nontarget trials when WM demands are increased. Finally, the AX-CPT proactive RT index showed a significant positive correlation with WM nontarget RT cost. Thus, more proactive AX-CPT RT performance is related to a greater increase in nontarget RT scores when WM demands are increased. There was only one significant correlation between the AX-CPT proactive RT score and WM N-back or PM task RT measures, suggesting that proactive control in the AX-CPT, as measured with RT, is only weakly related to performance under high WM and PM conditions.

Table 3c
Correlations between AX-CPT Scores and PM/N-back Scores for All Participants at Pretest

	AY Errors	BX Errors	Proactive Error Index
WM D' Cost	.24 **	.00	.13
PM D' Cost	-.17	-.02	.10
PM Cue Error Cost	-.04	.05	-.10

Note. Greater AY errors, fewer BX errors, greater proactive error index scores are indicative of more proactive patterns of performance. *p = .05, **p < .05, ***p < .01, ****p < .001

Table 3d
Correlations between AX-CPT Scores and PM/N-back Scores for All Participants at Pretest

	AY RT	BX RT	Proactive RT Index
WM Target RT Cost	.03	-.02	.03
WM Nontarget RT Cost	-.01	-.26 **	.25 **
PM Target RT Cost	-.08	.01	-.03
PM Nontarget RT Cost	.25**	-.07	.16
PM RT Cost	-.07	-.05	.00

Note. Greater AY RTs, lower BX RTs, and greater proactive RT index scores are indicative of more proactive patterns of performance. *p = .05, **p < .05, ***p < .01, ****p < .001

Relationship between AX-CPT and Task Switching. As shown in Table 3e, examination of correlations between the AX-CPT and task switching error scores demonstrated that there were no significant correlations.

As shown in Table 3f, the AX-CPT BX RT scores showed a significantly positive correlation with switch cost RTs, suggesting that participants showing the slowest BX RTs also had the largest switch costs. This might reflect a common form of interference effect. However, there were no significant correlations between AX-CPT proactive RT index scores and switching or mixing costs, weakening the inference that switch costs are directly related to proactive control during the AX-CPT.

Table 3e
Correlations between AX-CPT Scores and Task Switching Scores for All Participants at Pretest

	AY Errors	BX Errors	Proactive Error Index
Mixing Cost Errors	-.19	-.04	.15
Switching Cost Errors	-.08	.12	.04

Note. Greater AY errors, fewer BX errors, greater proactive error index scores are indicative of more proactive patterns of performance. *p = .05, **p < .05, ***p < .01, ****p < .001

Table 3f

Correlations between AX-CPT Scores and Task Switching Scores for all Participants at Pretest

	AY RT	BX RT	Proactive RT Index
Mixing Cost RT	.04	-.09	.12
Switch Cost RT	.08	.23**	-.19

Note. Greater AY RTs, lower BX RTs, and greater proactive RT index scores are indicative of more proactive patterns of performance. *p = .05, **p < .05, ***p < .01, ****p < .001

Relationship between AX-CPT and Modified Sternberg. As shown in Table 3g, significant positive correlations were uncovered between the AX-CPT AY and BX error scores and the modified Sternberg recency error interference cost scores. These significant correlations suggest that increased errors on both AY and BX trials of the AX-CPT, are related to increased recency interference-related errors on the Sternberg task. However, there was no correlation between the Sternberg interference-error cost measure and the proactive control error index in the AX-CPT. The absence of this predicted correlation makes it harder to argue for a common relationship between WM interference in the Sternberg and proactive control in the AX-CPT.

As shown in Table 3h, the modified Sternberg recency RT interference scores showed a significant negative correlation with AX-CPT BX RT, suggesting that individuals showing slower BX responses also tended to show more WM interference on the Sternberg task. However, this effect was complicated by a significant positive correlation between the AX-CPT proactive RT index and the Sternberg recency RT interference measure, suggesting that individuals showing more recency RT interference on the Sternberg task also tended to show a more proactive RT pattern in the AX-CPT.

Table 3g
Correlations between AX-CPT Scores and Modified Sternberg Scores for All Participants at Pretest

	AY Errors	BX Errors	Proactive Error Index
Recency Interference Error Cost	.31***	.31***	.04

Note. Greater AY errors, fewer BX errors, greater proactive error index scores are indicative of more proactive patterns of performance. *p = .05, **p < .05, ***p < .01, ****p < .001

Table 3h
Correlations between AX-CPT Scores and Modified Sternberg Scores for All Participants at Pretest

	AY RT	BX RT	Proactive RT Index
Recency Interference RT Cost	-.02	-.24**	.26**

Note. *Note*. Greater AY RTs, lower BX RTs, and greater proactive RT index scores are indicative of more proactive patterns of performance. *p = .05, **p < .05, ***p < .01, ****p < .001

Relationship between Dysexecutive Questionnaire (DEX) and performance on executive control tasks. It was hypothesized that scores on the DEX indicating executive complaints would correlate negatively with performance on executive control tasks at pretest. Therefore, all correlations between the DEX total score and all dependent variables listed in Table 2 were examined. However, only one significant correlation was uncovered between the DEX total score and the 1-back nontarget RT measure [$r = .25$, $p < .05$]. Thus, the lack of significant correlations suggest that this self-report measure of executive problems does not correlate with cognitive performance on the executive control tasks used in this study.

Comparison of correlations between AX-CPT and Dot-CPT and AX-CPT and PM/N-back. Hypothesis 1 also predicted that the relationship between AX-CPT and Dot AX-CPT variables would be significantly stronger than that found for the AX-CPT and other measures such as the far transfer task, the PM/N-back. We used the methods suggested by Meng, Rosenthan and Rubin (1992) to compare the strength of the relationships between the Dot-CPT and the AX-CPT with the strength of relationship between the AX-CPT and cost scores for the WM 1-back or 2-back and PM tasks. Only correlations that were significant and predicted (i.e., on the diagonal in the tables such as Dot-CPT BX RT and AX-CPT BX RT) were tested.

The strength of the relationship between AX-CPT proactive RT index and WM nontarget RT cost index was compared with the strength of the relationship between AX-CPT proactive RT index and Dot-CPT proactive RT index. As shown in Table 3i, the relationship between the AX-CPT and Dot-CPT proactive RT index scores was found to be trending toward showing a significantly stronger (p = .06) than that of AX-CPT proactive RT index and WM nontarget RT index scores. Thus, as shown through the patterns of correlations presented in Tables 3a and 3b, the relationships between AX-CPT and Dot-CPT demonstrate that both tasks measure proactive error and RT performance in similar ways that are highly related. As shown in Tables 3c and 3d, relationship between error and RT PM/N-back scores and AX-CPT errors was not related to proactive strategy use. Thus, the Dot-CPT appears to be a better measure of context processing RT performance than the PM/N-back measures in that it shows a stronger relationship with the AX-CPT proactive RT measure and the significant relationships between AX-CPT and Dot-CPT variables reflected a more theoretically predicted pattern (e.g., AX-CPT AY RT correlating significantly with Dot-CPT AY RT) compared with a less theoretically predicted pattern between AX-CPT and PM/N-back variables (e.g., AX-CPT BX RT correlating negatively with WM nontarget RT cost index scores, which suggests that more reactive AX-CPT performance is related to less effect of WM demands on the PM/N-back).

Table 3i.
Strength of Significant Correlations Uncovered Between AX-CPT BX RT and Dot-CPT BX RT Compared with Strength of Significant Correlations Uncovered between AX-CPT BX RT and PM/N-back RT scores.

	Correlation with AX-CPT Proactive RT Index	Z score comparison	P value
Dot-CPT Proactive RT Index	.47***	1.56	.06
WM Nontarget RT Cost	.25**		

Note. Greater proactive RT index scores are indicative of more proactive patterns of performance.
*p = .05, **p < .05, ***p < .01, ****p < .001

Hypothesis 1 Summary. There were few significant differences at pretest between participants assigned to the various training and exposure conditions. However, the variables that did show significant differences at pretest were not those that were found to produce significant differences as a result of interventions.

The pattern of relationships uncovered between AX-CPT and Dot-CPT performance suggested that more proactive performance on one task relates to more proactive performance on the other task. This finding was consistent with our theoretical prediction, and confirms that the Dot-CPT can serve as an appropriate near-transfer task for the AX-CPT. Few of the relationships found between the AX-CPT and tasks other than the Dot-CPT showed a pattern suggesting that proactive performance on the AX-CPT (i.e., greater AY errors/RTs, fewer BX errors/RT, or proactive index scores) was correlated with superior cognitive control on the other tasks (i.e., more accurate or faster performance, or reduced cost measures). Although there were some significant correlations uncovered between the AX-CPT and PM/N-back, the pattern of relationships did not suggest that the PM/N-back assesses proactive control as well as the Dot-CPT task. Therefore, it is concluded that the Dot-CPT was an appropriate near transfer task and the PM/N-back was an appropriate far transfer task. It is important to note that the choice to include the Dot-CPT as a near transfer task and the PM/N-back as the far transfer task was based on an a priori task process analysis. Specifically, the Dot-CPT was chosen as the near transfer task due to the commonalities in structure between the AX-CPT and Dot-CPT and the PM/N-back task was chosen as the far transfer task due to the fact that there were fewer commonalities in structure between the AX-CPT and PM/N-back. Thus, the near and far transfer tasks were chosen before the study was conducted and therefore, the correlation analyses reported above serve to confirm that they are appropriate measures, but the decision to include these tasks as transfer tasks was not dependent on the results of these analyses.

Performance on the DEX did not relate significantly to performance on the AX-CPT, and DEX scores were found to be correlated with only one cognitive measure. Thus, it appears that self-reported executive control ability as measured by the DEX is not easily related to performance on the tests of executive control used in this study.

Hypothesis 2: Performance on the AX-CPT

Overview. Hypotheses 2a, 2b, and 2c for the AX-CPT task were examined with an ANOVA for the proactive context processing error index (i.e., AY-BX/AY+BX) with training condition (training vs. practice) and exposure condition (multi task vs. single task) as between-subjects variables and session (pretest vs. posttest) as a within-subjects variable. An analogous ANOVA was performed for proactive context processing RT index scores. In the sections below, each hypothesis is presented and followed by the

ANOVA results that address that hypothesis. Detailed accuracy and reaction time (RT) data for proactive context processing index scores are presented in Table 4.

Hypothesis 2a. *It was predicted that all participants would show improvement on the AX-CPT task from pretest to posttest due to the benefit of practice with the task at pretest and during the intervention sessions.*

This hypothesis predicted a main effect of session demonstrating that performance becomes more proactive from pretest to posttest. Consistent with this hypothesis, a significant main effect of session was revealed for errors, [$F(1,82) = 6.22$, $p < .05$, partial $\eta^2 = .07$], with the proactive context processing error index increasing from pretest to posttest. Additionally, a significant main effect of session was uncovered for the proactive RT index, [$F\ (1,82) = 12.17$, $p < .01$, partial $\eta^2 = .13$], demonstrating that the proactive context processing RT index increased from pretest to posttest. Thus, when collapsing across the exposure and training conditions, participants demonstrated a more proactive pattern of performance at posttest compared with pretest in errors and RTs.

Hypothesis 2b. *It was predicted that participants in the single task conditions would show significantly improved performance on the AX-CPT at posttest compared with pretest above and beyond improvement shown by participants in the multi task conditions. Furthermore, it was predicted that participants in the single task practice condition would show a larger increase in proactive performance from pretest to posttest compared with the multi task practice group. It was also hypothesized that participants in the single task training condition would show a greater increase in proactive performance than participants in the multi task training condition.*

The session related improvements in proactive control did not differ between the single task and multi task groups, in either errors, [F (1, 82) = .00, p = .98, partial η^2 = .00, or RTs, [F (1, 82) = 1.2, p = .28, partial η^2 = .01]. Additionally, simple effects test indicated an absence of difference between single task vs. multi task training or single task vs. multi task practice. Thus, there is no evidence that performance from pretest to posttest was affected by differences in amount of experience with the AX-CPT as compared between single and multi task conditions.

Hypothesis 2c. *It was predicted that the degree of improvement in goal maintenance abilities from pretest to posttest on the AX-CPT would not be significantly different for the practice and training groups, which is predicted by the results of the previous study (Paxton et al., 2006).*

Consistent with this hypothesis, the effect of training versus practice did not interact with the session effect in terms of errors, [F(1, 82) = .52, p = .47, partial η^2 = .01]. However, for the proactive RT index, we did observe larger effects in the training conditions compared with the practice conditions [training condition by session interaction: [F (1,82) = 4.33, p < .05, partial η^2 =.05]]. A simple effects test indicated that in the training group, there was a significant improvement for the proactive RT index at posttest compared with pretest [F (1,41) = 16.04, p < .001, partial η^2 =.28]. In the practice condition there was no significant difference between pretest and posttest for the proactive RT index, [F (1, 43) = 1.09, p = .30, partial η^2 =.03]. Additionally, a follow-up contrast revealed a statistically significant difference between the training and practice groups at posttest for the proactive RT measure, [F (1,84) = 4.67, $p < .05$, partial $\eta^2 = .05$].

See Figure 2 for a graph depicting the effects of training versus practice on the proactive context processing RT index. Thus, these data suggest that the training interventions were more effective than practice interventions in increasing proactive RT performance. There were no interactions between training and exposure conditions, suggesting that participants in the training conditions, regardless of whether it be the single task training or multi task training, showed more proactive RT performance from pretest to posttest.

Table 4

Proactive Context Processing Error and RT Index Scores at Pretest and Posttest for All Conditions on the AX-CPT

Errors

	Multi Task Training	Multi Task Practice	Multi Task Total
Pre	.00 (.30)	-.14 (.39)	-.07 (.35)
Post	.08 (.28)	.00 (.33)	.04 (.30)
N	21	21	42
	Single Task Training	Single Task Practice	Single Task Total
Pre	-.05 (.37)	-.13 (.37)	-.09 (.36)
Post	.03 (.26)	.01 (.24)	.02 (.24)
N	21	23	44
	Training Total	Practice Total	All Participants
Pre	-.03 (.33)	-.14 (.37)	-.08 (.36)
Post	.05 (.27)	.01 (.28) *	.03 (.27) **
N	42	44	86

RTs

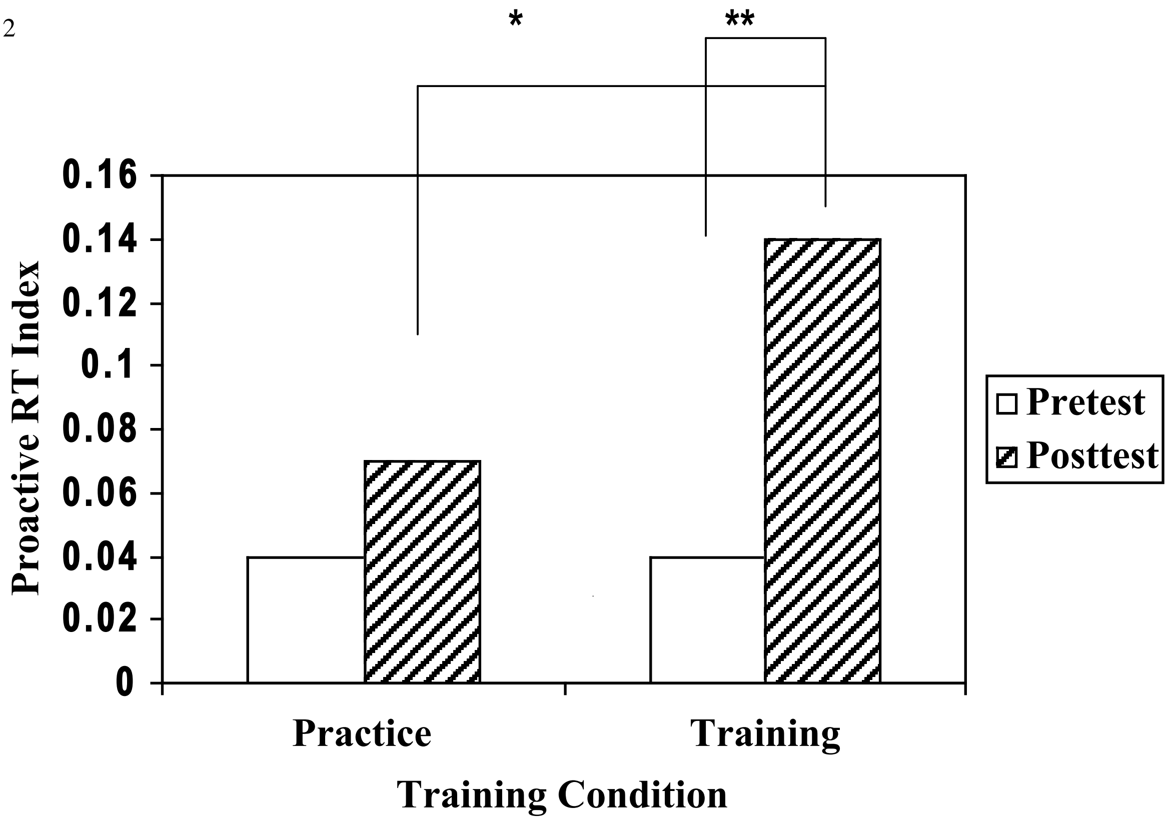
	Multi Task Training	Multi Task Practice	Multi Task Total
Pre	.08 (.19)	.07 (.16)	.08 (.17)
Post	.17 (.20) **	.06 (.13)	.12 (.18)
N	21	21	42
	Single Task Training	Single Task Practice	Single Task Total
Pre	.00 (.19)	.01 (.15)	.00 (.17)
Post	.10 (.15) ***	.07 (.13)	.08 (.14) ***
N	21	23	44
	Training Total	Practice Total	All Participants
Pre	.04 (.19)	.04 (.16)	.04 (.17)
Post	.14 (.18) ****	.07 (.13)	.10 (.16) ***

N	42	44	86

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Figure 2



* $p < .05$
** $p < .001$

Mean AX-CPT Proactive Context Processing RT Index Scores for Participants in the Training and Practice Conditions at Pretest and Posttest

Hypothesis 2 Supplementary Analyses

Examination of AY and BX scores in separate ANOVAs. Although the proactive context processing index scores for errors and RTs were used in the primary analyses, it was of interest to more closely examine AY and BX error and RT scores separately. These analyses were pursued to determine if the significant differences in RT for training conditions were driven by AY trials, BX trials, or both. Likewise, I was interested in determining whether either AY and/or BX errors, when examined in isolation, showed a pattern consistent with increased proactive performance, but that when these measures were combined into the proactive context processing indices they were not strong enough to produce a significant effect for exposure conditions. Thus, an ANOVA for AY error scores was conducted with training condition (training vs. practice) and exposure condition (multi task vs. single task) as between-subjects variables and session (pretest vs. posttest) as a within-subjects variable. Analogous ANOVAs were conducted for BX error scores, AY RTs, and BX RTs. Table 5 shows error rates and Table 6 shows RT data for AY and BX trials on the AX-CPT.

AY and BX errors in separate ANOVAs. When AY error scores were examined, there were no significant effects of session, [F (1, 82) = .06, p = .81, partial η^2 = .00]. Likewise, the session by training condition [F (1, 82) = .06, p = .81, partial η^2 = .00], session by exposure condition [F (1, 82) = .53, p = .47, partial η^2 = .01], and session by training condition by exposure condition [F (1, 82) = .06, p = .81, partial η^2 = .00] interactions were not significant.

When BX error scores were examined, a main effect of session was uncovered, [F (1,82) = 5.44, p < .05, partial η^2 = .06], which reflects a decrease in BX error scores from pretest to posttest for all participants. This main effect of session for BX errors is consistent with the main effect of session for proactive context processing error indices demonstrating a general increase in proactive error performance for all participants. The session by training condition [F (1, 82) = 2.60, p = .11, partial η^2 = .03], session by exposure condition interaction [F (1, 82) = .34, p = .56, partial η^2 = .00], and session by training condition by exposure condition [F (1, 82) = .17, p = .69, partial η^2 = .00] interactions were not significant.

AY and BX RTs in separate ANOVAs. When examining AY RT scores, the main effect of session was not significant, [F (1, 82) = .01, p = .94, partial η^2 =.00]. A main effect of training condition was uncovered, [F (1,82) = 8.26, p < .01, partial η^2 =.09], with participants in the training conditions showing slower RTs across pretest and posttest sessions. A significant session by training condition interaction was uncovered, [F (1,82) = 4.63, p < .05, partial η^2 =.05]. As shown in Table 6, participants in the training conditions showed a non-significant increase in AY RTs, [F (1, 41) = 1.99, p = .17, partial η^2 =.05], while participants in the practice conditions showed a non-significant decrease in AY RTs, [F (1, 43) = 2.40, p = .13, partial η^2 =.05]. This trend of increased

AY RTs in the training conditions and decreased AY RTs in the practice conditions was supported by the finding of significantly greater AY RTs at posttest in the training conditions compared with practice conditions, [F (1, 84) = 11.51, p < .01, partial η^2 =.12]. Also, a session by training condition by exposure condition interaction was found, [F (1,82) = 4.63, p < .05, partial η^2 = .05]. As shown in Table 6, AY RTs showed a non-significant decrease in all training/exposure condition combinations except the multi task training condition, which was the only condition to show a significant increase from pretest to posttest, [F (1,20) = 5.46, p < .05, partial η^2 = .21]. This pattern was consistent with the overall proactive control pattern, which assumes that increased proactive control would lead to a *slowing* of AY RTs in the posttest session. Thus, the multi task training, but not single task training, single task practice, or single task training conditions, produced AY slowing, consistent with a training-induced increase in proactive control.

When BX RTs were examined, a main effect of session was uncovered, [F (1,82) = 14.17, p < .0001, partial η^2 = .15], demonstrating that BX RTs decreased from pretest to posttest for participants in all conditions. In contrast with the lack of significant effects for exposure condition when the proactive context processing indices were examined, a session by exposure condition interaction was marginally significant, [F (1,82) = 3.57, p = .06, partial η^2 = .04]. Separate examination of each exposure condition demonstrated that participants in the single task conditions showed a significant decrease in BX RTs from pretest to posttest, [F (1, 43) = 15.59, p < .001, partial η^2 = .27], while participants in the multi task conditions showed a non-significant decrease in BX RTs, [F (1, 41) =

1.78, p = .19, partial η^2 =.04]. The session by training condition [F (1, 82) = 1.96, p = .17, partial η^2 =.02] and session by training condition by exposure condition [F (1, 82) = .00, p = .96, partial η^2 =.00] interactions were not significant. The absence of an interaction might be due to power and therefore, change in performance on various AX-CPT RT scores was explored separately for each of the training/exposure conditions. Interestingly, the single task training condition was the only training/exposure condition combination to show a significant decrease in BX RTs [F (1, 20) = 15.65, p < .01, partial η^2 = .44] as the single task practice [F (1, 22) = 3.91, p = .06, partial η^2 = .15], multi task training [F (1, 20) = 3.42, p = .08, partial η^2 = .15], and multi task practice [F (1, 20) = .04, p = .85, partial η^2 = .00] did not show a significant change in BX RT performance from pretest to posttest.

Examination of AY and BX scores in single ANOVA. Given that theory predicts that AY errors and RTs were hypothesized to increase and BX error and RTs were hypothesized to decrease as performance becomes more proactive, it is important to analyze these trial types together to determine whether interactions exist between them. Specifically, AY and BX error and RT scores were analyzed with analogous ANOVAs where trial type was an additional within subjects variable (AY vs. BX). Table 7 shows ANOVA results for error rates and Table 8 shows ANOVA results for RT data for the AX-CPT.

AY and BX Errors in single ANOVA. Consistent with the main effect of session for proactive context processing error indices demonstrating a general increase in proactive error performance for all participants, a main effect of session, [$F(1,82) = 4.27$, $p < .05$, partial $\eta^2 = .05$], was qualified by a session by trial type interaction, [$F(1, 82) = 4.71$, $p < .05$, partial $\eta^2 = .05$]. Specifically, examination of mean values shows that BX errors decreased significantly from pretest to posttest, [$F(1, 82) = 5.44$, $p < .05$, partial $\eta^2 = .06$], with no marked change in AY errors across sessions, [$F(1, 82) = .06$, $p = .81$, partial $\eta^2 = .00$]. There were no other significant effects for errors

AY and BX RTs in single ANOVA. When examining RT scores for AY and BX scores, a main effect of session, [$F(1,82) = 11.00$, $p < .01$, partial $\eta^2 =.12$], and main effect of trial type, [$F(1,82) = 9.52$, $p < .01$, partial $\eta^2 =.10$], were uncovered. These effects were qualified by a session by trial type interaction, [$F(1,82) = 12.26$, $p < .01$, partial $\eta^2 =.13$], demonstrating that BX RTs decrease significantly from pretest to posttest, [$F(1,82) = 14.17$, $p < .001$, partial $\eta^2 =.15$] with no significant change in AY trials from pretest to posttest, [$F(1, 82) = .01$, $p = .94$, partial $\eta^2 = .00$]. This finding is consistent with the main effect of session found for the proactive context processing RT indices, suggesting that all participants showed more proactive RT performance at posttest, which was driven by a decrease in BX RTs.

Consistent with the session by training type interaction found for the proactive context processing RT indices, a session by trial by training condition interaction was revealed when AY and BX RTs were examined, $F(1, 82) = 4.93$, $p < .05$, partial $\eta^2 =.06$. Further examination of performance from pretest to posttest in each trial type demonstrated that participants in the training conditions showed a significant decrease in BX RTs from pretest to posttest, $F(1,41) = 16.31$, $p < .001$, partial $\eta^2 = .29$, while participants in the practice conditions showed a trend toward decreased BX RTs [$F(1,43) = 2.51$, $p = .12$, partial $\eta^2 = .06$]. Participants in the training conditions showed a non-significant trend of increased AY RTs from pretest to posttest [$F(1, 41) = 1.99$, $p = .17$, partial $\eta^2 = .05$] while participants in the practice conditions showed a trend of decreased AY RTs from pretest to posttest [$F(1, 43) = 2.40$, $p = .13$, partial $\eta^2 = .05$]. This trend of increased AY RTs in the training conditions and decreased AY RTs in the practice conditions was supported by the finding of significantly longer AY RTs at posttest in the training conditions compared with practice conditions, [$F(1, 84) = 11.51$, $p < .01$, partial $\eta^2 = .12$]. Still, as is apparent in Table 8, the multi task training condition was the only condition combination to show an increase in AY RTs from pretest to posttest, and drives the finding that the mean AY RTs for training conditions (including multi task training and single task training) increase from pretest to posttest.

Also, in contrast with the lack of significant effects for intervention test number when the proactive context processing indices were examined, a session by exposure condition interaction was revealed, [$F(1,82) = 5.53$, $p < .05$, partial $\eta^2 = .06$], when AY and BX RTs were examined. When performance for participants in the single task conditions was examined separately, a significant decrease in RTs was uncovered, [$F(1, 43) = 15.59$, $p < .001$, partial $\eta^2 = .27$], whereas the decrease in RTs for the multi-task conditions was not significant, [$F(1, 41) = .49$, $p = .49$, partial $\eta^2 = .01$]. Thus, the single task conditions (in which participants gained more experience with the AX-CPT) led to a general decrease in RT from pretest to posttest. This effect was not specific to trial type and therefore was not shown with the more specific proactive context processing index.

Examination of Composite proactive index scores. It was important to investigate the combined effect of proactive error and RT performance in an effort to gain additional insight about the pattern of results for training and exposure conditions. Thus, the sum of the AX-CPT proactive error index scores and AX-CPT proactive RT index scores was computed and used as the dependent variable in ANOVAs with session as a within subjects variable and training condition (training vs. practice) and exposure condition (single vs. multi task) as between subjects variables. Table 9 shows the composite proactive index scores.

A main effect of session was uncovered for the composite proactive index, [F (1, 82) = 11.61, $p < .01$, partial $\eta^2 = .12$], demonstrating that composite proactive index scores increased significantly from pretest to posttest for all participants. As shown in Table 9, participants in all conditions showed significant improvements over time, and the session by training condition [F (1, 82) = .01, $p = .92$, partial $\eta^2 = .00$], session by exposure condition [F (1, 82) = .14, $p = .71$, partial $\eta^2 = .00$], and session by training condition by exposure condition [F (1, 82) = .13 $p = .72$, partial $\eta^2 = .00$] interactions were not significant. Still, when each training/exposure condition combination was examined separately, only the single task training condition showed a marginally significant increase in composite proactive index scores, [F (1, 20) = 4.27, p = .05, partial η^2 = .18].

AX-CPT Summary. Results demonstrated that, regardless of intervention condition, older adult participants become more accurate and efficient on the training task. Further examination of AY and BX scores for all participants indicated that there was a significant decrease in BX error and RT scores from pretest to posttest, but no significant change in AY errors or RTs.

In contrast the results did not conform to Hypothesis 2b as there was no effect of exposure condition on AX-CPT performance as assessed with proactive error or RT index scores. Additionally, there were no differences in exposure condition for AY or BX error scores. Participants in single task conditions showed a non-specific (collapsed across AY and BX) greater decrease in RT from pretest to posttest. Overall, there was no evidence that participants with extended exposure to the AX-CPT showed greater benefits in proactive performance compared with participants in the multi task exposure conditions.

In terms of Hypothesis 2c, participants assigned to the training conditions showed a greater increase in proactive RT index scores compared with participants in the practice conditions. Further inspection of AY and BX RT scores indicated that there was a significant difference between training conditions in the pattern with which AY and BX RTs change from pretest to posttest. Specifically, participants in the training conditions showed a significant decrease in BX RTs and non-significant increase in AY RTs while participants in the practice conditions showed a non-significant decrease in BX RTs and a non-significant decrease in AY RTs. Although the increase in AY RTs for training participants was driven by a significant increase for only the multi task training condition, those in either training condition combination showed a more proactive pattern of performance in terms of BX RTs compared with all participants in the practice conditions. The single task training condition was the only training/exposure condition combination that produced a significant decrease in BX RTs and a significant increase in composite proactive index scores. In summary, training was found to be more effective than practice when the relationship between change in AY and BX RT performance was evaluated such that the tendency for AY scores to increase and BX scores to decrease was compared (e.g., proactive RT index or trial type interaction in ANOVA). Still, when individual error and RT scores were evaluated separately, there was no evidence that the training condition was more effective than practice in leading to more proactive performance. Participants in the multi task training condition were the only participants to show a more proactive significant increase in AY RT scores and participants in the single task training condition were the only participants to show a more proactive significant decrease in BX RT scores.

Table 5.

Errors at Pretest and Posttest in AY and BX Trial Types All Conditions on the AX-CPT

Trial Type		Multi Task Training	Multi Task Practice	Multi Task Total
AY				
	Pre	.03 (.08)	.02 (.06)	.03 (.07)
	Post	.04 (.09)	.03 (.07)	.04 (.08)
	N	21	21	42
BX				
	Pre	.03 (.05)	.10 (.22)	.06 (.16)
	Post	.01 (.05)	.03 (.07)	.02 (.06)
	N	21	21	42
		Single Task Training	Single Task Practice	Single Task Total
AY				
	Pre	.04 (.12)	.02 (.05)	.03 (.09)
	Post	.03 (.06)	.02 (.04)	.02 (.05)
	N	21	23	44
BX				
	Pre	.07 (.20)	.12 (.29)	.10 (.25)
	Post	.05 (.20) **	.02 (.06)	.03 (.14)
	N	21	23	44
		Training Total	Practice Total	All Participants
AY				
	Pre	.04 (.10)	.02 (.06)	.03 (.08)
	Post	.04 (.08)	.03 (.05)	.03 (.07)
	N	42	44	86
BX				
	Pre	.05 (.14)	.11 (.26)	.08 (.21)
	Post	.03 (.14)	.02(.07) **	.03 (.11) **
	N	42	44	86

Note. Entries are means; standard deviations are in parentheses.

**** p < .001, *** p < .01, ** p < .05, * p = .05

Table 6

Median RTs at Pretest and Posttest in AY and BX Trial Types for All Conditions on the AX-CPT

Trial Type		Multi Task Training	Multi Task Practice	Multi Task Total
AY				
	Pre	716.36 (117.64)	694.83 (142.93)	705.60 (129.75)
	Post	780.57 (175.16) **	667.02 (93.90)	723.80 (150.23)
	N	21	21	42
BX				
	Pre	654.14 (273.04)	617.57 (203.56)	635.86 (238.58)
	Post	577.45 (251.17)	607.83 (187.78)	592.64 (219.57)
	N	21	21	42
		Single Task Training	Single Task Practice	Single Task Total
AY				
	Pre	714.55 (97.56)	655.78 (78.31)	683.83 (91.90)
	Post	698.60 (95.16)	638.63 (81.92)	667.25 (92.54)
	N	21	23	44
BX				
	Pre	756.40 (264.02)	674.52 (216.41)	713.60 (241.03)
	Post	595.07 (210.99) ***	575.24 (180.05)	584.70 (193.37) ****
	N	21	23	44
		Training Total	Practice Total	All Participants
AY				
	Pre	715.45 (106.75)	674.42 (114.14)	694.46 (111.86)
	Post	739.58 (145.27)	652.18 (87.98)	694.87 (126.87)
	N	42	44	86
BX				
	Pre	705.27 (270.27)	647.34 (209.91)	675.63 (241.61)
	Post	586.26 (229.28) ****	590.80 (182.37)	588.58 (205.39) ****
	N	42	44	86

Note. Entries are means; standard deviations are in parentheses.

**** p < .001, *** p < .01, ** p < .05, * p = .05

Table 7. ANOVA Summary for AX-CPT Errors

Source	df	*F*	η^2
Between subjects			
Training (T)	1	.63	
Exposure (E)	1	.69	
T x E	1	.55	
Error 1	82		
Within subjects			
Session (S)	1	4.27 *	.05
S x T	1	1.95	
S x E	1	.73	
S x T x E	1	.08	
Error 2	82		
Trial Type (TT)	1	2.19	
TT x T	1	1.68	
TT x E	1	.82	
TT x T x E	1	.17	
Error 3	82		
S x TT	1	4.71 *	.05
S x TT x T	1	2.35	
S x TT x E	1	.05	
S x TT x T x E	1	.21	
Error 4	82		

p* < .05. ** p < .01. * *p* < .001. **** *p* < .0001.

Table 8. ANOVA Summary for AX-CPT RTs

Source	df	*F*	η^2
Between subjects			
Training (T)	1	2.78	
Exposure (E)	1	.00	
T x E	1	.13	
Error 1	82		
Within subjects			
Session (S)	1	11.00 **	.12
S x T	1	.12	
S x E	1	5.53 *	.06
S x T x E	1	.69	
Error 2	82		
Trial Type (TT)	1	9.52 **	.10
TT x T	1	.79	
TT x E	1	3.22	
TT x T x E	1	.46	
Error 3	82		
S x TT	1	12.26 **	.13
S x TT x T	1	4.93 *	.06
S x TT x E	1	1.10	
S x TT x T x E	1	.92	
Error 4	82		

*$p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0001$.

Table 9

Composite Proactive Index Scores at Pretest and Posttest for All Conditions on the AX-CPT

	Multi Task Training	Multi Task Practice	Multi Task Total
Pre	.07 (.41)	-.07 (.44)	.00 (.43)
Post	.25 (.38)	.06 (.38)	.16 (.40) **
N	21	21	42
	Single Task Training	Single Task Practice	Single Task Total
Pre	-.05 (.51)	-.12 (.42)	-.09 (.46)
Post	.13 (.33) *	.08 (.31)	.10 (.32) **
N	21	23	44
	Training Total	Practice Total	All Participants
Pre	.01 (.46)	-.10 (.42)	-.04 (.44)
Post	.19 (.36) ***	.07 (.34) **	.13 (.36) ***
N	42	44	86

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Hypothesis 3: Performance on the Task Switching and Modified Sternberg

Hypothesis 3a. It was hypothesized that all participants would show worse performance in accuracy and RTs in mixed block trials compared with pure block trials. Likewise, it was expected that all participants would show worse performance in accuracy and RTs in mixed block switch trials compared with mixed block repeat trials. Also, it was predicted that all participants would show worse accuracy and RT performance in recent negative trials compared with novel negative trials on the modified Sternberg.

Overview. For the task switching measure, Hypothesis 3a was examined with separate ANOVAs for errors and RTs with training (training vs. practice) and exposure (single task vs. multi task) conditions as between-subjects variables and session (pretest vs. posttest) and mixing cost (repeat trials in mixed blocks vs. all trials in pure blocks) as within-subjects variables. Additional ANOVAs for errors and RTs were conducted with switch cost (switch vs. repeat trials in mixed blocks) as a within-subjects variable instead of mixing cost.

For the modified Sternberg measure, Hypothesis 3a was approached with separate ANOVAs for errors and RTs with training (training vs. practice) and exposure (single task vs. multi task) conditions as between-subjects variables and session (pretest vs. posttest) and trial type (recent negative vs. novel negative) as within-subjects variables.

Task Switching. In the task switching accuracy analysis, a main effect of trial type was found when mixing cost was a within-subjects variable, [F (1, 77) = 8.76, p < .01, partial η^2 = .10], demonstrating that significantly more errors were made for mixed block repeat trials than pure block trials. A main effect of trial type was uncovered when switch cost was a within-subjects variable, [F (1, 77) = 24.80, $p < .001$, partial $\eta^2 = .24$], showing that significantly more errors were made on switch trials than repeat trials. Due to these significant trial type effects for switching and mixing costs, the switching and mixing cost values were used as dependent variables in the analyses that follow.

When task switching RTs were examined with mixing cost as a within subjects variable, a main effect of trial type was found, [F (1, 77) = 105.36, $p < .001$, partial $\eta^2 =$ .58], showing that RTs for repeat trials were significantly greater than those found for pure block trials. Likewise when switching costs were analyzed, a main effect of trial type was found, [F (1, 77) = 58.31, $p < .001$, partial $\eta^2 = .43$], demonstrating that switch trial RTs were significantly greater than repeat trial RTs. Therefore, mixing and switching cost values were used as dependent variables in all analyses that follow.

Modified Sternberg. There was a main effect of trial for errors, [F (1, 79) = 58.18, $p < .001$, partial $\eta^2 = .42$], and RTs, [F (1, 79) = 106.34, $p < .001$, partial $\eta^2 = .57$], demonstrating that more errors and larger RT values were shown on negative recent trials compared with negative novel trials. Due to this effect of trial type, the analyses following involve a recency interference cost scores (negative recent – negative novel) to indicate increased difficulty of the negative recent trials in comparison to the negative novel trials.

Hypothesis 3b. It was predicted that all participants would show improvement on the task switching and modified Sternberg tasks from pretest to posttest due to benefit from exposure to the task at pretest in all conditions.

After verifying significant differences between trial types, Hypotheses 3b, 3c, and 3d for the task switching measures were approached with mixing cost scores (repeat trials from mixed blocks – all trials in pure blocks) and switching costs scores (switch trials from mixed block – repeat trials from mixed block) as dependent variables. Separate ANOVAs for mixing error cost scores, mixing RT cost scores, switching error cost scores, and switching RT cost scores were conducted with training (training vs. practice) and exposure (single task vs. multi task) conditions as between-subjects variables and session (pretest vs. posttest) as a within subjects variable. In the sections below, each hypothesis is presented followed by the ANOVA results that address that hypothesis. Detailed accuracy and RT data for mixing and switch costs are presented in Table 10 and 11.

After verifying significant differences among trial types, Hypotheses 3b, 3c, and 3d for the modified Sternberg task were approached with the recency interference score (recent negative – novel negative) as a dependent variable. Separate ANOVAs were conducted for recency interference error and RT cost scores with training (training vs. practice) and exposure (single task vs. multi task) conditions as between-subjects variables and session (pretest vs. posttest) and as a within-subjects variable. Detailed accuracy and RT data for each trial type are presented in Table 12 and 13.

Task Switching. A main effect of session was not significant for mixing error cost scores, [F (1, 77) = 1.01, p = .32, partial η^2 = .01], or switching error cost scores, [F (1, 77) = .17, p = .68, partial η^2 = .00], suggesting that participants' accuracy performance did not change significantly from pretest to posttest. When RTs were examined, the main effect of session was significant for mixing RT cost scores, [F (1, 77) = 4.62, p < .05, partial □^{2} = .06], demonstrating that mixing costs decreased from pretest to posttest. The main effect of session was not significant for switching RT cost scores, [F (1, 77) = 1.54, p = .22, partial □^{2} = .02].

Modified Sternberg. On the Modified Sternberg task, the main effect of session was not significant for the error, [F (1, 79) = .01, p = .91, partial □^{2} = .00], or RT recency interference cost scores, [F (1, 79) = .12, p = .74, partial □^{2} = .00].

Hypothesis 3c. Participants in the multi task conditions gained experience with the task switching and modified Sternberg tasks during the interventions sessions, whereas participants in the single task conditions only gained experience with these tasks during the pretest session. Because participants in the multi task conditions gained more experience with these two tasks during the two intervention sessions, it was hypothesized that participants in the multi task conditions (i.e., multi task training and multi task practice) would show a significantly greater improvement in performance than those in the single conditions on the task switching and the modified Sternberg at posttest compared with pretest.

Task Switching. The hypothesis that multi task conditions produce a greater improvement in performance would predict that session by exposure condition interactions would be uncovered. However, a session by exposure condition interaction for mixing error cost was not found, [F (1, 77) = .44, p = .51, partial □^{2} = .01]. Still, the main effect of exposure condition for mixing error cost was marginally significant, [F (1, 77) = 4.00, p = .05, partial □^{2} = .05], demonstrating that participants in the single task condition showed less of a cost associated with task-repeat trials compared with pure trials compared with those in the multi task condition on both pretest and posttest sessions. The session by exposure condition interaction was not significant for switching error cost scores, [F (1, 77) = 1.95, p = .17, partial η^2 = .03], mixing RT cost scores [F (1, 77) = 2.92, p = .09, partial η^2 = .04], or switching RT cost scores [F (1, 77) = .92, p = .34, partial η^2 = .01]. Thus, the lack of significant interactions between exposure condition and session suggests that the main effects of session in mixing cost discussed above are not related to amount of exposure. In summary, these analyses did not support the hypotheses that the multi task intervention conditions would produce greater performance changes as there were no significant effects of exposure condition when changes in performance from pretest to posttest were examined.

Modified Sternberg. On the modified Sternberg measure, the session by exposure condition interactions was not significant for recency interference error cost scores, [F (1, 79) = .12, p = .74, partial η^2 = .00], or recency interference RT cost scores, [F (1, 79) = .06, p = .82, partial η^2 = .00]. Thus, these results do not support the hypothesis that multi task conditions that provided more exposure to the modified Sternberg task would produce a greater improvement in interference cost than the single task conditions.

Hypothesis 3d. It was predicted that the multi task training group would show significantly greater improvement in performance than the multi task practice group on the task switching and modified Sternberg tasks at posttest compared with pretest.

Overview. Hypothesis 3d predicting a significant difference between multi task training and multi task practice would be supported through a significant session by training condition by exposure condition interaction in the ANOVAs described for Hypotheses 3b, 3c, and 3d (i.e., training and exposure conditions as between subjects variables and session as a within subjects variable). If such an interaction was uncovered, then contrasts between training/exposure condition combinations would be expected to demonstrate that the multi task training condition showed a more significant change in task switching and modified Sternberg scores than the multi task practice condition.

Task Switching. The session by training condition interaction was not significant for mixing error cost [F (1, 77) = .04, p = .85, partial η^2 = .00], switching error cost [F (1, 77) = .20, p = .66, partial η^2 = .00], mixing RT cost [F (1, 77) = .04, p = .85, partial η^2 = .00], or switching RT cost [F (1, 77) = .67, p = .42, partial η^2 = .01]. Likewise, the session by training by exposure condition interaction was not significant for mixing error cost [F (1, 77) = 2. 70, p = .11, partial η^2 = .04], switching error cost [F (1, 77) = .08, p = .78, partial η^2 = .00], mixing RT cost [F (1, 77) = .13, p = .72, partial η^2 = .00], or switching RT cost [F (1, 77) = 1.19, p = .28, partial η^2 = .02]. Thus, there is no evidence that the multi task training condition was significantly more effective than the multi task practice condition in changing task switching scores from pretest to posttest.

Modified Sternberg. The session by training condition interaction was not significant for recency interference error cost scores [F (1, 79) = .40, p = .53, partial η^2 = .01] or recency interference RT cost scores [F (1, 79) = .00, p = .99, partial η^2 = .00].

Likewise, the session by training by exposure condition interaction was not significant for recency interference error cost scores [F (1, 79) = .10, p = .75, partial η^2 = .00] or recency interference RT cost scores [F (1, 79) = .08, p = .77, partial η^2 = .00]. Thus, there is no evidence that the multi task training condition was significantly more effective than the multi task practice condition in changing modified Sternberg scores from pretest to posttest.

Task Switching and Modified Sternberg Summary. In contrast to Hypothesis 3b, among all variables examined on the task switching and modified Sternberg measures, only the mixing cost RT measure from the task switching test showed a significant improvement in performance from pretest to posttest for all participants. Hypothesis 3c predicted that participants in the multi task conditions would show greater improvement from pretest to posttest due to gaining additional experience with the task switching and modified Sternberg measures during the intervention sessions. In contrast to this hypothesis, performance on the task switching and modified Sternberg measures did not show greater change from pretest to posttest for those in multi task conditions. Furthermore, in contrast to Hypothesis 3d stating that participants in the multi task training condition would show greater improvement from pretest to posttest, there were no significant effects of training and/or exposure combinations in any of the task switching or modified Sternberg scores. Thus, there was no evidence that the multi task training intervention led to a greater increase in performance compared with the other training/exposure condition combinations.

Table 10

Errors at Pretest and Posttest for All Conditions on the Task Switching Measure

		Multi Task Training	Multi Task Practice	Multi Task Total
Mixing Cost				
	Pre	.03 (.07)	.00 (.10)	.01 (.09)
	Post	.00 (.02)	.02 (.04)	.01 (.03)
	N	19	21	40
Switching Cost				
	Pre	.03 (.07)	.03 (.07)	.03 (.07)
	Post	.03 (.06)	.01 (.04)	.02 (.05)
	N	19	21	40
		Single Task Training	Single Task Practice	Single Task Total
Mixing Cost				
	Pre	.04 (.10)	.08 (.17)	06 (.14)
	Post	.04 (.14)	.04 (.09)	.04 (.12)
	N	19	22	41
Switching Cost				
	Pre	.02 (.05)	.01 (.07)	.02 (.06)
	Post	.04 (.07)	.03 (.04)	.03 (.05)
	N	19	22	41
		Training Total	Practice Total	Total
Mixing Cost				
	Pre	.04 (.08)	.04 (.15)	.04 (.12)
	Post	.02 (.10)	.03 (.07)	.02 (.09)
	N	38	43	81
Switching Cost				
	Pre	.02 (.06)	.02 (.07)	.02 (.07)
	Post	.03 (.06)	.02 (.04)	.03 (.05)
	N	38	43	81

Note. Entries are means; standard deviations are in parentheses.

**** p < .001, *** p < .01, ** p < .05, * p = .05

Table 11

RTs at Pretest and Posttest for All Conditions on the Task Switching Measure

	Multi Task Training	Multi Task Practice	Multi Task Total
Mixing Cost			
Pre	224.11 (189.72)	179.65 (205.82)	200.77 (197.08)
Post	130.25 (180.56) **	93.64 (137.38)	111.03 (158.33) ***
N	19	21	40
Switching Cost			
Pre	103.95 (235.03)	122.14 (266.57)	113.50 (249.04)
Post	86.97 (235.95)	121.76 (176.19)	105.24 (204.75)
N	19	21	40
	Single Task Training	Single Task Practice	Single Task Total
Mixing Cost			
Pre	186.58 (165.78)	159.77 (138.42)	172.20 (150.37)
Post	189.00 (203.65)	136.85 (182.81)	161.02 (191.79)
N	19	22	41
Switching Cost			
Pre	144.45 (220.04)	207.89 (160.32)	178.49 (190.54)
Post	135.63 (169.41)	82.75 (116.01) **	107.70 (140.35) *
N	19	22	41
	Training Total	Practice Total	Total
Mixing Cost			
Pre	204.34 (176.75)	169.48 (172.78)	185.82 (174.74)
Post	159.63 (192.15)	115.75 (161.43)	135.78 (173.56) **
N	38	43	81
Switching Cost			
Pre	124.20 (225.50)	166.01 (220.38)	146.40 (222.39)
Post	111.30 (204.10)	101.80 (147.99)	107.98 (172.13)
N	38	43	81

Note. Entries are means; standard deviations are in parentheses.

**** p < .001, *** p < .01, ** p < .05, * p = .05

Table 12

Errors at Pretest and Posttest for All Conditions on the Modified Sternberg Measure

		Multi Task Training	Multi Task Practice	Multi Task Total
Recency Interference Score				
	Pre	.07 (.10)	.06 (.08)	.07 (.09)
	Post	.09 (.14)	.06 (.10)	.07 (.12)
	N	20	20	40
		Single Task Training	Single Task Practice	Single Task Total
Recency Interference Score				
	Pre	.07 (.10)	.12 (.14)	.10 (.12)
	Post	.07 (.12)	.11 (.12)	.09 (.12)
	N	20	23	43
		Training Total	Practice Total	Total
Recency Interference Score				
	Pre	.07 (.10)	.09 (.11)	.08 (.11)
	Post	.08 (.13)	.09 (.11)	.08 (.12)
	N	40	43	83

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Table 13

RTs at Pretest and Posttest for All Conditions on the Modified Sternberg Measure

		Multi Task Training	Multi Task Practice	Multi Task Total
Recency Interference Score				
	Pre	96.20 (140.55)	77.58 (104.81)	86.89 (122.74)
	Post	93.30 (107.23)	84.15 (64.46)	88.73 (87.45)
	N	20	20	40
		Single Task Training	Single Task Practice	Single Task Total
Recency Interference Score				
	Pre	101.00 (118.44)	76.24 (125.17)	87.76 (121.28)
	Post	116.38 (120.07)	80.91 (106.04)	97.41 (112.84)
	N	20	23	43
		Training Total	Practice Total	Total
Recency Interference Score				
	Pre	98.60 (128.31)	76.86 (114.79)	87.34 (121.24)
	Post	104.84 (112.97)	82.42 (88.16)	93.22 (100.88)
	N	40	43	83

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Hypothesis 4: Performance on the Near Transfer Task: Dot-CPT

Overview. Hypotheses 4a and 4b for the Dot-CPT task were examined with an ANOVA where the proactive context processing error index (i.e., AY-BX/AY+BX) was the dependent variable and training condition (training vs. practice) and exposure condition (multi task vs. single task) were between-subjects variables and session (pretest vs. posttest) was a within-subjects variable. An analogous ANOVA was performed for proactive context processing RT index scores. In the sections below, each hypothesis is presented followed by the ANOVA results that address that hypothesis. Detailed accuracy and RT data for proactive context processing index scores are presented in Table 14.

Hypothesis 4a. It was hypothesized that all participants would show improvement on the Dot-CPT task from pretest to posttest due to simple exposure to the task at pretest.

A significant main effect of session was uncovered for the proactive context processing error index, [F (1, 81) = 4.48, p < .05, partial η^2 = .05], demonstrating an increase in proactive context processing error index scores from pretest to posttest. For the context processing RT scores, the main effect of session was not significant, [F (1, 81) = 1.37, p = .25, partial η^2 = .02].

Hypothesis 4b. It was hypothesized that participants in the multi task training condition would show a significantly greater increase in proactive performance on the near transfer task, the Dot-CPT, from pretest to posttest than participants in the single task training, multi task practice, or single task practice conditions.

Hypothesis 4b predicting a significant difference between multi task training and the other three training/exposure condition combinations would be supported through a significant session by training condition by exposure condition interaction in the ANOVAs described for hypotheses 4a and 4b (i.e., training and exposure conditions as between subjects variables and session as a within subjects variable). If such an interaction was uncovered, then contrasts between training/exposure condition combinations would be expected to demonstrate that the multi task training condition showed a more significant change in proactive error and RT scores from pretest to posttest.

First, the effect of training condition (training vs. practice) was examined. This factor did not interact with session for either the proactive error [F (1, 81) = .90, p = .35, partial $\square^2$= .01] or RT [F (1, 81) = 00, p = .96, partial $\square^2$= .00] indices. Still, as apparent through inspection of scores in Table 12, the training conditions showed a greater increase in proactive error scores from pretest to posttest compared with the practice conditions. Specifically, when the training and practice conditions were analyzed separately, participants in the training condition showed a significant main effect of session for Dot-CPT proactive error index scores, [F (1, 40) = 4.76, p < .05, partial $\square^2$= .09] while the participants in the practice condition did not show a significant main effect of session, [F (1, 43) = .75, p = .39, partial $\square^2$= .02].

Next, the effect of exposure condition (single task vs. multi task) was examined. This effect was not significant for the proactive RT index [F (1, 81) = .50, p = .49, partial $\square^2$= .01], but it did interact with session for the proactive error index [F (1,81) = 4.68, p <

.05, partial η^2= .06]. Participants in the single task groups showed a significant pretest to posttest improvement in proactive control in error scores [F (1, 42) = 7.57, p < .01, partial η^2= .15], but participants in the multi task conditions did not show any improvement [F (1, 41) = .00, p = .97, partial η^2= .00]. Figure 3 shows the significant effect of exposure condition on change from pretest to posttest in proactive error index scores. Although it is encouraging to observe that participants in the single task conditions showed a significant increase in proactive error index scores, this result should be interpreted with caution. As is obvious from visual inspection of Figure 3, participants in the single task conditions showed a trend toward significantly lower scores at the pretest session than participants in the multi task condition, [F (1, 84) = 3.02, p = .09]. Also, the difference between posttest scores for participants in the single task conditions and participants in the multi task conditions did not approach significance, [F (1, 84) = .84 p = .36].

The omnibus ANOVA presented above did not uncover a session by training condition by exposure condition interaction for proactive errors [F (1, 81) = .10, p = .75, partial η^2= .00] or RTs [F (1, 81) = 1.30, p = .26, partial η^2= .02]. Still, because there was evidence that the training condition was more effective than the practice condition and the single task condition was more effective than the multi task condition in producing proactive error scores, it was of interest to determine whether the single task training condition would be more effective than other conditions. Therefore, each training/exposure condition combination was examined individually. These analyses indicated that the single task training condition was the only condition combination that resulted in a significant increase in proactive error index scores from pretest to posttest, [F (1, 19) = 5.64, p < .05, partial η^2= .23]. Conversely, the multi task practice condition showed a non-significant decrease, [F (1, 20) = .59, p = .45, partial η^2= .03], and the multi task training, [F (1, 20) = .45, p = .51, partial η^2= .02] and the single task practice, [F (1, 22) = 2.55, p = .12, partial η^2= .10] conditions showed a non-significant increase in proactive error index scores from pretest to posttest.

Table 14.

Proactive Context Processing Error and RT Index Scores at Pretest and Posttest for All Conditions on the Dot-CPT

Errors

	Multi Task Training	Multi Task Practice	Multi Task Total
Pre	.11 (.37)	.12 (.38)	.11 (.37)
Post	.17 (.32)	.05 (.29)	.11 (.31)
N	21	21	42
	Single Task Training	Single Task Practice	Single Task Total
Pre	-.10 (.48)	-.02 (.54)	-.06 (.51)
Post	.17 (.37) **	.18 (.35)	.18 (.35) ***
N	20	23	43
	Training Total	Practice Total	All Participants
Pre	.01 (.43)	.05 (.47)	.03 (.45)
Post	.17 (.34) **	.12 (.33)	.14 (.33) **
N	41	44	85

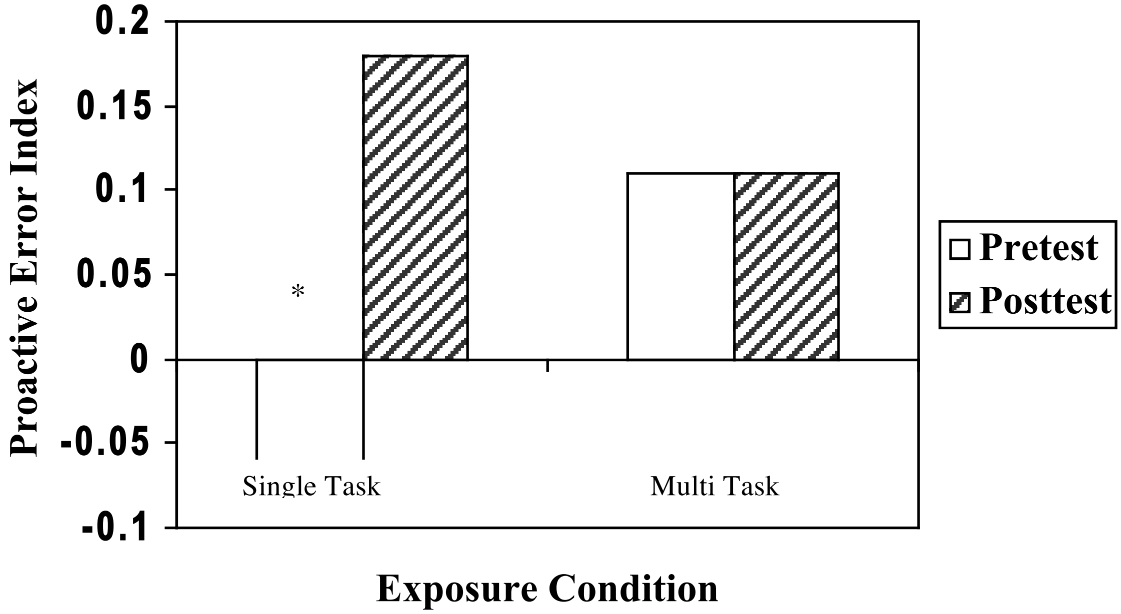
RTs

	Multi Task Training	Multi Task Practice	Multi Task Total
Pre	.15 (.15)	.08 (.16)	.11 (.16)
Post	.14 (.15)	.10 (.14)	.12 (.15)
N	21	21	42
	Single Task Training	Single Task Practice	Single Task Total
Pre	.09 (.16)	.08 (.17)	.08 (.16)
Post	.14 (.13)	.09 (.15)	.11 (.14)
N	20	23	43
	Training Total	Practice Total	All Participants
Pre	.12 (.16)	.08 (.16)	.10 (.16)
Post	.14 (.14)	.10 (.15)	.12 (.14)
N	41	44	85

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Figure 3



* p < .01

Mean Dot-CPT Proactive Context Processing Error Index Scores for Participants in the Single and Multi Task Conditions at Pretest and Posttest

Hypothesis 4: Supplementary Analyses

Examination of AY and BX scores in separate ANOVAs. Although the proactive context processing index scores for errors and RTs were used in the primary analyses, it was of interest to more closely examine AY and BX error and RT scores separately. Thus, an ANOVA for AY error scores was conducted with training condition (training vs. practice) and exposure condition (multi task vs. single task) as between-subjects variables and session (pretest vs. posttest) as a within-subjects variable. Analogous ANOVAs were conducted separately for BX error scores, AY RTs, and BX RTs. Table 15 shows error rates and Table 16 shows RT data for AY and BX trials on the Dot-CPT.

AY and BX errors in separate ANOVAs. In contrast to the main effect of session for proactive error index scores demonstrating a general increase in proactive error performance for all participants, the main effect of session was not significant for AY errors, [F (1, 81) = .18, p = .67, partial η^2 = .00]. The session by exposure condition interaction was marginally significant, [F (1,81) = 3.07, p = .08, partial η^2 = .04]. Specifically, participants in the single task conditions showed a non-significant increase in AY errors [F (1, 42) = 2.35, p = .13, partial η^2 = .05] while participants in the multi task conditions showed a non-significant decrease in AY errors [F (1, 41) = .87, p = .36, partial η^2 = .02]. The session by training condition [F (1, 81) = .23, p = .63, partial η^2 = .00] and session by training by exposure condition [F (1, 81) = .21, p = .65, partial η^2 = .00] interactions were not significant.

When BX errors were investigated, a main effect of session was uncovered, [*F* (1,81) = 9.54, $p < .01$, partial $\eta^2 = .11$], demonstrating that BX errors decreased from pretest to posttest for all participants. A session by exposure condition interaction showed a trend toward significance, [*F* (1,81) = 2.63, $p = .11$, partial $\eta^2 = .03$]. When the exposure conditions were tested separately, the single task condition showed a significant decrease in BX errors from pretest to posttest, [*F* (1,42) = 8.83, $p < .01$, partial $\eta^2 = .17$], while participants in the multi task conditions showed a non-significant decrease in BX errors, [*F* (1, 41) = 1.46, $p = .23$, partial $\eta^2 = .03$]. The trend toward a significant session by exposure condition interaction for BX errors should be interpreted cautiously because examination of pretest performance demonstrated that participants in the single task condition showed a trend toward significantly greater BX errors at pretest compared with participants in the multi task conditions, [*F* (1, 84) = 2.92, $p = .09$]. Also, there was not a significant difference between scores for participants in single and multi task conditions at posttest, [*F* (1, 84) = .32, $p = .57$]. These differences at pretest in BX error scores correspond to the pretest differences found for proactive error index scores discussed in the Hypothesis 4b section. The session by training condition [*F* (1, 81) = 1.28, $p = .26$, partial $\eta^2 = .02$] and session by training by exposure condition [*F* (1, 81) = .78, $p = .38$, partial $\eta^2 = .01$] interactions were not significant.

AY and BX RTs in separate ANOVAs. When AY RTs were explored, a main effect of session was uncovered, [*F* (1,81) = 19.33, $p < .001$, partial $\eta^2 = .19$], demonstrating that AY RTs decreased from pretest to posttest. These RT results demonstrating that AY

RTs decreased indicate a shift to a more reactive pattern, which is consistent with the lack of significant effects found when proactive context processing RT index scores were investigated. A session by exposure condition interaction was uncovered for AY RTs, [F (1,81) = 4.32, $p < .05$, partial $\eta^2 =$ .05]. When exposure conditions were investigated separately, participants in the single task conditions showed a marginally significant decrease in AY RTs from pretest to posttest, [F (1,42) = 3.77, $p = .06$, partial $\eta^2 =$ .08], and participants in the multi task conditions showed a significant decrease in AY RTs, [F (1,41) = 17.30, $p < .01$, partial $\eta^2 =$ .30]. The session by training condition, [F (1, 81) = .25, $p = .62$, partial $\eta^2 =$ .00] and session by training condition by exposure condition [F (1, 81) = 1.66, $p = .20$, partial $\eta^2 =$ .02] interactions were not significant.

When BX RTs were investigated, a main effect of session was uncovered, [F (1,81) = 8.87, $p < .01$, partial $\eta^2 =$ .10], demonstrating that BX RTs decreased for all participants from pretest to posttest. The session by training condition [F (1, 81) = .10, p = .75, partial $\eta^2 =$ .00], session by exposure condition [F (1, 81) = .08, $p = .78$, partial η^2 = .00], and session by training condition by exposure condition [F (1, 81) = .54, $p = .46$, partial $\eta^2 =$ .01] interaction were not significant.

Examination of AY and BX scores in single ANOVA. It is also important to investigate scores on AY and BX trials together in the same ANOVA to determine whether interactions exist between them. Specifically, AY and BX error and RT scores were analyzed with analogous ANOVAs where trial type was an additional within subjects variable (AY versus BX). Table 17 shows ANOVA results for error rates and Table 18 shows ANOVA results for RT data for the Dot-CPT.

AY and BX Errors in single ANOVA. First, a main effect of session was uncovered, [F (1,81) = 6.25, $p < .05$, partial η^2 = .07] showing a decrease in errors from pretest to posttest. This effect was qualified by a session by trial interaction, [F (1, 81) = 8.03, $p < .01$, partial η^2 = .09], with AY errors showing a nonsignificant increase from pretest to posttest, [F (1, 81) = .18, $p = .67$, partial η^2 = .09], and BX errors showing a significant decrease, [F (1,81) = 9.54, $p < .01$, partial η^2 = .11]. Furthermore, a session by trial type by exposure interaction was uncovered for error scores, [F (1,81) = 5.04, $p < .05$, partial η^2 = .06]. Examination of performance from pretest to posttest for each trial type revealed that participants in the single task conditions showed a significant decrease in BX errors from pretest to posttest, [F (1,42) = 8.83, $p < .01$, partial η^2 = .17]. Participants in the multi task conditions also showed a decrease in BX errors, but this did not approach significance, [F (1, 41) = 1.46, $p = .23$, partial η^2 = .03). A nonsignificant increase in AY errors was demonstrated with participants in the single task conditions, [F (1, 42) = 2.35, p =.13, partial η^2 = .05] and multi task conditions, [F (1, 41) = .87, p =.36, partial η^2 = .02]. There were no other significant effects for error scores.

AY and BX RTs. When AY and BX RTs were explored, a main effect of session was uncovered, [F (1,81) = 21.48, $p < .001$, partial η^2 = .21], demonstrating that RTs decreased for both AY and BX trials from pretest to posttest. Also, a main effect of trial for RTs, [F (1, 81) = 46.63, p < .001, partial $\square^2$ = .37] revealed that AY RTs were greater than BX RTs across sessions and conditions. These RT results are consistent with the lack of significant effects found for training and test number conditions when proactive context processing RT index scores were investigated. There were no other significant effects for RT scores

Examination of composite proactive index scores. Given that there were differences in the pattern of RTs between single and multi task conditions that were not detected when the proactive context processing RT index was analyzed alone, it was important to investigate the combined effect of proactive error and RT performance. Thus, the composite proactive index score (sum of Dot-CPT proactive error index scores and Dot-CPT proactive RT index scores) was used as the dependent variable in ANOVAs with session as a within subjects variable and training condition (training vs. practice) and exposure condition (single vs. multi task) as between subjects variables. Table 19 shows composite proactive index scores.

A main effect of session was uncovered for the composite proactive index scores, [F (1, 81) = 5.75, p < .05, partial $\square^2$ = .07], demonstrating that composite proactive index scores increased significantly from pretest to posttest for all participants. A session by exposure intervention condition interaction was also found, [F (1, 81) = 5.29, p < .05, partial $\square^2$ = .06]. When each exposure condition was analyzed separately, the single task condition showed a significant increase in composite proactive index scores from pretest to posttest, [F (1, 42) = 9.25, p < .01, partial $\square^2$ = .18], while participants in the multi task conditions did not show a significant change in composite proactive index scores from pretest to posttest, [F (1, 41) = .01, p = .94, partial η^2= .00]. These results with the composite proactive index confirmed results with proactive error index scores presented above showing that participants in the single task condition demonstrated a significantly greater proactive shift from pretest to posttest compared with participants in the multi task conditions. The session by training condition [F (1, 81) = .87, p = .35, partial η^2 = .01] and the session by training by exposure condition [F (1, 81) = .00, p = .97, partial η^2 = .00] interactions were not significant. Still, given that the training conditions brought about more proactive performance on the Dot-CPT proactive error scores, it is important to investigate whether the single task training condition would produce more proactive performance on the Dot-CPT composite scores. Thus, when the change in performance from pretest to posttest was examined with Dot-CPT composite proactive index scores for participants in each training/exposure condition combination, only participants in the single task training conditions showed a significant increase in composite proactive index scores from pretest to posttest, [F (1, 19) = 7.02, p < .05, partial η^2 = .27]. Conversely, participants in the single task practice [F (1, 22) = 2.93, p = .10, partial η^2 = .12], multi task practice [F (1, 2) = .24, p = .63, , partial η^2 = .01] and multi task training [F (1, 20) = .26, p = .62, partial η^2 = .01] did not show a significant increase in composite proactive index scores from pretest to posttest.

Dot-CPT Summary. Hypothesis 4a predicted that participants in all conditions would become more proactive from pretest to posttest, and a significantly more proactive pattern of performance was found for Dot-CPT proactive error index, composite proactive index, BX errors, and BX RT scores. Conversely, proactive RT index scores and AY error scores did not show a significantly more proactive pattern of performance from pretest to posttest for all participants. AY RTs showed a significantly more reactive change (decrease in scores instead of a more proactive increase) from pretest to posttest, which was in contrast to hypotheses that all participants would become more proactive as a result of exposure to the task at pretest.

Hypothesis 4b predicted that participants in the multi task training condition would show a greater increase in proactive performance compared with the other three training/exposure condition combinations. When proactive error index and composite proactive index scores assessing the degree with which AY and BX scores changed in divergent directions were analyzed, participants in the training conditions were found to produce a significant increase in proactive performance from pretest to posttest, but did not differ significantly from the pattern of performance found for participants in the practice conditions. When each training/exposure condition combination was assessed, participants in the single task training condition showed a significant increase in proactive error index and composite proactive index scores, but did not differ significantly from the scores for participants in the other three training/exposure condition combinations. Participants in single task conditions showed significantly greater proactive performance compared with participants in the multi task conditions for the proactive error index, composite proactive index scores, and the interaction between AY and BX errors within the trial factor of an ANOVA. Thus, there was significant evidence that participants in the single task conditions showed a more proactive pattern of performance when the degree with which AY and BX scores changed in divergent directions was analyzed. Also, the AY RT scores, which showed a pattern of becoming more reactive from pretest to posttest for all participants, showed a significantly less reactive change for single task participants compared with multi task participants. Although there were no significant differences between participants according to exposure condition, participants in the single task conditions showed a significant decrease in BX errors an a non-significant increase in AY errors while participants in the multiple tasks conditions showed a non-significant decrease in BX error and a non-significant decrease in AY errors. In summary, the results suggest that training conditions may be helpful in facilitating proactive change when the differences in pattern of performance between AY and BX errors are assessed, but those in the training conditions do not show significantly divergent patterns of performance compared with those in the practice conditions. There was substantial evidence that single task participants show a more proactive change in comparison with participants in the multi task conditions when the pattern of performance between AY and BX was compared with proactive index measures. There were hints that individual AY and BX error scores showed a greater degree of proactive change for those in the single task conditions, but they did not differ significantly from performance for those assigned to the multi task conditions. Still, as mentioned above, evidence that the single task conditions led to more proactive change should be interpreted with caution due to trend level differences in BX error and proactive error index scores at pretest.

Summary of AX-CPT and Dot-CPT results.

Overall, results demonstrated that participants in the training conditions showed significantly increased proactive performance according on the AX-CPT according to proactive RT index scores whereas participants in the single task conditions showed the greatest increase in Dot-CPT proactive error index scores. Thus, the common element in the intervention conditions that led to improvement in proactive performance on the AX-CPT and Dot-CPT is the single task training condition. Moreover, participants in the single task training condition were the only participants to show at least trend level significantly increased proactive performance on AX-CPT composite proactive index scores, Dot-CPT proactive error index scores, and Dot-CPT composite proactive error index scores. Aside from the single task training condition, there was no other training/exposure combination that led to significant improvement on both the AX-CPT and Dot-CPT without another condition combination also showing significant change from pretest to posttest.

It is interesting that RTs were most affected on the AX-CPT task while errors were most affected on the Dot-CPT task. Furthermore, change in AX-CPT RT proactive index scores from pretest to posttest showed a positive and significantly correlation with change in Dot-CPT proactive error index scores from pretest to posttest ($r = .27$, $p < .05$).

Table 15.

Errors at Pretest and Posttest in AY and BX Trial Types for All Conditions on the Dot-CPT

Trial Type		Multi Task Training	Multi Task Practice	Multi Task Total
AY				
	Pre	.11 (.13)	.07 (.10)	.09 (.12)
	Post	.09 (.15)	.05 (.07)	.07 (.11)
	N	21	21	42
BX				
	Pre	.10 (.24)	.03 (.06)	.06 (.18)
	Post	.02 (.05)	.04 (.06)	.03 (.06)
	N	21	21	42
		Single Task Training	Single Task Practice	Single Task Total
AY				
	Pre	.05 (.07)	.07 (.11)	.06 (.09)
	Post	.09 (.13)	.09 (.11)	.09 (.12)
	N	20	23	43
BX				
	Pre	.16 (.31)	.15 (.31)	.16 (.30)
	Post	.04 (.14) *	.05 (.17) *	.04 (.16) ***
	N	20	23	44
		Training Total	Practice Total	All Participants
AY				
	Pre	.08 (.11)	.07 (.10)	.07 (.11)
	Post	.09 (.14)	.07 (.09)	.08 (.12)
	N	41	44	85
BX				
	Pre	.13 (.27)	.09 (.23)	.11 (.25)
	Post	.03 (.10) **	.04 (.13)	.04 (.12) ***
	N	41	44	85

Note. Entries are means; standard deviations are in parentheses,
**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Table 16

RTs at Pretest and Posttest in AY and BX Trial Types for All Conditions on the Dot-CPT

Trial Type		Multi Task Training	Multi Task Practice	Multi Task Total
AY				
	Pre	894.38 (115.89)	798.67 (138.59)	846.52 (135.15)
	Post	805.10 (126.96) ***	728.79 (92.18) **	766.94 (116.19) ****
	N	21	21	42
BX				
	Pre	679.69 (212.14)	705.60 (219.49)	692.64 (213.60)
	Post	629.40 (213.80)	606.83 (158.57)	618.12 (186.26) **
	N	21	21	42
		Single Task Training	Single Task Practice	Single Task Total
AY				
	Pre	778.10 (115.97)	783.85 (115.46)	781.17 (114.35)
	Post	772.29 (117.26) **	733.41 (113.73)	751.97 (115.75)
	N	20	23	43
BX				
	Pre	689.20 (240.69)	691.24 (203.70)	690.29 (218.96)
	Post	622.52 (234.59)	638.87 (222.18)	631.07 (225.66)
	N	20	23	43
		Training Total	Practice Total	All Participants
AY				
	Pre	837.66 (128.71)	790.92 (125.74)	813.46 (128.58)
	Post	788.69 (121.84) **	731.20 (102.84) ***	759.28 (115.53) ****
	N	41	44	85
BX				
	Pre	684.33 (223.70)	698.09 (209.02)	691.45 (215.04)
	Post	625.96 (221.71)	623.58 (192.91) **	624.74 (206.25) ***
	N	41	44	85

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Table 17. ANOVA Summary for Dot-CPT Errors

Source	df	*F*	η^2
Between subjects			
Training (T)	1	.38	
Exposure (E)	1	1.43	
T x E	1	.82	
Error 1	81		
Within subjects			
Session (S)	1	6.25 *	.07
S x T	1	.56	
S x E	1	.28	
S x T x E	1	1.02	
Error 2	81		
Trial Type (TT)	1	.04	
TT x T	1	.03	
TT x E	1	2.17	
TT x T x E	1	.08	
Error 3	81		
S x TT	1	8.03 **	.09
S x TT x T	1	1.44	
S x TT x E	1	5.04 *	.06
S x TT x T x E	1	.27	
Error 4	81		

*$p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0001$.

Table 18. ANOVA Summary for Dot-CPT RTs

Source	df	*F*	η^2
Between subjects			
Training (T)	1	.69	
Exposure (E)	1	.45	
T x E	1	.55	
Error 1	81		
Within subjects			
Session (S)	1	21.48 ****	.21
S x T	1	.26	
S x E	1	1.46	
S x T x E	1	.00	
Error 2	81		
Trial Type (TT)	1	46.63 ****	.37
TT x T	1	2.32	
TT x E	1	1.34	
TT x T x E	1	.63	
Error 3	81		
S x TT	1	.31	
S x TT x T	1	.00	
S x TT x E	1	.56	
S x TT x T x E	1	1.63	
Error 4	81		

*$p < .05$. ** $p < .01$. *** $p < .001$. **** $p < .0001$.

Table 19

Composite Proactive Index Scores at Pretest and Posttest for All Conditions on the Dot-CPT

	Multi Task Training	Multi Task Practice	Multi Task Total
Pre	.26 (.42)	.19 (.46)	.23 (.44)
Post	.31 (.37)	.15 (.34)	.23 (.36)
N	21	21	42
	Single Task Training	Single Task Practice	Single Task Total
Pre	-.01 (.57)	.06 (.58)	.03 (.57)
Post	.29 (.41) **	.27 (.40)	.28 (.40) ***
N	20	23	43
	Training Total	Practice Total	All Participants
Pre	.13 (.51)	.12 (.53)	.12 (.52)
Post	.30 (.39) **	.21 (.37)	.26 (.38) **
N	41	44	85

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Hypothesis 5: Performance on the Far Transfer Task: PM/N-back

Hypothesis 5a: It was predicted that all groups would show improvement on the PM/N-back task from pretest to posttest due to simple exposure effects.

For Hypothesis 5a, in order to evaluate whether performance changed significantly from pretest to posttest, a mixed model ANOVA was conducted for each of the PM/N-back dependent variables listed in Table 2 and not in bolded font. Session (pretest vs. posttest) was a within subjects variable and exposure condition (single task vs. multi task) and training condition (training vs. practice) were between subjects variables.

As shown in Table 20, the only accuracy measure showing a significant improvement in performance from pretest to posttest was the 1-back d' scores. Some RT measures showed a significant improvement in performance from pretest to posttest such as 1-back target RT, 1-back nontarget RT, 2-back target RT, and 1-PM-back nontarget RT. Although not presented in this table or in text, it is also important to note that when change from pretest to posttest was evaluated for these individual accuracy and RT scores, there were no significant effects of training condition or exposure condition.

Hypothesis 5b. It was also predicted that all participants would show worse performance in terms of d' scores and RTs in 2-back condition compared with the 1-back condition indicating effects of increased working memory load. Likewise, it was hypothesized that participants would show worse performance on the 1-PM-back condition compared with the 1-back condition due to greater prospective memory demands.

Investigation of the effects of increased working memory (WM) and prospective memory (PM) demands on PM/N-back performance was conducted with separate ANOVAs for d’ and RT scores. To investigate the effects of working memory load (WM-load) on d’ scores, an ANOVA assessed working memory load where session (pretest vs. posttest) and working memory load (WM-load; 1-back vs. 2-back) were within-subjects variables. To investigate the effects of prospective memory load (PM-load) on d’ scores, an ANOVA was used with session and prospective memory condition (1-back vs. 1-PM-back) as within-subjects variables. Investigation of WM-load and PM-load for RTs was completed with analogous ANOVAs with an additional within subjects variable of target type (target vs. nontarget RT).

A main effect of WM load was uncovered for d’ scores, [F (1, 73) = 247.65, p < .001, partial η^2 = .77], showing that d’ scores were significantly lower in the 2-back condition compared with the 1-back condition. When prospective memory condition was evaluated for d’ scores, a main effect of PM load was shown, [F (1, 74) = 64.63, p < .001, partial η^2 = .47], showing that d’ prime scores were lower in the PM condition compared for the 1-back condition. RT scores showed a main effect of WM load, [F (1,75) = 135.12, p < .001, partial η^2 = .64], indicating that RTs were significantly greater for the 2-back condition compared with the 1-back condition. Evaluation of PM RTs showed a main effect of load, [F (1, 76) = 726.72, p < .001, partial η^2 = .92], demonstrating greater RTs in the condition with greater PM demands, 1-PM-back condition, compared with the condition with less PM demands, the 1-back condition. The use of more concise cost index scores described in the Statistical Analyses section was justified by results confirming that performance was worse in more difficult WM and PM conditions paired with the fact that no effects of training or exposure intervention conditions were uncovered for individual scores. Thus, all analyses that follow used only the cost index scores. It is important to note that when exploratory analyses were completed with d' and RT scores for each condition, and results did not differ in a conclusive way.

Overview of Analyses for Hypotheses 5c and 5d. All of the analyses for Hypotheses 5c and 5d were examined with the WM and PM cost scores that were bolded in Table 2. As presented in the Statistical Analyses section, the WM index scores evaluated the cost of the more WM demanding 2-back condition compared with the 1-back condition. The PM cost index scores evaluated the cost on performance of the PM demands on the 1-PM-back compared with nontarget trials from the 1-back that did not entail a PM component. A higher score on all d' and RT WM cost indicates greater WM cost while the PM cost index scores indicates greater PM cost.

Examination of accuracy was completed with the three error cost scores as dependent variables in separate mixed model ANOVAs with training condition and exposure condition as between subjects variables and session as a within subjects variable. Analogous ANOVAs were conducted for the five bolded RT cost index scores presented in Table 2. In the sections below, each hypothesis is presented followed by the ANOVA results that address that hypothesis. Table 21 shows error cost index scores for all conditions. Table 22 shows WM RT cost index scores and Table 23 show the PM RT cost index scores for all participants for all conditions.

Hypothesis 5c. It was predicted that all participants would show more improvement in d' scores and RTs from pretest to posttest on the 2-back condition compared with the 1-back *condition indicated through a significant change in WM cost scores from pretest to posttest. Also, it was predicted that all participants would show more improvement on the 1-PM-back condition compared with the 1-back condition indicated through a significant change in PM cost scores from pretest to posttest.*

Errors: WM load. The main effect of session was not significant for WM cost error scores, [F (1, 70) = .18, p = .67, partial η^2 = .00], suggesting that WM cost does not change from pretest to posttest for all participants. Thus, the lack of a significant session effect indicates that participants did not show a reduced effect of WM load at posttest relative to pretest.

Errors: PM load. The main effect of session was not significant for PM d' error cost scores [F (1, 71) = .54, p = .47, partial η^2 = .01] or PM cue error cost scores [F (1, 73) = .19, p = .67, partial η^2 = .00], suggesting that the cost associated with PM load did not decrease significantly from pretest to posttest for all participants.

RT: WM load. The main effect of session was not significant for WM target RT cost index scores, [F (1, 72) = .00, p = .95, partial η^2 = .00]. A significant main effect of session was uncovered for WM nontarget RT index scores, [F (1, 72) = 8.03, p < .01, partial η^2 = .10], demonstrating a significant increase in WM RT cost from pretest to posttest. This latter effect was opposite to what was theoretically predicted. Hence, follow-up analyses revealed that the effect was due to a significant reduction in RT in the low WM load 1-back condition from pretest to posttest, [F (1, 72) = 23.90, p < .001, partial η^2 = .25], rather than a significant change in performance in the high-load 2-back condition from pretest to posttest, [F (1, 72) = .61, p = .44, partial η^2 = .01].

RT: PM load. When PM RT cost was evaluated, the main effect of session was not significant for PM target RT cost index, [F (1, 73) = .28, p = .60, partial η^2 = .00] and PM nontarget RT cost index [F (1, 73) = 2.27, p = .14, partial η^2 = .03]. However, when PM cue RT cost index scores were evaluated, a main effect of session was found, [F (1, 73) = 5.24, p < .05, partial η^2 = .07], showing that PM cue RT cost increased significantly from pretest to posttest. Thus, the lack of a significant session effect for target and nontarget PM trials suggested that performance in the PM condition did improve from pretest to posttest. The RT cost for PM cue trials was significant, but increased in the posttest relative to pretest. Follow-up analyses indicated that this effect was due to significantly faster RTs in the no-PM load 1-back condition at posttest compared with pretest, [F (1 76) = 19.82, p < .001, partial η^2 = .21], rather than a significant change in the RTs from pretest to posttest for the 1-PM-back PM condition, [F (1, 76) = .13, p = .73, partial η^2 = .00].

Hypothesis 5d. It was hypothesized that participants the multi task training condition would show a greater increase in d' and greater decrease in RTs from pretest to posttest on all PN/N-back tasks than participants in the single task training, multi task practice, and single task practice conditions.

Errors: WM load. The analysis of WM d' cost index scores did not produce a significant session by training condition, [F (1, 70) = .19, p = .66, partial η^2 = .00], session by exposure condition [F (1, 70) = .12, p = .73, partial η^2 = .00], or session by training by exposure condition [F (1, 70) = 1.24, p = .27, partial η^2 = .02] interaction.

Errors: PM load. In the analyses for PM d' cost index presented in Hypothesis 5b, the main effect of session was not significant. Similarly, the analysis of PM d' cost index scores did not produce a significant session by training condition, [F (1, 71) = .26, p = .61, partial η^2 = .00] or session by exposure condition [F (1, 71) = .13, p = .72, partial η^2 = .00] interaction. Still, the session by training by exposure condition [F (1, 71) = 4.44, p < .05, partial η^2 = .06] interaction was significant. When each training/exposure condition combination was examined separately, only the single task training condition showed a significant increase in PM d' cost index scores from pretest to posttest, [F (1, 20) = 5.78, p < .05, partial η^2 = .22]. The multi task practice [F(1, 18) = .60, p =. 45, partial η^2 = .03], multi task training [F (1, 15) = .40, p = .54, partial η^2 = .03], and single task practice [F (1, 18) = .68, p = .42, partial η^2 = .04] conditions showed a non-significant decrease in PM d' cost index scores from pretest to posttest.

The session by training condition [F (1, 73) = .28, p =.60, partial η^2 = .00], session by exposure condition [F (1, 73) = .51, p = .48, partial η^2 = .01], and session by training condition by exposure condition [F (1, 73) = .22, p = .64, partial η^2 = .00] interactions were not significant for the PM cue error cost index score.

RTs: WM and PM load. For the WM target RT cost analysis, the session by training condition [F (1, 72) = .05, p = .82, partial η^2 = .00], session by exposure condition [F (1, 72) = .05, p = .83, partial η^2 = .00], and session by training condition by exposure condition [F (1, 72) = 1.33, p = .25, partial η^2 = .02] interactions were not significant. For the WM nontarget RT cost analysis, the session by training condition [F (1, 72) = .17, p =.68, partial η^2 = .00], session by exposure condition [F (1, 72) = .09, p = .77, partial η^2 = .00], and session by training condition by exposure condition [F (1, 72) = .90, p = .35, partial η^2 = .01] interactions were not significant. For the PM target RT cost analysis, the session by training condition [F (1, 73) = .10, p = .76, partial η^2 = .00], session by exposure condition [F (1, 73) = 1.45, p = .23, partial η^2 = .02], and session by training condition by exposure condition [F (1, 73) = .04, p = .84, partial η^2 = .00] interactions were not significant. For the PM nontarget RT cost analysis, the session by training condition [F (1, 73) = .93, p = .34, partial η^2 = .01], session by exposure condition [F (1, 73) = .21, p = .65, partial η^2 = .00], and session by training condition by exposure condition [F (1, 73) = .94, p = .34, partial η^2 = .01] interactions were not significant. Although the session by exposure condition [F (1, 73) = .09, p = .77, partial η^2 = .00] and the session by training condition by exposure condition [F (1, 73) = .19, p =

.67, partial $\eta^2 = .00$] interactions were not significant for PM cue RT cost index scores, the session by training condition interaction was significant [F (1, 73) = 7.13, $p < .05$, partial $\eta^2 = .09$]. When training conditions were investigated separately, the training conditions showed a significant increase in PM cue RT cost scores from pretest to posttest, [F (1, 36) = 12.44, $p < .01$, partial $\eta^2 = .26$] while the practice intervention conditions showed a non-significant decrease in PM cue RT cost scores [F (1, 39) = .08, $p = .79$, partial $\eta^2 = .00$]. Follow-up analyses indicated that these effects were again primarily due significant changes in PM cue trials for the no-PM load 1-back conditions for practice [F (1, 39) = 8.18, $p < .01$, partial $\eta^2 = .17$] and training [F (1, 36) = 11.61, $p < .01$, partial $\eta^2 = .24$] while the change on PM cue trials for the PM condition were only significant for the training condition [F (1, 36) = 4.88, $p < .05$, partial $\eta^2 = .12$], but not the practice conditions [F (1, 39 = 1.72, $p = .20$, partial $\eta^2 = .04$].

PM/N-back Summary. It was predicted in Hypothesis 5a that all participants would improve from pretest to posttest, but an improvement was found for only one accuracy score and four out of seven RT scores. Also, in contrast to Hypothesis 5c, there was no posttest improvements observed in the high WM (2-back) or PM conditions. Hypothesis 5d predicted that the multi task training condition would show more significant improvements in performance from pretest to posttest than the other conditions. However, there were no interpretable effects of training or exposure conditions.

Table 20

Errors and RTs at Pretest and Posttest for All Participants on PM/N-back Measure.

Errors

Trial Type	Pre	Post	F (df)
1-back D’	3.75 (.48)	3.90 (.36)	(1, 75) = 6.27*
2-back D’	2.87 (.75)	2.95 (.59)	(1, 80) = .36 .
1-PM-back D’	3.19 (.80)	3.24 (.84)	(1, 81) = .35
1-PM-back PM cue trials	.16 (.23)	.17 (.24)	(1, 84) = .28

RTs

Trial Type	Pre	Post	F (df)
1-back target RT	753.25 (145.69)	704.92 (145.74)	(1, 76) = 14.20 ***
1-back nontarget RT	721.39 (117.53)	670.33 (115.14)	(1, 76) = 27.01 ***
2-back target RT	924.20 (194.03)	847.98 (186.70)	(1, 82) = 17.76 ***
2-back nontarget RT	804.51 (135.02)	798.00 (140.59)	(1, 82) = .25
1-PM-back target RT	1021.61 (179.22)	980.82 (178.73)	(1, 84) = 3.57
1-PM-back nontarget RT	1003.02 (198.57)	919.82 (169.82)	(1, 84) = 17.17 ***
1-PM-back PM cue RT	973.09 (217.84)	969.01 (230.85)	(1, 84) = .02

Note. Entries are means; standard deviations are in parentheses. Greater D’ scores are indicative of increased accuracy, greater 1-PM-back PM errors are indicative of decreased accuracy.

*** $p < .001$, ** $p < .01$., * $p < .05$.

Table 21.
Error Cost Scores at Pretest and Posttest for All Conditions on the PM/N-back Measure

Cost Score		Multi Task Training	Multi Task Practice	Multi Task Total
WM D' Cost:	Pre	1.02 (.71)	.85 (.77)	.92 (.74)
	Post	.87 (.69)	1.02 (.51)	.95 (.59)
	N	15	19	34
PM D' Cost:	Pre	.78 (.85)	.53 (1.07)	.64 (.97)
	Post	.64 (.70)	.76 (.93)	.70 (.82)
	N	16	19	35
PM Cue Cost:	Pre	.16 (.19)	.12 (.23)	.14 (.21)
	Post	.20 (.23)	.16 (.31)	.18 (.27)
	N	16	20	36
		Single Task Training	Single Task Practice	Single Task Total
WM D' Cost:	Pre	.98 (.98)	.82 (.58)	.90 (.81)
	Post	1.12 (.41)	.83 (.62)	.98 (.53)
	N	21	19	40
PM D' Cost:	Pre	.40 (.58)	.69 (.88)	.54 (.74)
	Post	.82 (1.02) *	.51 (.65)	.68 (.87)
	N	21	19	40
PM Cue Cost:	Pre	.13 (.18)	.19 (.26)	.15 (.22)
	Post	.15 (.21)	.15 (.19)	.15 (.20)
	N	21	20	41
		Training Total	Practice Total	All Participants
WM D' Cost:	Pre	.99 (.87)	.84 (.67)	.91 (.77)
	Post	1.02 (.55)	.92 (.57)	.97 (.56)
	N	36	38	74
PM D' Cost:	Pre	.56 (.73)	.61 (.97)	.59 (.85)
	Post	.74 (.89)	.63 (.80)	.69 (.84)
	N	37	38	75
PM Cue Cost:	Pre	.14 (.18)	.15 (.24)	.15 (.21)
	Post	.18 (.22)	.15 (.25)	.16 (.24)
	N	37	40	77

Note. Entries are means; standard deviations are in parentheses, *** $p < .001$, ** $p < .01$, * $p < .05$,

Table 22
RT Cost Scores at Pretest and Posttest for All WM conditions on the PM/N-back Measure

Cost Score		Multi Task Training	Multi Task Practice	Multi Task Total
WM Target RT Cost:				
	Pre	212.06 (172.97)	152.33 (165.29)	178.87 (169.00)
	Post	177.199.43)	179.86 (204.55)	178.84 (199.40)
	N	16	20	36
WM Nontarget RT Cost:				
	Pre	87.06 (110.16)	66.95 (66.57)	75.89 (87.39)
	Post	113.75 (134.58)	107.90 (77.81)	110.50 (105.16) **
	N	16	20	36
		Single Task Training	Single Task Practice	Single Task Total
WM Target RT Cost:				
	Pre	151.76 (193.39)	210.21 (120.27)	179.53 (163.49)
	Post	178.79 (142.88)	195.45 (171.51)	186.70 (155.30)
	N	21	19	40
WM Nontarget RT Cost:				
	Pre	54.07 (132.12)	145.76 (139.33)	97.63 (141.64)
	Post	113.69 (97.73) **	169.29 (144.36)	140.10 (123.72)**
	N	21	19	19
		Training Total	Practice Total	All Participants
WM Target RT Cost:				
	Pre	177.84 (184.83)	180.53 (146.19)	179.22 (165.01)
	Post	178.26 (167.07)	187.45 (186.86)	182.98 (176.38)
	N	37	39	76
WM Nontarget RT Cost:				
	Pre	68.34 (122.59)	105.35 (113.74)	87.33 (118.81)
	Post	113.72 (113.37) **	137.81 (117.75)	126.08 (115.50) ***
	N	37	39	76

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Table 23
RT Cost Scores at Pretest and Posttest for All PM conditions on the PM/N-back Measure

Cost Score		Multi Task Training	Multi Task Practice	Multi Task Total
PM Target RT Cost:	Pre	329.47 (185.03)	283.23 (178.17)	303.78 (180.13)
	Post	315.56 (149.19)	263.72 (208.79)	286.76 (184.08)
	N	16	20	36
PM Nontarget RT Cost:	Pre	308.56 (100.85)	282.45 (131.49)	294.06 (117.98)
	Post	166.84 (109.91)	241.00 (163.93)	252.49 (141.19)
	N	16	20	36
PM Cue RT Cost:	Pre	245.69 (182.02)	277.97 (165.63)	263.62 (171.33)
	Post	414.75 (200.26) **	262.67 (164.13)	330.26 (194.13)
	N	16	20	36
		Single Task Training	Single Task Practice	Single Task Total
PM Target RT Cost:	Pre	226.62 (119.74)	274.50 (153.88)	249.98 (137.86)
	Post	281.60 (146.24) **	304.50 (126.53)	292.77 (135.77)
	N	21	20	41
PM Nontarget RT Cost:	Pre	231.76 (119.93)	329.23 (185.85)	279.30 (161.34)
	Post	250.00 (103.41)	265.95 (143.06)	258.04 (123.00)
	N	21	20	41
PM Cue RT Cost:	Pre	214.10 (213.27)	295.74 (259.15)	253.92 (237.42)
	Post	339.79 (208.08) **	288.35 (267.65)	314.70 (237.39)
	N	21	20	41
		Training Total	Practice Total	All Participants
PM Target RT Cost:	Pre	271.09 (157.79)	278.86 (164.38)	275.13 (160.24)
	Post	296.28 (146.45)	284.11 (171.65)	289.96 (159.11)
	N	37	40	77
PM Nontarget RT Cost:	Pre	264.97 (117.12)	305.84 (160.66)	286.20 (142.01)
	Post	257.57 (105.08)	253.48 (152.39)	255.44 (130.96)
	N	37	40	77
PM Cue RT Cost:	Pre	227.76 (198.37)	286.85 (214.85)	258.46 (207.87)
	Post	372.20 (205.38) ***	275.51 (219.53)	321.97 (216.97) **
	N	37	40	77

Note. Entries are means; standard deviations are in parentheses.

**** $p < .001$, *** $p < .01$, ** $p < .05$, * $p = .05$

Hypothesis 6: Performance on the DEX

Hypothesis 6a. Given recent evidence that explicit training aimed to improve goal maintenance abilities in real-life situations improved DEX scores (Levine et al., 2007), it was hypothesized that DEX total scores would decline from pretest to posttest.

Although I conducted a factor analysis to determine appropriate factor scores for the DEX, these analyses were inconclusive. Still, a recent study showed conclusive evidence that the twenty questions assessing executive complaints on the DEX are best represented as a single factor, the sum of all items (Gerstorf et al., 2008). Thus, hypothesis 6a was tested with an ANOVA comparing the DEX total scores with training condition and exposure condition as between-subjects variables and session as a within-subjects variable. Table 24 shows DEX total scores for all exposure and training condition combinations.

The main effect of session was not significant [F (1, 80) = .01, p = .94, partial η^2 = .00], suggesting that all participants did not show a decline in DEX scores from pretest to posttest. The session by training condition [F (1, 80) = .83, p = .36, partial η^2 = .01] and session by exposure condition [F (1, 80) = .22, p = .64, partial η^2 = .00] interactions were not significant. Still, a session by training condition by exposure condition was uncovered, [F (1, 80) = 5.27, p < .05, partial η^2 = .06], suggesting that degree of change on the DEX varied as a function of training and exposure conditions. Therefore, each training/exposure condition combination was examined separately for change from pretest to posttest. DEX total scores showed a non-significant decrease from pretest to posttest in the single task practice [F (1, 22) = 2.55, p = .12, partial η^2 = .10] and multi task training [F (1, 20) = 1.15, p = .30, partial η^2 = .05] conditions, but the single task training [F(1, 18) = 2.62, p = .12, partial η^2 = .13] and multi task practice [F (1, 20) = .18, p = .68, partial η^2 = .01] conditions showed a non-significant increase from pretest to posttest. Due to the lack of significant change in any of the conditions, it cannot be concluded that the training or exposure condition interventions affected DEX total scores.

Hypothesis 6b. It was hypothesized that a quantitative measure of improvement in goal maintenance ability from pretest to posttest would show a positive relationship with a quantitative measure of decline in self-rating scores of daily executive control dysfunction.

Regression analyses were used to derive the residual scores representing change in performance from pretest to posttest for each all cognitive tests (i.e., AX-CPT, Dot-CPT, task switching, modified Sternberg, and PM/N-back) and the DEX using all test variables listed in Table 2. It was hypothesized that a positive correlation between DEX residual scores and the cognitive residual scores would indicate that self-rating of executive dysfunction decreases with improvement on executive control task.

The DEX residual score only correlated with three cognitive residual scores: task switching mixing RT cost [r = .25, p < .05], task switching mixed repeat RTs [r = .26, p < .05], and 1-PM-back nontarget RT [r = .27, p < .05]. Finding only three significant correlations out of forty seven tests suggest the possibility of a false positive (and indeed these correlations are weak enough that they do not survive correction for multiple comparisons). Thus, these results are convergent with the findings described in the Hypothesis 1 section suggesting that self-ratings on the DEX do not relate well to performance on laboratory-based executive control tasks, or change over time on these tasks.

DEX Summary. Although Hypothesis 6a predicted that DEX scores would decrease from pretest to posttest, no overall change in DEX scores for all participants was found and differences in decline among training and exposure conditions were not interpretable. Hypothesis 6b predicted that change in DEX total scores from pretest to posttest would be related to change in cognitive test performance from pretest to posttest, but only three out of forty seven possible correlations were significantly correlated, and therefore, it was concluded that the DEX does not relate to change in performance over time.

Table 24.

Total Scores at Pretest and Posttest for All Conditions on the DEX

	Multi Task Training	Multi Task Practice	Multi Task Total
Pre	15.24 (10.74)	14.00 (9.05)	14.62 (9.83)
Post	14.05 (9.31)	14.67 (10.06)	14.36 (9.58)
N	21	21	42
	Single Task Training	Single Task Practice	Single Task Total
Pre	14.95 (9.06)	12.74 (6.98)	13.74 (7.97)
Post	17.47 (11.31)	10.96 (6.32)	13.90 (9.40)
N	19	23	42
	Training Total	Practice Total	All Participants
Pre	15.10 (9.85)	13.34 (7.96)	14.18 (8.90)
Post	15.68 (10.32)	12.73 (8.43)	14.13 (9.44)
N	40	44	84

Note. Entries are means; standard deviations are in parentheses.

**** p < .001, *** p < .01, ** p < .05, * p = .05

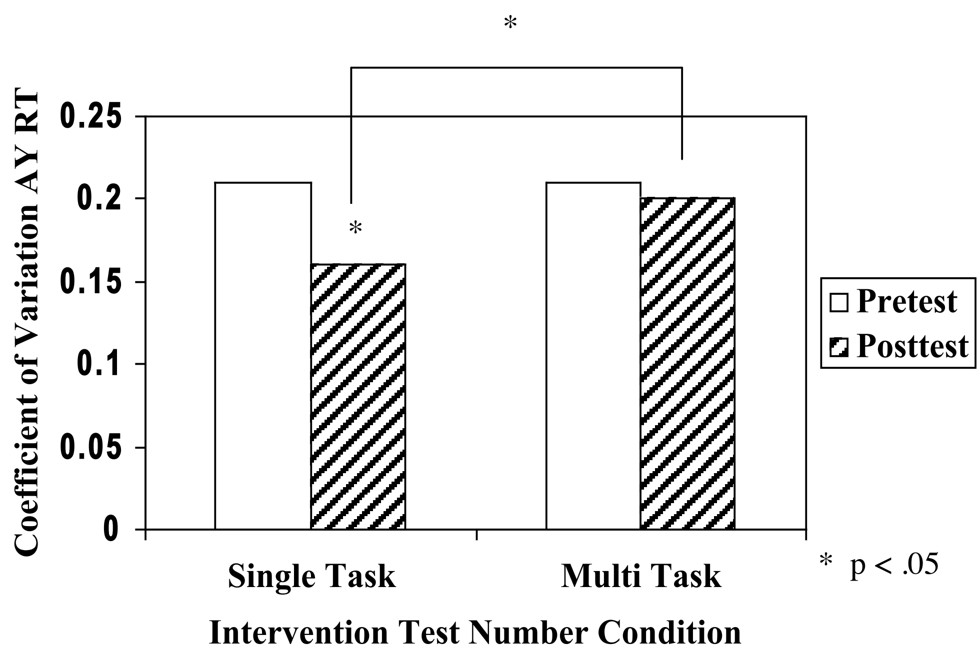
Supplemental Analyses

Examination of Variability on AX-CPT. The results presented in the section for Hypothesis 2 outlined how performance on AX-CPT errors and median RTs change as a result of the various interventions, but a question remains about whether the variability in RTs changes after participants have undergone these various interventions. Furthermore, one might argue that an effective intervention should not only change the proportion of errors and RTs, but also lead to increased consistency in performance. Thus, it is important to evaluate consistency of performance change in order to determine whether the intervention changes performance by way of a permanent shift in the cognitive process used, which would likely result in more consistent performance. Thus, the coefficient of variation (standard deviation/mean) was computed for AY and BX RT measures at pretest and posttest. When these coefficient of variation scores were compared between training and exposure conditions at posttest, a significant difference was found between AY coefficient of variation between participants in the single-task and multi task conditions, [F (1, 84) = 5.02, p < .05, partial η^2 = .06]. RT variation was lower at posttest for participants single task conditions (M = .16) compared with the multi task conditions (M = .20). When the single task conditions were examined separately, there was a significant change from pretest to posttest for AY coefficient of variation scores, [F (1, 43) = 5.83, p = .01, partial η^2 = .12], but the change for multi task conditions was not significant [F (1, 41) = .06, p = .80, partial η^2 = .00]. See Figure 4 for a graphical representation of changes in the AY RT coefficient of variation in the exposure conditions. There were no significant differences between training conditions for AY or BX trials and no differences between exposure conditions for BX trials at posttest.

A question arises about whether performance becomes more or less stable as participants become more proactive on the AX-CPT. Therefore, I was motivated to investigate how proactive change in performance from pretest to posttest relates with consistency in performance from pretest to posttest. Thus, finding that a change in performance from pretest to posttest is related to more consistent performance would suggest that the intervention brought about a change in the way that the task is consistently approached and would lead to effective long-term changes. Alternatively, finding that change in performance is related to less consistent performance would suggest that the means by which participants are improving their performance is apt to change over time and is more susceptible to situational factors such as fluctuating attention.

Specifically, the relationship between a coefficient of variation change indices (i.e., posttest – pretest) for RTs on AY and BX trials and proactive change indices (i.e., posttest – pretest) for RT on the AX-CPT were examined. When all participants were analyzed, there was a significantly positive relationship between proactive change RT index and BX RT coefficient of variation change index [$r = .34$, $p < .01$], suggesting that as the proactive context processing RT index increases, BX RTs show more variability. The direction of this relationship is opposite to that which would be expected as it is anticipated that more proactive performance would lead to less variable and more consistent performance. When these correlations were examined separately for training and exposure interventions, participants in the practice conditions showed a significantly stronger positive relationship between BX RT coefficient of variation change score and proactive RT change score ($r = .66$, $p < .001$) than did participants in the training conditions ($r = .09$, $p = .60$; $z = -3.06$, $p = .01$). When exposure condition was examined separately, the relationship uncovered between BX RT coefficient of variation change scores and proactive RT change scores did not differ significantly for participants in the single task conditions ($r = .41$, $p < .01$) and those in the multi task conditions ($r = .30$, $p = .07$). Thus, for all participants except those in the training conditions, an increase in proactive RT performance from pretest to posttest is significantly related to an increase in variability in BX RT. This suggests that, compared with practice interventions, training interventions lead to less variable BX RT performance at posttest compared with pretest.

Figure 4



Pretest and Posttest AX-CPT AY RT Coefficient of Variation Scores

CHAPTER SIX – DISCUSSION

Overview

The goal of the present study was to evaluate training (i.e., practice versus training) and exposure (i.e., single task versus multi task) intervention conditions in order to determine the most effective way to improve goal maintenance abilities on the task trained and transfer tasks in older adults. The present investigation attempted to address the following questions: (1) will the strategy training procedure used in our previous study (Paxton et al., 2006) with the AX-CPT improve performance more than practice interventions on the AX-CPT and other executive control tasks requiring goal maintenance abilities; (2) will the single task conditions involving extended experience with only the AX-CPT or multi task conditions with three goal maintenance tasks show differences in performance from pretest to posttest; (3) will benefits in performance derived from practice and/or strategy training interventions transfer to untrained tasks; (4) will transfer be facilitated by the multi task training condition which was designed to provide participants with experience flexibly transferring a goal maintenance strategy to multiple tasks during training; and (5) will training and/or exposure conditions used during intervention sessions improve performance using different cognitive mechanisms?

Pretest Performance

One of the primary aims of this study was to assess the effectiveness of various interventions in improving performance on the near and far transfer tasks. Before discussing these effects, it is important to examine the relationship between performance on these tests at pretest to assess the strength of relationship between the test used in all interventions, the AX-CPT, and the near and far transfer testes. Specifically, if the Dot-CPT is an appropriate test of near transfer, then we would expect that performance on this test would show stronger correlations with the trained task, the AX-CPT, compared with the far transfer task, the PM/N-back.

Relationship between the AX-CPT and near and far transfer tasks at pretest. The Dot-CPT task was chosen as the test to evaluate near transfer because it is identical to the AX-CPT with dot patterns replacing letters as stimuli. The PM/N-back task was chosen as a measure of far transfer because it does not resemble the AX-CPT in structure, but entails three conditions with different levels of difficulty and demands on goal maintenance abilities. It was hypothesized that, compared with the PM/N-back, the Dot-CPT would show a stronger relationship with the AX-CPT due to the similarity in task structure. Proactive performance on the AX-CPT was significantly related to more proactive performance on the Dot-CPT. Even though some scores on the PM/N-back were significantly related to some scores on the AX-CPT, the significant correlations did not suggest that the PM/N-back was related to a proactive pattern of performance on the AX-CPT (i.e., only one significant correlation between PM/N-back score and AX-CPT proactive index scores) on the AX-CPT. Thus, we concluded that: 1) the Dot-CPT was a more effective measure of near transfer due to a correspondence between proactive performance on the AX-CPT and Dot-CPT, and 2) the PM/N-back was an appropriate measure of far transfer because it correlated weakly with some indices of AX-CPT performance, but was not as closely related as the near transfer measure.

Change in performance from pretest to posttest in all participants.

Performance on all tasks except the DEX showed some evidence of significant improvement (i.e., decrease in error or RT scores or more proactive pattern on the AX-CPT or Dot-CPT trials when AY and BX trials were compared directly) from pretest to posttest. Significant improvement on tasks was observed for some trial types, but not others. For instance, on the AX-CPT, BX errors and RTs decreased significant from pretest to posttest, while AY trials showed no significant change for all participants. The lack of significant change in AX-CPT AY errors from pretest to posttest differs from results of our previous study (Paxton et al., 2006) where AY errors showed a statistically significant increase. A question arises about why we did not see a significant increase in AY errors, and the possible explanations for this may be found in examining the differences between this study and the previous study. Unlike the previous study where the posttest session occurred immediately after the training or practice intervention, the current study required that participants maintain what they learned over the course of days or weeks. Participants may not have been able to maintain any changes in AY errors on the AX-CPT over the course of time. This result suggests that improvements in the ability to use proactive control to inhibit a prepotent response based on stimulus response associations on BX trials may be more sustainable than improvements in the ability to use proactive control to predict upcoming events (AY trials).

Effects of Interventions on AX-CPT Performance

Effects of training on AX-CPT performance. As described above, one of the goals of this study was to determine whether proactive training was more effective than practice in leading to a more proactive pattern of performance on the task trained, the

AX-CPT. As shown by the primary and supplementary results for Hypothesis 2, the training condition can be concluded to be preferable to the practice conditions in terms of: 1) improvement in proactive context processing RT index on the AX-CPT; 2) a non-significant improvement in proactive pattern on AY RTs (driven by multi task training condition); and 3) more stable and consistent BX RT scores when AX-CPT RTs became more proactive from pretest to posttest. I found no evidence of practice conditions being preferable to training conditions or evidence of training conditions producing reactive performance. Thus, it can be concluded that training interventions were more effective than practice intervention in improving proactive context processing performance when measured with scores assessing the degree to which AY and BX scores changed in divergent directions from pretest to posttest.

Finding that training interventions were significantly different than practice interventions in terms of improving proactive context processing RT scores was consistent with our theoretically-based predictions. Still, the pattern was different from that observed in a previous study, in which the training and practice groups were also compared in terms of improvements in proactive AX-CPT performance (Paxton et al., 2006). In that study, we could not establish that the training group showed significantly greater benefits than the practice group. It could be that the different patterns of results uncovered between training and practice groups in the current study was due to having slightly greater power to detect differences in the current study compared with the previous study. Participants in the training conditions (i.e., single task training and multi task training) totaled 42 participants with 44 participants in the practice conditions (i.e., single task practice and multi task practice) whereas in the previous study, there were 33 participants in the training group, 36 participants in the instruction control group, and 36 participants in the practice control group. Also, as mentioned earlier, the current study required that participants maintain what they learned over the course of days or weeks whereas the previous study assessed training and practice effects directly after the intervention. Furthermore, our finding that training interventions led to significantly greater proactive improvement in the current study when AY and BX performance patterns were directly compared, but not the previous study, leads to a few suggestions. First, these results suggest that training and practice may not produce different patterns of performance when maintenance is not required (in the previous study), but training is more effective in improving proactive performance as measured in BX errors and RTs or the pattern of performance in AY and BX trials when maintenance is required (in the current study). Another difference between the two studies is that the current study involved two intervention sessions whereas the previous study involved one intervention session. Thus, it could be that the process of learning the strategy training instructions in the first intervention study followed by retrieval and more practice in the second intervention session led to better encoding of a more proactive strategy, which resulted in significant improvement when AY and BX trials were directly compared in analyses.

Effects of exposure condition on AX-CPT Performance. One aim of this study was to determine whether more extensive experience with the AX-CPT as provided by the single task conditions would produce greater proactive performance benefits on the AX-CPT. The results demonstrated that single task conditions were preferable to multi task conditions in terms of: 1) non-specific decrease in RT scores from pretest to posttest; and 2) increasing consistency of performance on AY RT at posttest. There was also a trend level difference between single and multi task conditions in BX RTs. Still, enhanced experience with the AX-CPT provided by the single tasks conditions were not found to be preferable to multi task conditions in terms of changes in the pattern of performance on AY RTs from pretest to posttest. Specifically, participants in the single task conditions, but not the multi task condition, showed a significant decrease in AY RTs, which is consistent with a shift toward a more reactive instead of proactive pattern of performance. Thus, compared with multi task conditions, single task conditions were found to be more effective in producing proactive patterns of performance in BX RT scores and increasing consistency in AY RT, but led to more reactive performance on AY RTs.

Ideally, an effective intervention would produce more proactive performance on both AY and BX trials, but the single task condition only improved proactive performance on BX RTs. The faster AY RT performance combined with no change in AY error performance suggests results was not due to a speed accuracy trade-off, but is indicative of faster and more accurate performance. Given that these findings are counter to hypotheses and prior results (Paxton et al., 2006), it is difficult to determine how enhanced experience with the AX-CPT produced more reactive performance on AY trials. It is important to consider that these findings could be due to some aspect of the study design. For instance, participants in the single task conditions were exposed to 600 AX-CPT trials over the course of two intervention sessions. It could be that participants initially become more proactive and produced more AY errors and longer AY RTs, but with greater amounts of practice, they may have realized that they were responding incorrectly and put effort into overcoming the bias to then self-correct. It is also possible that participants became more proactive with experience, but were unable to maintain this change from the time of the last intervention session until the posttest session.

Effects of Interventions on Task Switching and Modified Sternberg Performance

Effects of exposure conditions on task switching and modified Sternberg performance. In contrast to my hypotheses, there were no significant differences between single and multi task conditions in term of change in cost scores on the task switching or modified Sternberg measures from pretest to posttest. It was surprising that the enhanced experience provided by the multi task conditions did not lead to an improvement in either errors or RT on the task switching or modified Sternberg measures. It is possible that the lack of significant change is due to participants making few errors at pretest, and therefore, not showing much room for improvement.

Effects of training conditions on task switching and modified Sternberg performance. Also, counter to hypotheses, the training intervention did not have a significant effect on error or RT performance on the task switching or modified Sternberg tasks. The training procedures were designed to be as similar as possible to the strategy training procedures on the AX-CPT in terms of instructing participants to use information presented early in each trial in order to prepare in advance for later responses. Even though the strategy training interventions were effective in producing more proactive performance on the AX-CPT, the lack of significant change on the task switching and modified Sternberg tasks suggests that the strategy training procedures designed for these tasks were not effective. It is possible that training proactive performance is not as straightforward on other tasks as it is on the AX-CPT, in which a very specific pattern of performance has been identified to be consistent with proactive performance. It is interesting that visual inspection of RT values reveal that, compared with participants in the training conditions, participants in the practice conditions showed greater decreases in RTs from pretest to posttest. This numerical pattern hints at the possibility that the training was detrimental to performance and interfered with the ability to effectively use spontaneously developed strategies for performing the tasks. The training procedures developed for both the task switching and modified Sternberg required that participants first state aloud the information that would be used to make a response (e.g., whether they are identifying the number or letter of the pair for task switching and the four words presented for the modified Sternberg). Then participants were required to practice stating aloud and silently the specific stimuli that would correspond with a target response (e.g., if odd, then red for the task switching test and the four words for the modified Sternberg). Even though the strategy training procedures were consistent with an approach that would lead to correct responses, it could be that having to state these response contingencies as required by the training procedures interfered with the ability to perform the task quickly and effectively.

Effects of Interventions on Dot-CPT Performance (Near Transfer)

It was hypothesized that participants in the multi task training condition would show the greatest improvement in proactive performance on the Dot-CPT due to this condition being designed to train participants to flexibly apply the same strategy to different tasks. However, the training conditions did not differ significantly in their influence on proactive performance on the Dot-CPT. Thus, even though the strategy training procedures were found to be effective for increasing proactive RT performance on the AX-CPT, these benefits of learning to use a proactive strategy on the AX-CPT showed minimal transfer to the Dot-CPT. Specifically, there were hints that training was effective in producing a significant increase in Dot-CPT proactive error index scores, but there was not a significant difference between proactive error index scores between training and practice participants. We also hypothesized that the multi task conditions would be more effective than the single task conditions in leading to enhanced performance on the Dot-CPT. However, in contrast, the single task conditions were found to be preferable to multi task conditions in terms of: 1) increasing proactive performance on proactive context processing error scores; 2) increasing proactive performance in terms of composite proactive context processing index; 3) less reactive performance on AY RTs compared with multi task participants; and 4) showing a greater decrease in BX errors when AY and BX errors were analyzed together. Thus, in conclusion, participants in the single task conditions showed more proactive error performance on the Dot-CPT when the degree to which AY and BX error scores changed in divergent directions was assessed with proactive index scores or within a single ANOVA. Still, as noted in the results section, these results for the single task conditions should be interpreted with caution due to the possibility that they were driven by pretest differences.

Although we hypothesized that strategy training with multiple tasks would facilitate transfer, it is still encouraging that the additional experience on the AX-CPT provided by the single task condition showed some evidence of more proactive BX error performance on a task with similar structure, but different stimuli, the Dot-CPT. Given that the AX-CPT and Dot-CPT have different stimuli, we can conclude that participants in the single task conditions learned something more general than stimulus response mappings specific to the letter stimuli on the AX-CPT. Thus, it could be that experience with the AX-CPT led to the adoption of a general proactive strategy such that initial cue information was attended to, maintained, and integrated into an action plan that is used on the Dot-CPT to lead to more proactive error performance. Alternatively, it could be that participants learn to apply a strategy specific to the structure of the AX-CPT and Dot-CPT such as knowing that when any letter other than A appears, prepare for a nontarget response on the AX-CPT, which is transferred and adapted where the appropriate Dot-CPT symbols replace the letters. The results discussed thus far do not allow for differentiation between these two possibilities.

Single task training as an effective intervention for AX-CPT and Dot-CPT performance? As reviewed above, AX-CPT results suggested that the single task training condition may be preferable for improving proactive performance in BX RT and composite proactive scores, but there were no differences between the two training conditions (single task training vs. multi task training) in terms of effectiveness in improving proactive performance on context processing RT index scores, which accounts for both AY and BX RT performance on the AX-CPT. The single task training condition was found to be the only training/exposure condition combination that led to a significant increase in Dot-CPT proactive error index scores and a significant increase in Dot-CPT composite proactive index scores from pretest to posttest. Thus, although not evident in the omnibus analyses, these results demonstrate that the single task training condition produces significant increases in proactive performance on the trained task (i.e., AX-CPT BX RTs and composite proactive index score) and the near transfer task (i.e., Dot-CPT proactive error index and composite proactive index score). It is encouraging that the same combination of increased experience and strategy training on the AX-CPT aided performance on both the AX-CPT and Dot-CPT tasks.

Effects of Interventions on PM/N-back Performance (Far Transfer)

One of the primary questions addressed in this study was whether benefits of extended exposure or strategy training proven to benefit AX-CPT performance in the previous study (Paxton et al., 2006) would transfer to an untrained task. Further, it was hypothesized that participants in the multi task training condition would show the greatest improvement on the PM/N-back. Although we found that some of the PM/N-back scores improved from pretest to posttest, there were no interpretable findings demonstrating that training or exposure conditions affected performance on this far transfer test. Failure to find any enhanced effect for multi task or training conditions suggests that these interventions did not result in either the learning of an effective strategy and or the ability to flexibly apply an effective strategy to the PM/N-back. The inability of the our procedure to produce far transfer measured by the PM/N-back could be due to the procedure used in the intervention conditions or the far transfer task used, which will be addressed in the following section.

Possible explanations for lack of far transfer: cognitive tasks assessed. In this section, I will discuss differences between the tasks used as a possible explanation as to why skills gained through additional experience with the AX-CPT showed some evidence of transfer to the Dot-CPT, but not the PM/N-back. The AX-CPT and Dot-CPT are very similar in structure with a single cue and single probe and were designed to assess whether participants develop a proactive bias by expecting to see an X probe when an A cue appears. This bias is very specific to this task as it is believed to be created by the greater proportion of trials where an X probe follows an A probe. Thus, on the AX-CPT and Dot-CPT, proactive performance is indicated by a very specific pattern of performance, increased errors and RTs on AY trials and decreased errors and RTs on BX trials. On the other hand, the PM/N-back task requires that participants remember the overall goal of the task (e.g., make a target response when a previously presented word appears) and maintain the identity of the stimuli in working memory (e.g., the last word was "tree," if the next word is "tree," then press the target button). Thus, more proactive performance on the PM/N-back task involves remembering the task instructions and stimuli, which is assumed to lead to a general decrease in errors and RT scores. Still, the PM/N-back task was structured quite differently from the AX-CPT and Dot-CPT, and may be less selective in detecting patterns of performance associated with proactive control. Instead, effective cognitive control on the PM/N-back would be expected to improve performance on all types of task trials. Thus, it is possible that even in the training conditions, participants were not able to generalize enough about common features between the AX-CPT and PM/N-back in order to apply a proactive strategy to the PM/N-back task.

Conclusions about near and far transfer. The inability of the interventions to facilitate far transfer paired with some evidence of near transfer achieved for participants in single task conditions (when AY and BX performance was compared) allows for conclusions about the cognitive processes that were used to facilitate near transfer. Thus, the improvement found in Dot-CPT proactive error index scores after extended exposure to the AX-CPT suggests that it is possible for participants to gain a skill (e.g., either stimulus response mapping or a general strategy) on the AX-CPT that can be transferred to another similar task. In contrast, the lack of evidence for far transfer to the PM/N-back tasks suggests that what is learned on the AX-CPT and transferred to the Dot-CPT may be specific to these two tasks, as a result of their very similar structure. Given that what was learned on the AX-CPT in the single task condition showed some evidence of transfer to the Dot-CPT task, it is safest to assume that participants learned a stimulus response associations on the AX-CPT through extended experience that could be altered to apply to stimuli on the Dot-CPT.

These findings are consistent with a hypothesis generated based on several previous studies that tasks requiring procedural skills (e.g., AX-CPT) will produce limited transfer whereas tasks based on facts or declarative information (e.g., learning facts with associative strategies) will produce more robust transfer (Healy, 2007). Also, our findings of greater near transfer than far transfer agree with several previous studies finding that strategy training and/or practice interventions only benefit untrained tasks that are very similar in structure to the trained tasks (Baltes, Dittmann-Kohli, & Kliegl, 1986; Willis, Blieszner, & Baltes, 1981). Interestingly, in a recent study, training lasting 45 days that consisted of practicing working memory tasks resulted in improvement in the task trained and transfer to two near transfer tasks: 1.) a working memory with different stimuli and similar structure and 2.) the same task with increased difficulty, but did not result in far transfer to a task with dissimilar stimuli and structure (Li et al., 2008). Additionally, a recent study with older adults over the age of 80 used visual working memory training tasks and found improvement on the trained task, but only near transfer to untrained visual working memory tasks (Buschkuehl et al., 2008). They did not find transfer to verbal working memory tasks (e.g., digit span), and interpreted the failure to find transfer effects to a different type of working memory task as being due to the possibility that the participants may have developed strategies specific to the training tasks during the training phase (Buschkuehl et al., 2008).. The results of these previous studies are similar to our current results in finding limited transfer, which leaves lingering questions about the cognitive mechanisms enabling near transfer, and the cognitive mechanisms that were not used, but were necessary for far transfer to be achieved.

DEX Performance

Relationship between self-reported executive complaints on the DEX and performance on executive control tasks. It was hypothesized that participants' self-reported executive control abilities in daily life as measured by the DEX would correlate negatively with performance on tests of goal maintenance abilities at pretest. The DEX total scores only correlated significantly with one measure of goal maintenance ability out of thirty-six possible correlations. Therefore, it was concluded that the DEX total scores did not relate to goal maintenance abilities as assessed by the tasks included in this study. Thus, the DEX may not be sensitive to objective cognitive performance, which may be due to the limitations of the measures used in this study or a general weakness of this self-report instrument or a weakness of self-report measures more generally. The lack of a significant relationship observed between DEX self-rating scores and objective cognitive measures in the current study was also consistent with previous studies. In studies with neurologically normal participants across the lifespan using simple DEX scores (Gerstorf et al., 2008) and other studies using DEX factors studies, very few relationships have been uncovered between DEX performance and objective cognitive measures (Chan, 2001; Amieva et al., 2003). Furthermore, in a study of neurologically impaired participants, there was only one significant correlation when DEX self-report scores were correlated with neuropsychological test scores. In contrast, neuropsychological tests scores did tend to correlate significantly with DEX ratings made by caregivers (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). These results demonstrate the potential limitations of self-report measures, and suggest that self-ratings on the DEX do not correspond strongly with performance on cognitive tests.

Change in DEX performance from pretest to posttest. In contrast to hypotheses, DEX performance did not change significantly from pretest to posttest for all participants and change in DEX scores from pretest to posttest was not affected in an interpretable way by training or exposure conditions. Also, change in DEX scores was not found to relate significantly to change in performance on the cognitive measures. Thus, this finding is not surprising given that DEX scores did not relate to pretest performance and provides further evidence that self-reported executive control does not relate to objective scores on the tests of executive control used in this study.

Conclusions about Strategy Training Versus Practice

There was some evidence that strategy training interventions were found to be more effective than practice interventions. Strategy training on the AX-CPT was found to lead to a significantly more proactive pattern of RT performance on the AX-CPT test when the degree with which the pattern of performance observed between AY and BX scores reflected a proactive pattern. There were hints that strategy training led to more proactive error performance on the near transfer task (Dot-CPT), but did not lead to a more proactive pattern of performance on the Dot-CPT than practice interventions. Also, there were no effects of strategy training on the far transfer task. Also, as discussed in the section for the task switching and modified Sternberg tasks, results suggest that the training procedures developed for task switching and modified Sternberg tests were not effective in improving performance, but the results do not provide insight as to why the strategy training procedures were not beneficial. These findings suggest that strategy training produced the greatest benefit on one of the specific tasks that was trained.

One of the primary questions that motivated the development of this study was whether training and practice lead to improvements in proactive performance on the AX-CPT using similar or different cognitive mechanisms. Thus, the transfer tasks were included with the aim of determining whether participants in the training and practice intervention conditions used similar or different cognitive mechanisms. Unfortunately, there were no differences between training and practice interventions in ability to facilitate transfer to untrained tasks. These findings that strategy training only benefited performance on the task trained when a specific pattern of performance was examined is consistent with previous results showing that transfer does not always occur after strategy training (Ball et al., 2002; Healy, Wohldmann, Parker, & Bourne, 2005; Healy, Wohldmann, Sutton, & Bourne, 2006). Thus, it is impossible to draw interpretable conclusions about the cognitive mechanisms used in order to produce more proactive performance on the AX-CPT. Thus, the primary conclusion that can be drawn about the strategy training intervention is that it results in some improvement on the task trained when analyses are aimed to evaluate whether the results show a specific hypothesized pattern of increased AY scores and decreased BX scores. This finding is consistent with previous studies in older adults showing that strategy training improves the specific task trained whether it be an executive control task (Levine et al., 2007), reasoning task (Ball et al, 2002; Plemons et al., 1978; Willis et al., 1981), or a memory task (Scogin et al., 1985; Verhaeghen et al., 1992; Kliegl et al., 1990). Finding that AX-CPT strategy training intervention did not transfer to untrained tasks suggests that the proactive strategy training procedure did not lead to the development of a general proactive strategy that can be flexibly applied to novel tasks.

Our results suggest that the strategy training procedure employed in the current study provided a very specific sequence of actions to be made in response to specific stimuli. This procedure is similar to skill learning that relies only on mental representation of goals and the learning of specific steps to execute in order to perform well (i.e., pay attention to whether the letter is A; if the letter is A, then say "if x, then red'). A question arises about whether all strategy training procedures are so specific to the task trained that they do not lead to generalizable benefits. Interestingly, in a recent study, performance on a complex task was compared between participants given a list of actions to follow and participants given a sequence of steps with environmental contingencies for actions (Taatgen, Huss, Dickison, & Anderson, 2008). The latter condition was designed to give general, non-specific instructions that would be flexible enough to be adapted to environmental cues and unanticipated circumstances. Thus, participants in the latter condition were more accurate and faster. Interestingly, being given less specific instructions that allowed for adaptation based on environmental input lead to more flexibility and generalization as evidenced through more complete solutions and faster performance. These results and the theoretical reasoning supporting them suggest that providing a simpler, more adaptable strategy is more likely to result in transfer effects. Thus, it could be that the strategy training procedures used on the all training tests in the current study were too specific to be easily adapted and transferred to a new task.

Interpretation of limited intervention effects.

Although the performance for all participants (regardless of intervention condition) changed significantly from pretest to posttest on several measures, there were few significant interactions between intervention condition and change in performance from pretest to posttest. As stated previously, strategy training was only found to be more effective than practice when a specific pattern of performance was investigated on the trained task, the AX-CPT. Likewise, enhanced exposure to the trained task led to a significant improvement on the near transfer task, the Dot-CPT, but only when a specific pattern of performance was assessed. Moreover, these results need to be interpreted with caution due to pretest differences in performance. The lack of transfer suggests that neither training nor practice with the AX-CPT lead to widely generalizable skills, because the greatest benefit of training and/or practice with the AX-CPT was found on a task with identical structure, the Dot-CPT. These results suggest that what is gained through training and/or practice with the AX-CPT are skills that are highly specific to the structure and demands of the AX-CPT. These findings are consistent with results showing that proceduralized tasks show very little transfer and show performance benefits when the same skills are required at initial test and outcome assessment (Healy et al., 1990). For example, a study showed that improvements on a skill learning task were only found when participants practiced with the exact same task (e.g., prose letter detection instead of detection of letters in scrambled form), suggesting that there is not much adaptability in the skills learned (Healy et al., 1990). Furthermore, results from a study examining retention differences in aspects of a decoding task requiring abstract versus procedural processing suggested that procedural processing leads to better retention of the specific skill, whereas abstract processing leads to more generalizable skills that are not retained (Clawson, Healy, Ericsson, & Bourne, 2001). Thus, the researchers responsible for these prior studies have asserted that retention of learning is best facilitated by learning a specific proceduralized skill instead of one that is generalizable. Additionally, this prior work also found that the expectations that participants develop during training have a greater influence on post-training performance than any pre-training expectations (Bourne, Healy, Pauli, Parker, & Birbaumer, 2005). This suggests that the actual content and structure of the training procedure has an effect on the performance gains that arise from it.

Overall, these patterns from the skill training literature are highly consistent with the findings from the current study, where proceduralized learning of the AX-CPT through strategy training or practice may have best facilitated performance on that very skill (AX-CPT performance) rather than a more generalizable set of skills or processes. Thus, training of the AX-CPT may have improved proceduralized AX-CPT skills, which led to retention of performance gains, but without any additional transfer to new tasks (Healy, 2007).

Given that the current results suggest that what is gained through enhanced experience and/or training with the AX-CPT is very proceduralized, it is important to ask what aspects of this task result in it being proceduralized instead of responsive to strategy changes. The AX-CPT may not appear to be difficult enough for participants to be motivated to put effort into developing specific strategies. It could be that participants approach it with the idea that they must just encode the stimulus response rules and will perform well. Although performance changes across time and performance differences among groups of participants have demonstrated statistically significant and reliable differences, the error rates and RTs effects were relatively small in general.

Given the growing interest in studying cognitive interventions in executive control abilities, it is important to consider whether all tasks could be highly proceduralized as the results of the current study suggest that the AX-CPT is. We did not find significant differences for many of the task switching or modified Sternberg scores even for participants that gained experience with these tasks during the intervention sessions. Thus, it could be that these tasks are less proceduralized and gains were not maintained from intervention session to posttest. As stated previously, performance at pretest may have been near ceiling and not allowing for much improvement in scores. Still, it is important to attempt to decode whether abstract or proceduralized skills are being gained in interventions studies by comparing similar tasks or subtasks. As discussed in a later section outlining studies showing more successful transfer effects, it appears that not all tasks used in interventions studies elicit proceduralized learning of skills specific to one task, but train more abstract processing skills.

Conclusions about Multi Task Training Condition

The multi task training condition was designed to train participants to flexibly apply the same general strategy to the AX-CPT, task switching, and modified Sternberg tests. Hence, it was hypothesized that, compared with other training/exposure combinations, participants in the multi task training condition would show greater improvement on task switching, modified Sternberg, Dot-CPT, and PM/N-back scores. In contrast to hypotheses, the multi task training condition was not found to be more effective than other interventions in improving performance on the trained tasks or untrained transfer tasks. There are two possible interpretations for our finding that the multi task training condition failed to facilitate transfer to untrained tasks. First, it could be that transfer cannot be facilitated by an intervention aimed to train the ability to flexibly apply a general strategy. Alternatively, it may possible be possible to train participants to flexibly apply a general proactive strategy, but we just did not observe these effects in this study. These alternative explanations for the lack of success in the multi task training intervention will be explored.

Explanation #1: Transfer cannot be facilitated by practice applying a general strategy to novel tasks. As discussed in the training section above, many studies have shown that strategy training facilitates improved performance on the training task, but does not facilitate transfer to untrained tasks. Such evidence suggests that it may not be possible to train participants to apply a strategy in a flexible manner in order to achieve transfer as was discussed more thoroughly in a previous section.

Explanation #2: Transfer can be facilitated by training in applying a general strategy to novel tasks, but was not shown in the current study. Given that previous studies have shown that very slight variations in training procedures can produce different results in terms of performance on tasks trained and transfer tasks (e.g., Derwinger et al., 2003), it is important to consider aspects of the study design that may have resulted in multi task training condition failing to produce the desired transfer effects. To assess what aspect of the procedure might have resulted in the failure to produce transfer, it is helpful to consider the processes that likely would be required in order for a multi task training condition to be effective such as: (1) successfully encoding and applying the strategy on the trained task in a way that enhances performance on that task; (2) understanding that the same general strategy can be used on multiple tasks, and (3) flexibly adapting the successfully applied strategy used on the training task to a novel task.

The first process described above suggests that each training procedure must effectively improve performance on the task trained, and this was only satisfied for the AX-CPT when AY and BX performance was compared. As discussed earlier, the strategy training procedures designed for the task switching and modified Sternberg tasks did not improve performance on these tasks, suggesting that these training procedures were not effective. The participants might not have comprehended that the same proactive strategy could be applied flexibly to novel tasks when strategies for task switching and modified Sternberg that were not effective, even on the tasks trained.

Another reason that the multi task training condition may have failed to be effective in producing transfer is that the procedure failed to teach participants to learn a general proactive strategy and realize that it can be flexibly applied to other tests. Although instructions emphasized that the strategy training procedures for the AX-CPT, task switching, and modified Sternberg were similar and adapted from the AX-CPT to fit the goals of the current task, it is possible that the commonalities among strategy training procedures were not clear enough or were not understood. Furthermore, it is possible that the training procedures used did not emphasize the commonalities between the AX-CPT strategy training procedure and the strategy training procedures for the task switching and modified Sternberg tasks enough to train flexibility.

Even if participants were able to effectively use the training strategies on each of the three training tasks and recognize the commonalities among the three strategies, participants in the multi task condition may not have obtained the flexibility or problem solving skills necessary to apply strategies learned to an untrained task. This could have arisen for two reasons. First, participants may not have realized that adapting and applying the general proactive strategy would help performance on a new test at posttest, and thus, did not attempt to do so. Alternatively, participants in the multi task conditions may have attempted to apply the general proactive strategy to new tests at posttest, but were not able to do so due to failing to gain specific skills in flexibly adapting the general strategies. This reasoning coincides with the theory that transfer is facilitated when one develops skills in generating novel strategies that are needed to complete the training and transfer tasks, which was referred to as "transfer-appropriate training" (McDaniel & Schlager, 1990, pp. 154). Similarly, Healy et al. (2006) propose that, "effective performance on a skill at test demands that training of the skill include the same configuration of procedures required during testing" (pp. 545). If it is true that the processes engaged during training must be the same as those required in order to perform better on the transfer task, then our failure to find transfer may be due to the fact that the multi task training condition did not actually allow for attainment of skills in flexibly adapting strategies to be applied on untrained tasks. Thus, participants may have understood that the strategies needed to be adapted for each task, but the multi task training procedure did not require that the participants actually flexibly adapt the strategies. Hence, participants might have depended on the examiner to provide instructions about how to flexibly adapt the general proactive strategies to untrained tasks, and therefore, the skills learned during training were not the same skills required for successful transfer at posttest.

How might we develop more effective interventions for facilitating far transfer?

As discussed in Chapter 2, transfer is both very desirable and difficult to achieve, especially in older adults (Dahlin, Nyberg, Backman, Stigsdotter Neely, 2008a; Derwinger et al., 2003; Stigsdotter Neely et al., 1993; Ball et al., 2002). Given that far transfer is difficult to achieve, it is not too surprising that far transfer was not achieved with any of the intervention conditions used in this study. Still, the failure to achieve far transfer in this study raises the possibility that the procedures used in our study did not possess some necessary elements common to interventions that lead to transfer. Thus, it is important to examine the interventions that appear more promising in terms of facilitating transfer.

First, effective transfer has been observed in previous studies employing intervention procedures involving a change in task structure or procedures. These interventions often involved ongoing feedback about performance, gradual increases in task difficulty dependent on performance, and/or variability in task presentation. These procedures were designed to require participants to gain experience with particular cognitive processes that may enable participants to develop the flexibility to transfer benefits. For example, as discussed in Chapter 2, in a variable priority training in which the demands for coordinating dual task conditions changed during the training, participants were able to improve on the dual task test on which they were trained as well as novel dual task test (Kramer, Larish, & Strayer, 1995). These results suggested that the aspect of the training procedure requiring participants to learn to coordinate task demands enabled learning of a generalizable coordinating skill (Kramer, Larish, Strayer, 1995). Similar transfer effects were found with a variable training procedure in a later study (Bherer et al., 2005). Another successful transfer intervention involved recognition memory, in which increasing the lag between words to be recognized, resulted in improvements in performance on the recognition memory test as well as transfer of improvement to other neuropsychological measures (Jennings et al., 2005). Finally, a recent study in young adults found transfer effects to measures of fluid intelligence after participants were trained on a demanding working memory training task in which difficulty incrementally increased (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008). These results suggest that an effective intervention allows the participant to gain skills in flexibility and ability to adapt to changing task demands while practicing the cognitive processes required for the training task.

Several studies have shown transfer in executive control tasks, using a procedure in which extensive practice is given with several different tasks thought to entail the same cognitive process and particular neural network. For example, successful transfer was found for young adults in executive control domains such as updating (Dahlin et al., 2008) or interference resolution (Persson & Reuter-Lorenz, 2008), when practice was given in multiple tasks that putatively tapped into that domain. Additionally, older adults who underwent plasticity training designed to stimulate and exercise language processes, demonstrated transfer of benefits to neuropsychological tests (Mahncke et al., 2006). Similarly, plasticity training on attention processes led to successful transfer in brain injured participants (Sohlberg et al., 2000) and plasticity training in multiple cognitive domains transferred to result in improvements in neuropsychological tests in patients with Alzheimer's disease (Cipriani, Bianchetti, & Trabucchi, 2006). The success of such interventions supports the idea that transfer can occur when the trained and transfer tasks engage the same cognitive processes and brain regions.

Additionally, many researchers propose that transfer is achieved through interventions that train the processing system instead of changing the approach or strategy used on the training task (Jaeggi et al., 2008). For instance, young adults who practiced a working memory task for 5 weeks showed decreased RTs and transfer of improvement in RT on the Stroop test (Oleson, Westerberg, & Klingberg, 2004). It was also determined that fMRI activation in the prefrontal and parietal areas increased after practice in the same areas activated before practice, which suggests that the same strategy was used before and after the practice intervention, but with greater proficiency after the intervention (Jonides, 2004). Furthermore, these results suggest that successful transfer does not necessarily require that a new strategy be introduced and learned, but instead that becoming proficient on a task may lead to spontaneous adoption of an effective processing strategy, simply as a side effect of practicing/exercising the cognitive processes engaged during the task.

The idea that spontaneous adoption of a cognitive strategy may be important for transfer is supported by recent study on memory training (Lustig & Flegal, 2008). In the study, participants trained on a specific memory strategy performed worse on a word memory transfer task than participants who were encouraged to generate their own strategy during training tasks (Lustig & Flegal, 2008). These results were interpreted as suggesting that strategy self-generation is important for both training and transfer, because performance on the training task was related to performance on the transfer task. Alternatively, these researchers suggested that participants trained on specific strategies may not have been able to transfer the strategies they learned, because transfer performance in this group was only related to pretest ability on a vocabulary measure and not to training performance. Overall, these results suggest that allowing and encouraging participants to generate strategies on their own instead of training specific strategies may be the best means of achieving transfer. Still, it must be considered that even when strategies are not explicitly trained, it is still possible that participants will develop strategies specific to the training tasks, which may interfere with far transfer (Buschkuehl et al., 2008). In conclusion, results from the recent literature on cognitive training suggest that future research should not aim to directly change the cognitive mechanism or strategy used, but rather to enable practice and thus, improvements, in a spontaneously developed approach or strategy.

Finally, close inspection of the intervention procedures used in studies that achieved transfer revealed that the intervention sessions were usually quite extensive. For instance, training sessions ranged from 8 – 19 sessions (Jaeggi et al., 2008), 10 sessions within a two week period (Persson & Reuter-Lorenz, 2008), 5 weeks of training (Dahlin et al., 2008a), 8 training sessions per week for 3 weeks (Jennings & Jacoby, 2003), and about 24 days (Klingberg, Forssberg, & Westerberg, 2002) in various studies showing transfer effects. Furthermore, a significant relationship between time spent training and improvement from pretest to posttest was uncovered, suggesting that more training leads to more benefit (Jaeggi et al., 2008). In the current study only two training sessions were provided, which was substantially less time training than other studies showing transfer. Hence, in the future, studies seeking to facilitate transfer should employ intervention procedures with a lengthy and frequent training schedule.

Plasticity in Aging

Results from several studies including this dissertation study show that older adults show performance benefits (at least on the task trained) as a result of cognitive interventions, suggesting that the brains of healthy older adults remain plastic with increasing age (e.g.,. Baltes et al., 1989; Mahncke et al., 2006; Paxton et al, 2006). Still, many previous studies have shown that young adults show greater benefit than older adults from cognitive interventions aimed to improve abilities such as episodic memory (Jones et al., 2006). Furthermore, several recent studies have shown significant improvement on the working memory task trained in older adults, but failed to show substantial transfer or transfer to tasks very similar in structure (Buschkuehl et al., 2008; Dahlin et al., 2008a; Li et al., 2008). An fMRI study investigating transfer and training effects on some of the same measures assessed in (Dahlin et al., 2008a), suggested that older adults' failure to transfer benefits of training could be due to older adults' impaired ability to use the same brain region, specifically the striatum, during both training and transfer (Dahlin et al., 2008b). Several studies were reviewed above and in Chapter 2 in order to glean information about the effectiveness of various interventions in to facilitate improvements in performance on the task trained and in novel transfer tasks. A portion of the studies reviewed in this discussion showing significant training and transfer effects involved young adult participants, and therefore, it must be considered that intervention procedures used in previous studies that led to promising transfer effects in young adults (e.g., Jaeggi et al., 2008; Persson & Reuter-Lorenz, 2008) might not show such promising transfer effects in older adults. Further research assessing the effectiveness of various interventions in facilitating improvements in performance on trained and transfer tasks are necessary in order to gain understanding about how cognitive plasticity differs between healthy older and younger adults.

Limitations

There were several limitations of this dissertation study. As discussed in the section on transfer effects, there were only two intervention sessions in this study, which is a less intensive intervention than used in many studies showing transfer. Also, less than 24 participants were assigned to each intervention condition, which limited the power to detect significant differences. Aside from the AX-CPT and Dot-CPT, the measures of executive control that were included may not be sensitive measures of proactive control and may not benefit from use of a proactive strategy.

The current study did not include a no-contact control group. Thus, some of the improvements from pre to post test could have reflected simple practice effects rather than any effects of specific practice or training. To address this issue, a no-contact control group is being recruited. I will compare effects in this no-contact control group with effects for all participants to determine if there are overall differences between participants undergoing any intervention. I will also compare the differences between posttest and pretest performance for participants in the no-contact control condition and participants in each of the interventions conditions to determine if the significant effects found for training and single task conditions are significantly greater than the performance changes that can be expected even with no interventions.

Future Directions

Facilitating Transfer. The results of this study raise several questions that could be addressed by further investigations. Questions remain as a result of finding that the Dot-CPT, which is very similar to the AX-CPT, showed some evidence of transfer effects, but the PM/N-back, that was dissimilar from the AX-CPT, did not show transfer. Thus, it is important to further investigate the types of tasks that would show near transfer effects after enhanced experience with the AX-CPT. Hence, one possible way to investigate the parameters of transfer of benefit due to more experience with the AX-CPT would be to investigate transfer effects on several tasks that were more similar to the AX-CPT than the PM/N-back, but not as similar to the AX-CPT as the Dot-CPT. Such an investigation would provide information about how similar a task must be to the AX-CPT in order to benefit from increased experience with the AX-CPT. Thus, such information would allow for more confident conclusions about the cognitive mechanism by which transfer occurs, such as whether participants simply learn stimulus-response mappings on the AX-CPT that can be directly modified to apply to the Dot-CPT or whether they learn a more general proactive strategy.

Improving the multi task training condition. As discussed in a previous section, several aspects of the multi task training intervention procedure may have resulted in its failure to produce transfer, even assuming that it is possible to train participants to transfer strategies to an untrained task. One way of determining which aspect of the multi task training procedure led to ineffective results would be to conduct studies investigating effects of this intervention with theoretically driven alterations to the procedure. Such changes to the procedure could be aimed to more specifically target specific processes that are thought to be necessary for the multi task training procedure to be effective. In regard to contemplating future studies, I've focused on one specific explanation for the failure of the multi task training condition to produce transfer: that participants in the multi task training condition did not actually learn the skills necessary to apply a general proactive strategy to untrained tasks, because they relied on the experimenter to provide explicit strategies during the intervention sessions. Likewise, McDaniel and Schlager (1990) suggest that skills for generating novel strategies in new situations are only gained when one is required to derive a strategy to solve a problem. Given that ability to transfer a general strategy to untrained tasks requires that one actually derive the strategy independently, it may have been more effective to train participants to use the AX-CPT proactive strategy and then ask them to generate an effective strategy with the aim of using initially presented information to prepare in advance for responses on the task switching and modified Sternberg tasks. Asking participants to self-generate effective proactive strategies and flexibly apply them to a novel task during training would more closely reflect the cognitive process of flexibly transferring a strategy that is required for effective transfer of strategy training benefits to an untrained task. Also, it is possible that self generated strategies for all trained tasks except the AX-CPT (i.e., task switching and modified Sternberg) may be more effective than the strategy training procedures provided, especially when considering that the strategy training procedures on these tasks did not lead to an improvement in performance. It is important to investigate transfer effects after changing the multi task training procedure to require that participants must discover or derive an effective way of adapting the general proactive strategy. Thus, through such an evaluation, we could test whether the failure of the multi task training condition to produce transfer was due to the failure of the procedure to train participants to effectively adapt and apply a general strategy training procedure.

Efforts to facilitate early diagnosis of dementia. One interesting area of inquiry that could potentially assist with the early detection of dementia would be to investigate the degree to which ability to improve over time helps to discriminate between those with and without mild cognitive impairment (MCI) or early dementia. It has been suggested that, compared with a single test score, cognitive plasticity (i.e., ability to benefit from some type of training or practice intervention) as assessed by posttest – pretest scores might be a better indicator of participants at risk for, or with early stage dementia. This hypothesis is based on the idea that individuals suffering from early stage dementia or at risk for dementia will have difficulty learning and improving due to cognitive impairments associated with the dementia process (Baltes, Kuhl, & Sowarka, 1992). Studies training fluid intelligence (Baltes, et al., 1992) and training cognitive domains associated with dementia (e.g., visuospatial, verbal recall, executive control, verbal fluency; Fernandez-Ballesteros, Zamarron, & Tarrage, 2005) demonstrated that posttest vs. pretest change scores were better than pretest scores at discriminating between healthy older participants and those with Alzheimer's disease (AD) or MCI. Further, it has been shown that participants who were determined to be at risk for dementia did not benefit from fluid intelligence training, while healthy participants did benefit (Baltes et al., 1992).

Thus, it is of interest to determine whether individuals who are at risk for dementia or in very early stages would benefit from interventions designed to improve executive control on tasks such as the AX-CPT and Dot-CPT. When patients with AD were compared with age-matched healthy controls on the AX-CPT, the AD patients showed a pattern of performance suggesting impaired context processing evidenced by greater BX errors and a tendency to respond quickly instead of accurately on BX trials (Braver et al., 2005). These results suggest that participants with AD have more room to improve than the healthy older adults assessed in the current study. It would also be important to investigate whether different interventions affect those determined to be at risk for dementia and healthy elderly in different ways, which could possibly provide insight into the cognitive mechanism employed by each of these groups while performing the AX-CPT and Dot-CPT tasks.

Also, given that it is often difficult to discriminate between participants with different types of neurodegenerative disorders leading to dementia such as AD, Dementia with Lewy Bodies, and Frontotemporal dementia (e.g., Welsh-Bohmer, 2008). It would be informative, through longitudinal investigations, to determine whether there are differences in ability to benefit from training among those at risk for dementia that proceed to develop different types of dementia. Also, by comparing practice and training interventions in participants at risk for dementia, information regarding the degree to which the ability to spontaneously derive strategies is affected by the dementia process (or different in different forms of dementia) could be provided. It may be that executive difficulties occurring early in the disease process may lead to difficulty generating and maintaining an effective strategy, and therefore, the strategy training intervention would provide necessary structure and direction for improving performance. Thus, to answer these questions and better understand ability to discriminate among at risk and healthy older adult as well as between different types of dementia, it would be informative to use procedures used in the current study to compare training and practice on the AX-CPT and Dot-CPT in a longitudinal study with older adults with and without a diagnosis of dementia.

Conclusions

This study sought to address five primary questions. The answer to the first question is that the strategy training procedure used in our previous study with the AX-CPT (Paxton et al., 2006) was successful in improving AX-CPT performance when the pattern of RTs was compared between trial types. Moreover, the performance improvements were greater than those observed for purely practice-based interventions in terms of producing a specific pattern of performance for RTs associated with stronger proactive control. The answer to the second question was that the single task interventions, focused solely on the AX-CPT, led to improvement in near transfer performance in terms of producing a more proactive pattern in errors on the Dot-CPT when AY and BX errors were examined together. Moreover, this improvement in ability of participants in the single task conditions to show a specific pattern of error performance associated with stronger proactive control was greater than that observed for participants who underwent the multi task intervention procedure. The answer to the third question was that there were only slight suggestions that strategy training affected performance on the near transfer task and was not found to be significantly different from practice interventions in terms of facilitating transfer to untrained tasks. The answer to our fourth question was that transfer was not facilitated by the multi task training condition, which was designed to provide participants with experience transferring a goal maintenance strategy to multiple tasks during training. Lastly, the answer to the fifth question was that conclusions cannot be drawn from the current results regarding whether training or multi task interventions used during intervention sessions led to improved performance by engaging different cognitive mechanisms than engaged by the practice interventions or single task interventions.

REFERENCES

Amieva, H., Phillips, L., & Della Sala, S. (2003). Behavioral dysexecutive symptoms in normal aging. *Brain and Cognition, 53*, 129-132.

Arnsten, A.F., Cai J.X., Steere J.C., & Goldman-Rakic P.S. (1995). Dopamine D2 receptor mechanisms contribute to age-related cognitive decline: the effects of quinpirole on memory and motor function in monkeys. *Journal of Neuroscience, 15*, 3429-3439.

Baddeley, A. (2002). Fractionating the central executive. In D.T. Stuss & R.T. Knight (Eds.)*Principles of Frontal Lobe Function*. New York: Oxford University Press. pp. 246- 260.

Ball, K., Berch, D. B., Helmers, K. F., Jobe, J. B., Leveck, M. D., Marsiske, M., Morris, J.N., Rebok, G. W., Smith, D. M., Tennstedt, S. L., Unverzagt, F. W., & Willis, S. L. (2002). Effects of cognitive training interventions with older adults: A randomized controlled trial. *JAMA: Journal of the American Medical Association*. *288*(18), 2271-2281.

Baltes, P. B., Dittmann-Kohli, F., & Kliegl, R. (1986). Reserve capacity of the elderly in aging-sensitive tests of fluid intelligence: Replication and extension. *Psychology and Aging, 1,* 172–177.

Baltes, M.M., Kuhl, K.P., & Sowarka, D. (1992). Testing for limits of cognitive reserve capacity: A promising strategy for early diagnosis of dementia? Journal of Gerontology: Psychological Sciences, 47: 165 - 167.

Baltes, P. B., & Schaie, K. W. (1976). On the plasticity of intelligence in adulthood and old age: Where Horn and Donaldson fail. *American Psychologist*.

31(10), 720-725.

Baltes, P. B., Sowarka, D., & Kliegl, R. (1989). Cognitive training research on fluid intelligence in old age: What can older adults achieve by themselves? *Psychology and Aging*. *4*(2), 217-221.

Baron, A., & Mattila, W. R. (1989). Response slowing of older adults: Effects of time-limit contingencies on single- and dual-task performances. *Psychology and Aging*. *4*(1), 66-72.

Bherer, L., Kramer, A. F., Peterson, M. S., Colcombe, S., Erickson, K., & Becic, E. (2005). Training Effects on Dual-Task Performance: Are There Age-Related Differences in Plasticity of Attentional Control? *Psychology and Aging*. *20*(4), 695-709.

Bherer, L., Kramer, A. F., Peterson, M. S., Colcombe, S., Erickson, K., & Becic, E. (2006). Testing the limits of cognitive plasticity in older adults: Application to attentional control. *Acta Psychologica*. *123*(3), 261-278.

Bissig, D., & Lustig, C. (2007). Who benefits from memory training? Psychological Science, 18, 720 - 726.

Blackburn, J. A., Papalia-Finlay, D., Foye, B. F., & Serlin, R. C. (1988). Modifiability of figural relations performance among elderly adults. *Journal of Gerontology*. *43*(3), 87-89.

Blieszner, R., Willis, S. L., & Baltes, P. B. (1981). Training research in aging on the fluid ability of inductive reasoning. *Journal of Applied Developmental Psychology*. *2*(3), 247-265.

Boron, J. B., Turiano, N. A., Willis, S. L., & Schaie, K. W. (2007). Effects of cognitive training on change in accuracy in inductive reasoning ability. *Journals of Gerontology: Series B: Psychological Sciences and Social Sciences*. *62*(3), 179-186.

Braver, T.S., & Barch D.M. (2002). A theory of cognitive control, aging cognition, and neuromodulation. *Neuroscience and Biobehavioral Reviews. 26*, 809-817.

Braver, T.S., Barch D.M., Keys B.A., Carter C.S., Cohen J.D., Kaye J.A., Janowksy J.S., Taylor, S.F., Yesavage J.A., & Mumenthaler M.S.et al. (2001). Context processing in older adults: Evidence for a theory relating cognitive control to neurobiology in healthy aging. *Journal of Experimental Psychology: General. 130*, 746-763

Braver, T.S., Gray, J.R., & Burgess, G.C. (2007). Explaining the many varieties of working memory variation: Dual mechanisms of cognitive control. In A. Conway, C. Jarrold, M., Kane, A. Miyake, & J.Towse (Eds.), *Variation in working memory*. Oxford, England: Oxford University Press. 76-106.

Braver, T.S., Satpute A.B., Keys B.A., Racine C.A., & Barch D.M. (2005). Context processing and context maintenance in healthy aging and early-stage dementia of the Alzheimer's type. *Psychology and Aging, 20*, 33-46.

Braver, T.S. and Ruge, H. Functional Neuroimaging of Executive Functions. *Handbook of Functional Neuroimaging of Cognition,* Second Edition. R. Cabeza and A.Kingstone (Eds.), MIT Press

Burgess, P. W., Alderman, N., Evans, J., Emslie, H., & Wilson, B. A. (1998). The ecological validity of tests of executive function. *Journal of the International Neuropsychological Society*. *4*(6), 547-558.

Burgess, P.W., & Robertson, I.H. (2002). Principles of the Rehabilitation of Frontal Lobe Function. In D.T. Stuss & R.T. Knight (Eds). *Principles of Frontal Lobe Function*. New York: Oxford University Press.

Buckner, R.L. (2005). Three principles for cognitive aging research: Multiple causes and sequelae, variance in expression and response, and the need for integrative theory. In R. Cabeza, D.C. Park, & L. Nyberg, (Eds). *Cognitive Neuroscience of Agin*g. New York: Oxford University Press.

Buschkuehl, M. Jaeggi, S.M., Hutchison, S., Perrig-Chiello, P., Dapp, C., Muller, M., Breil, F., Hoppeler, H., & Perrig, W.J. (2008). Impact of working memory training on memory performance in old-old adults. *Psychology and Aging, 4*, 743-753.

Cabeza, R. (2001). Functional neuroimaging of cognitive aging. In: Cabeza R., & Kingstone A.,(Eds). *Handbook of Functional Neuroimaging of Cognition.* Cambridge, MA: MIT Press.

Cabeza, R., Anderson N.D., Locantore J.K., & McIntosh A.R. (2002). Aging gracefully: Compensatory brain activity in high-performing older adults. *NeuroImage, 17,* 1394-402.

Cabeza, R., Daselaar S.M., Dolcos F., Prince S.E., Budde M., & Nyberg L. (2004). Task-independent and task-specific age effects on brain activity during working memory, visual attention and episodic retrieval. *Cerebral Cortex. 14*, 364-75.

Carlson, M.C., Saczynski, J.S., Rebok, G.W., Seeman, T., Glass, T.A., McGill, S., Tielsch, J., Frick, K.D., Hill, J., Fried, L.P. (2008). Exploring the effects of an "Everyday" activity program on executive function and memory in older adults:

Experience corps. *The Gerontologist, 48*, 793 - 801.

Cerella, J. (1985). Information processing rates in the elderly. *Psychological Bulletin, 98*, 67-83.

Chan, R.C. (2001). Dysexecutive symptoms among a non-clinical sample: A study with the use of the dysexecutive questionnaire. British Journal of Psychology, 92, 551-565.

Cipriani, G., Bianchetti, A., & Trabucchi, M. (2006). Outcomes of a computer-based cognitive rehabilitation program on Alzheimer's disease patients compared with those on patient affected by mild cognitive impairment. *Archives of Gerontology and Geriatrics*. *43*(3), 327-335.

Clawson, D.M., Healy, A.F., Ericsson, K.A., & Bourne, L.E. (2001). Retention and transfer of morse code reception skill by novices: Part-whole training. *Journal of Experimental Psychology: Applied, 7*, 129 - 142.

Cohen, J.D., Barch D.M., Carter C., & Servan-Schreiber D. (1999). Context-processing deficits in schizophrenia: Converging evidence from three theoretically motivated cognitive tasks. *Journal of Abnormal Psychology, 108*, 120-133.

Cohen, J.D., MacWhinney, B., Flatt, M.R., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments & Computers, 25*, 257-271.

Colcombe, S.J., Kramer, A.F., Erickson, K.I., & Scalf, P. (2005). The implications of cortical recruitment and brain morphology for individual differences in inhibitory function in aging humans. *Psychology and Aging, 20*, 363-375.

Craik, F.I.M., & Byrd M. (1982). Aging and cognitive deficits: The role of attentional resources. In Craik, F.I.M., & Trehub S., (Eds). *Aging & Cognitive Processes: Advances in the Study of Communication and Affect.* New York: Plenum Press. 191-211.

Craik, F.I.M., & Bialystok, E. (2006). Planning and task management in older adults: Cooking breakfast. *Memory & Cognition* 34, 1236-1249.

Dahlin, E., Nyberg, L., Backman, L., Stigsdotter Neely, A. (2008). Plasticity of executive fucntioning in young and older adults: Immediate training gains, transfer, and long-term maintenance. *Psychology and Aging, 23*, 720 - 730.

Dahlin, E., Stigsdotter Neely, A., Larsson, A., Backman, L., & Nyberg, L. (2008) Transfer of learning after updating training mediated by the striatum. *Science* 320: 1510 - 1512.

Davidson, D. J., Zacks, R. T., & Williams, C. C. (2003). Stroop interference, practice, and aging. *Aging, Neuropsychology, and Cognition*. *10*(2), 85-98.

Dempster, F.N. (1992). The rise and fall of the inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review*, 12, 45-75.

Derwinger, A., Stigsdotter Neely, A., Persson, M., Hill, R. D., & Bäckman, L. (2003). Remembering Numbers in Old Age: Mnemonic Training Versus Self-Generated Strategy Training. *Aging, Neuropsychology, and Cognition*. *10*(3), 202-214.

Draganski, B., Winkler, J., Flügel, D., & May, A. (2004). Selective activation of ectopic grey matter during motor task. *Neuroreport: For Rapid Communication of Neuroscience Research*. *15*(2), 251-253.

Dulaney, C. L., & Rogers, W. A. (1994). Mechanisms underlying reduction in Stroop interference with practice for young and old adults. *Journal of Experimental*

Psychology: Learning, Memory, and Cognition. *20*(2), 470-484.

Edwards, J. D., Wadley, V. G., Vance, D. E., Wood, K., Roenker, D. L., & Ball, K. K. (2005). The impact of speed of processing training on cognitive and everyday performance. *Aging & Mental Health*. *9*(3), 262-271.

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science*. *14* (6), 286-290.

Fernandez-Ballesteros, R., Zamarron, M.D., Tarraga, L. (2005). Learning potential: A new method for assessing cognitive impairment. *International Psychogeriatrics, 17*; 119 - 128.

Houdé, O., Zago, L., Mellet, E., Moutier, S., Pineau, A., Mazoyer, B., & Tzourio-Mazoyer, N. (2000). Shifting from the perceptual brain to the logical brain: The neural impact of cognitive inhibition training. *Journal of Cognitive Neuroscience*. *12*(5), 721-728.

Hummel, J. E., & Holyoak, K. J. (2005). Relational Reasoning in a Neurally Plausible Cognitive Architecture: An Overview of the LISA Project. *Current Directions in Psychological Science*. *14*(3), 153-157.

Fisk, J.E., & Sharp, C.A. (2004). Age-related impairment in executive functioning: Updating, inhibition, shifting, and access. Journal of Clinical and Experimental *Neuropsychology,* 26, 874-890.

Gerstorf, D., Siedlecki, K.L., Tucker-Drob, E.M., & Salthouse, T.A. (2008). Executive dysfunctions across adulthood: Measurement properties and correlates of the DEX self-report questionnaire. *Aging, Neuropsychology, and Cognition, 15*: 424 - 445.

Godefroy, O., & Rousseaux, M. (1997). Novel decision making in patients with prefrontal or posterior brain damage. *Neurology*. *49*(3), 695-701.

Goldman, P. S., Rosvold, H. E., & Mishkin, M. (1970). Evidence for behavioral impairment following prefrontal lobectomy in the infant monkey. *Journal of Comparative and Physiological Psychology*. *70*(3, Pt.1), 454-463.

Gollwitzer, P. M., & Brandstätter, V. (1997). Implementation intentions and effective goal pursuit. *Journal of Personality and Social Psychology*. *73*(1), 186-199.

Grady, C.L., McIntosh A.R., Bookstein F., Horwitz B., Rapoport S.I., & Haxby J.V. (1998). Age-related changes in regional cerebral blood flow during working memory for faces. *NeuroImage. 8*, 409-425.

Grady, C.L., McIntosh, A.R., Horwitz, B., Maisog, J.M., Ungerleider, L.G., Mentis, M.J., Pietrini, P., Shapiro M.B., & Haxby J.V. (1995). Age-related reductions in human recognition memory due to impaired encoding. *Science. 269*, 218-221.

Gunning-Dixon, F. M., & Raz, N. (2003). Neuroanatomical correlates of selected executive functions in middle-aged and older adults: A prospective MRI study. *Neuropsychologia*. *41*(14), 1929-1941.

Hasher, L., & Zacks R.T. (1988). Working memory, comprehension and aging: A review and a new view. In G.H. Bower, (Ed). *The Psychology of Learning and Motivation*. New York: Academic Press. 193-225.

Haut, M.W., Kuwabara, H., Leach, S., & Callahan, T. (2000). Age-related changes in neural activation during working memory performance. A*ging, Neuropsychology, and Cognition, 7,* 119-129.

Hybertson, D., Perdue, J., & Hybertson, D. (1982). Age differences in information acquisition strategies. *Experimental Aging Research, 8*, 109-113.

Healy, A.F., Fendrich, D.W., & Proctor, J.D. (1990). Acquisition and retention of letter-detection skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 270 - 281.

Healy, A. F., Wohldmann, E. L., Parker, J. T., & Bourne, L. E., Jr. (2005). Skill training, retention, and transfer: The effects of a concurrent secondary task. *Memory & Cognition, 33,* 1457-1471.

Healy, A.F., Wohldmann, E.L., Sutton, E.M., & Bourne, L.E. (2006). Specificity effects in training and transfer of speeded responses. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 534-546.

Healy, A.F. (2007). Transfer: Specificity and generality. In H.L. Roediger, Y. Dudai, & S.M. Fitzpatrick, (Eds). *Science of memory: concepts,* New York: Oxford University Press. 271-276.

Insel, K., Morrow, D., Brewer, B., & Figueredo, A. (2006). Executive function, working memory, and medication adherence among older adults. *Journal of Gerontology: Psychological Sciences*, 61B, 102-107.

Jacoby, L.L., Bishara, A.J., Hessels, S., & Toth, J.P. (2005). Aging, subjective experience, and cognitive control: Dramatic false remembering in older adults. *Journal of Experimental Psychology: General*, 134, 131-148.

Jaeggi, S.M., Buschkuehl, M., Jonides, J., & Perrig, W.J., (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences, 105*, 6829 - 6833.

Jennings, J.M., & Jacoby, L.L. (2003). Improving memory in older adults: Training recollection. *Neuropsychological Rehabilitation, 13*, 417 - 440.

Jennings, J. M., Webster, L. M., Kleykamp, B. A., & Dagenbach, D. (2005). Recollectiontraining and transfer effects in older adults: Successful use of a repetition-lag procedure. *Aging, Neuropsychology, and Cognition*. *12*(3), 278-298.

Johnson, M.K., Mitchell, K.J., Raye, C.L., & Greene, E.J. (2004). An age-related deficit in prefrontal cortical function associated with refreshing information. *Psychological Science. 15*, 127-132.

Johnson, M. K., Reeder, J. A., Raye, C. L., & Mitchell, K. J. (2002). Second thoughts versus second looks: An age-related deficit in reflectively refreshing just-activated information. *Psychological Science*. *13*(1), 64-67.

Jones, S., Nyberg, L., Sandblom, J., Stisdotter Neely, A., Ingvar, M., Magnus Petersson, K., & Backman, L. (2006). Cognitive and neural plasticity in aging: General and task-specific limitations. *Neuroscience and Biobehavioral Reviews, 30*, 864-871.

Jonides, J. (2004). How does practice makes perfect? Nature Neuroscience, 7, 10-11.

Jonides, J., Marshuetz, C., Smith, E. E., Reuter-Lorenz, P. A., & Koeppe, R. A. (2000). Age differences in behavior and PET activation reveal differences in interference resolution in verbal working memory. *Journal of Cognitive Neuroscience*. *12*(1), 188-196.

Katzman, R., Brown, T., Fuld, P., Peck, A., Schecter, R., & Schimmel, H. (1983). Validation of a short Orientation-Memory-Concentration test of cognitive impairment. *American Journal of Psychiatry, 140*, 734-739.

Klingberg, T., Forssberg, H., Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology, 24*, 781- 791.

Kramer, A. F., Hahn, S., & Gopher, D. (1999). Task coordination and aging: Explorations of executive control processes in the task switching paradigm. *Acta Psychologica*. *101*(2-3), 339-378.

Kramer, A. F., Humphrey, D. G., Larish, J. F., & Logan, G. D. (1994). Aging and inhibition: Beyond a unitary view of inhibitory processing in attention. *Psychology and Aging*. *9*(4), 491-512.

Kramer, A. F., Larish, J. F., & Strayer, D. L. (1995). Training for attentional control in dual task settings: A comparison of young and old adults. *Journal of Experimental Psychology: Applied*. *1*(1), 50-76.

Kramer, J.H., Mungas, D., Reed, B.R., Wetzel, M.E., Burnett, M.M., Miller, B.L., Weiner, M.W., & Chui, H.C. (2007). Longitudinal MRI and cognitive change in healthy elderly. *Neuropsychology,* 21, 412-418

Kramer, A. F., & Willis, S. L. (2002). Enhancing the cognitive vitality of older adults. *Current Directions in Psychological Science*. *11*(5), 173-177.

Kliegl, R., Smith, J., & Baltes, P. B. (1990). On the locus and process of magnification of age differences during mnemonic training. *Developmental Psychology*. *26*(6), 894-904.

Kray, J., & Lindenberger, U. (2000). Adult age differences in task switching. *Psychology and Aging*, 2000, 126-147.

Langenecker, S.A., & Nielson, K.A. (2003). Frontal recruitment during response inhibition in older adults replicated with fMRI. *NeuroImage, 20*, 1384-1392.

Langenecker, S.A., Nielson, K.A., & Roa, S.M. 2004. fMRI of healthy older adults during Stroop performance. *NeuroImage, 21*, 192-200.

Leimkuhler, M.E., & Mesulam, M-M. (1985). Reversible go-no go deficits in a case of frontal lobe tumor. *Ann Neurology*, 18, 617-619.

Levine, B., Stuss, D. T., Winocur, G., Binns, M. A., Fahy, L., Mandic, M., Bridges, K., & Robertson, I. H. (2007). Cognitive rehabilitation in the elderly: Effects on strategic behavior in relation to goal management. *Journal of the International Neuropsychological Society*. *13*(1), 143-152.

Lezak, M. D., Howieson, D. B., Loring, D. W., Hannay, H. J., & Fischer, J. S. (2004). *Neuropsychological assessment (4th ed.)*. New York, NY, US: Oxford University Press.

Li, S., Schmiedek, F., Huxhold, O., Rocke, C., Smith, J., & Lindenberger, U. Working memory plasticity in old age: Practice gain, transfer, and maintenance. Psychology and Aging, 23: 731-742.

Light, L.L. (1991). Memory and aging: Four hypotheses in search of data. In M.R. Rosenzweig, LW. Porter (Eds). *Annual Review of Psychology*. Palo Alto, CA: Annual Reviews, p. 600.

Logan, J.M., Sanders A.L., Snyder A.Z., Morris J.C., & Buckner R.L. (2002). Under recruitment and nonselective recruitment: Dissociable neural mechanisms associated with aging. *Neuron. 33,* 827-840.

Lustig, C., & Flegal, K.E., (2008). Targeting latent function: Encouraging effective encoding for successful memory training and transfer. *Psychology and Aging, 23*, 754-764.

MacDonald, A. W., III, Goghari, V. M., Hicks, B. M., Flory, J. D., Carter, C. S., & Manuck, S. B. (2005). A Convergent-Divergent Approach to Context Processing, General Intellectual Functioning, and the Genetic Liability to Schizophrenia. *Neuropsychology*. *19*(6), 814-821.

Mahncke, H.W., Connor, B.B., Appelman, J., Absanuddin, O.N., Hardy, J.L., Wood, R.A., Joyce, N.M., Boniske, T., Atkins, S.M. & Merzenich, M.M. (2006). Memory enhancement in healthy older adults using a brain plasticity based training program: a randomized, controlled study. *Proc Natl Acad Sci*, 103, 12523-12528.

McDaniel, M.A., & Einstein, G.O. (2007). Prospective Memory: An overview and synthesis of an emerging field. Thousand Oaks, CA: Sage Publications.

McDaniel, M. A., & Schlager, M. S. (1990). Discovery learning and transfer of problem-solving skills. *Cognition and Instruction*. *7*(2), 129-159.

Meng, X, Rosenthal, R., Rubin, D.B. (1992). Comparing correlated correlation coefficients. *Psychological Bulletin. 111*, 172-175.

Mesulam, M.M. (2000). Behavioral Neuroanatomy: Large-Scale Networks, Association Cortex, Frontal Syndroms, the Limbic System, and Hemispheric Specializations. In. M.M. Mesulam (Ed.) *Principles of Behavioral and Cognitive Neurology, Second Edition*. Oxford: Oxford University Press. 1-91.

Milham, M.P., Erickson, K.I., Banich, M.T., Kramer, A.F., Webb, A., Wszalek, T., & Cohen, N.J. (2002). Attentional control in the aging brain: Insights from an fMRI study of the Stroop task. *Brain and Cognition, 49*, 277 -296.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*. *41*(1), 49-100.

Miller, E.K., & Cohen J.D. 2001. An integrative theory of prefrontal cortex function. Annual Review of *Neuroscience. 21*, 167-202.

Milner, B. (1963). Effects of different brain lesions on card sorting. *Archives Neurology*, 9, 90-100.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus

transfer appropriate processing. *Journal of Verbal Learning & Verbal Behavior*. *16*(5), 519-533.

Mosvovitch, M. & Wincour, G. (1995). Frontal lobes, memory, and aging. *Annals of the New York Academy of Sciences, 769*, 119 - 150.

Myerson, J., Emery, L., White, D. A., & Hale, S. (2003). Effects of age, domain, and processing demands on memory span: Evidence for differential decline. *Aging, Neuropsychology, and Cognition*. *10*(1), 20-27.

Neely, A. S., & Bäckman, L. (1993). Long-term maintenance of gains from memory training in older adults: Two 3½-year follow-up studies. *Journals of Gerontology*. *48*(5), 233-237.

Nieuwenhuis, S., Broerse, A., Nielen, M. M. A., & de Jong, R. (2004). A goal activation approach to the study of executive function: An application to antisaccade tasks. *Brain and Cognition*. *56*(2), 198-214.

Noice, H., Noice, T., & Staines, G. (2004). A Short-Term Intervention to Enhance Cognitive and Affective Functioning in Older Adults. *Journal of Aging and*

Health. *16*(4), 562-585.

Nyberg, L., Sandblom, J., Jones, S., Neely, A.S., Petersson, K.M., Ingvar, M., Backman, L (2003). Neural correlates of training-related memory improvement in adulthood and aging. *Proc Natl Acad Sci,* 100, 13728-13733.

Oberauer, K. (2001). Removing irrelevant information from working memory: A cognitive aging study with the modified Sternberg task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. *27*(4), 948-957.

Oberauer, K. (2005). Control of the Contents of Working Memory--A Comparison of Two Paradigms and Two Age Groups. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. *31*(4), 714-728.

Oleson, P.J., Westerberg, H., & Klingberg, T. (2004). Increased prefrontal and parietal activity after training of working memory. *Nature Neuroscience, 7*, 75 -79.

Park, N. W., Proulx, G.-B., & Towers, W. M. (1999). Evaluation of the attention process training programme. *Neuropsychological Rehabilitation*. *9*(2), 135-154.

Paxton, J.L., Barch, D.M., Storandt, M., & Braver, T.S. (2006). Effects of environmental support and strategy training on older adults' use of context. *Psychology and Aging, 21,* 499-509.

Paxton, J.L., Barch, D.M., Racine, C.A., & Braver, T.S. (2008). Cognitive control, goal maintenance, and prefrontal function in healthy aging. *Cerebral Cortex, 10*, 1010-1028.

Persson, J. & Reuter-Lorenz, P. A.. (2008). Gaining control: Training of executive function and far transfer of the ability to resolve interference. *Psychological Science, 19,* 881– 889.

Persson, J., Sylvester, C.Y., Nelson, J.K., Welsh, K.M., Jonides, J., & Reuter-Lorenz, P.A. (2004). Selection requirements during verb generation: differential recruitment in older and younger adults. *Neuroimage. 23*, 1382-90.

Peters, A., Sethares, C., & Moss, M.B. (1998). The effects of aging on layer 1 in area 46 of prefrontal cortex in the rhesus monkey. *Cerebral Cortex. 8*, 671-684.

Plemons, J. K., Willis, S. L., & Baltes, P. B. (1978). Modifiability of fluid intelligence in aging: A short-term longitudinal training approach. *Journal of Gerontology*. *33*(2), 224-231.

Raichle, M. E., Fiez, J. A., Videen, T. O., MacLeod, A.-M. K., & et al. (1994). Practice-related changes in human brain functional anatomy during nonmotor learning. *Cerebral Cortex*. *4*(1), 8-26.

Raz, N., Gunning, F.M., Head, D., Dupuis, J.H., McQuain, J.D., Briggs, S.D., Loken, W.J., Thornton, A.E., & Acker, J.D. 1997. Selective aging of the human cerebral cortex observed in vivo: Differential vulnerability of the prefrontal gray matter. *Cerebral Cortex. 7*, 268-282.

Raz, N., Lindenberger, U., Rodrigue, K.M., Kennedy, K.M., Head, D., Williamson, A., Dahle, C., Gerstorf, D. & Acker, J.D. (2005). Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex*, 15, 1676-1689.

Rhodes, M. G. (2004). Age-Related Differences in Performance on the Wisconsin Card Sorting Test: A Meta-Analytic Review. *Psychology and Aging*. *19*(3), 482-494.

Rosen, A.C., Prull, M.W., O'Hara, R., Brace, E.A., Desmond, J.E., Glover, G.H., Yesavage, J.A., & Gabrieli, J.D.E. 2002. Variable effects of aging on frontal lobe contributions to memory. *Neuroreport, 13*, 2425-2428.

Rosvold, H.E., Mirsky A.F., Sarason I., Bransome E.D., & Beck L.H. (1956). A continuous performance test of brain damage. *Journal of Consulting Psychology, 20,* 343-350.

Rush, B.K., Barch, D.M., & Braver, T.S. (2006). Accounting for cognitive aging: Context processing, inhibition, and processing speed? *Aging, Neuropsychology, and Cognition*, 13, 588-610.

Rypma, B., & D'Esposito M. (2000). Isolating the neural mechanisms of age-related changes in human working memory. *Nature Neuroscience, 3*, 509-515.

Saczynski, J. S., Willis, S. L., & Schaie, K. W. (2002). Strategy use in reasoning training with older adults. *Aging, Neuropsychology, and Cognition*. *9*(1), 48-60.

Salthouse, T.A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review,. 103*, 403-428.

Schaie, K. W., Willis, S. L., Hertzog, C., & Schulenberg, J. E. (1987). Effects of cognitive training on primary mental ability structure. *Psychology and Aging*. *2*(3), 233-242.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. *Psychological Science*. *3*(4), 207-217.

Scogin, F., Storandt, M., & Lott, L. (1985). Memory-skills training, memory complaints, and depression in older adults. *Journal of Gerontology*. *40*(5), 562-568.

Sheikh, J. I., Hill, R. D., & Yesavage, J. A. (1986). Long-term efficacy of cognitive training for age-associated memory impairment: A six-month follow-up study.

DevelopmentalNeuropsychology. *2*(4), 413-421.

Singer, T., Lindenberger, U., & Baltes, P. B. (2003). Plasticity of memory for new learning in very old age: A story of major loss? *Psychology and Aging*. *18*(2), 306-317.

Sohlberg, M. M., McLaughlin, K. A., Pavese, A., Heidrich, A., & Posner, M. I. (2000). Evaluation of attention process training and brain injury education in persons with acquired brain injury. *Journal of Clinical and Experimental Neuropsychology*. *22*(5), 656-676.

Spieler, D.H., Balota D.A., & Faust M.E. (1996). Stroop performance in healthy younger and older adults and in individuals with dementia of the Alzheimer's type. *Journal of Experimental Psychology: Human Perception and Performance, 22,* 461-479.

Stigsdotter-Neely, A., & Backman, L. Maintenance of gains following multi-factorial and uni-factorial memory training in late adulthood. *Educational Gerontology*, 1993*,* *19*, 105–117.

Stine-Morrow, E.A.L., Parisi, J.M., Morrow, D.G., Park, D.C. (2008). The effects of an engaged lifestyle on cognitive vitality: A field experiment. *Psychology and Aging, 23*, 778 - 786.

Taatgen, N.A., Huss, D., Dickison, D., Anderson, J.R. (2008). The acquisition of robust and flexible cognitive skills. *Journal of Experimental Psychology: General, 137*, 548 - 565.

Tisserand, D.J., & Jolles, J. (2003). On the involvement of prefrontal networks in cognitive ageing. *Cortex, 39*, 1107-1128.

Touron, D.R., & Hertzog, C. (2004). Distinguishing age differences in knowledge, strategy use, and confidence during strategic skill acquisition. *Psychology and Aging, 19,* 452-466.

Townsend, J., Adamo, M., & Haist, F. (2006). Changing channels: An fMRI study of aging and cross-modal attention shifts. *NeuroImage, 15*, 1682-1692.

Vance, D., Dawson, J., Wadley, V., Edwards, J., Roenker, D., Rizzo, M., & Ball, K. (2007). The Accelerate Study: The Longitudinal Effect of Speed of Processing Training on Cognitive Performance of Older Adults. *Rehabilitation Psychology*. *52*(1), 89-96.

Verhaeghen, P., Cerella, J., Bopp, K.L., & Basak, C. (2005). Aging and varieties in cognitive control; A review of meta-analyses on resistance to interference, coordination, and task switching, and experimental exploration of age-sensitivity in the newly identified process of focus switching. In R.W. Engle, G.W. Sedek, U. von Hecker, & D.N. McIntosh (Eds). *Cognitive Limitations in aging and psychopathology*. New York: Cambridge University Press. 435 - X.

Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging*. *7*(2), 242-251.

Volkow, N.D., Gur, R.C., Wang, G.-J., Fowler, J.S., Moberg, P.J., Ding, Y.-S., Hitzemann R., Smith G., & Logan J. (1998). Association between declines in brain dopamine activity with age and cognitive and motor impairment in healthy individuals. *American Journal of Psychiatry, 155*, 344-349.

Welsh-Bohmer, K.A. (2008). Defining "prodromal" Alzheimer's Disease, Frontotemporal Dementia, and Lewy Body Dementia: Are we there yet?

Neuropsychol Rev, 18: 70 - 72.

West, R.L. (1996). An application of prefrontal cortex function theory to cognitive aging. *Psychological Bulletin, 120*, pp. 272-292.

West, R., & Baylis, G. C. (1998). Effects of increased response dominance and contextual disintegration on the Stroop interference effect in older adults. *Psychology and Aging*. *13*(2), 206-217.

Willis, S. L., Blieszner, R., & Baltes, P. B. (1981). Intellectual training research in aging: Modification of performance on the fluid ability of figural relations. *Journal of Educational Psychology, 73,* 41–50.

Willis, S. L., & Nesselroade, C. S. (1990). Long-term effects of fluid ability training in old-old age. *Developmental Psychology*. *26*(6), 905-910.

Willis, S.L., Tennstedt, S.L., Marsiske, M., Ball, K., Elias, J., Koepke, K.M., Morris, J.N., Rebok, G.W., Unverzagt, F.W., Stoddard, A.M., & Wright, E. (2006). Long-term effects of cognitive training on everyday functional outcomes in older adults. *JAMA: Journal of the American Medical Association*.296, 2805-2814.

Yesavage, J.A., & Brink, T.L. (1983). Development and validation of a geriatric depression screening scale: A preliminary report. *Journal of Psychological Research,* 17, 41.