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Does Chronic Stress Accelerate Late-aging Cognitive Decline In Memory And Executive Functioning?

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DOES CHRONIC STRESS ACCELERATE LATE-AGING COGNITIVE DECLINE IN MEMORY AND EXECUTIVE FUNCTIONING?

by

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ABSTRACT

Few studies exist examining the relationship between self-reported stress and cognitive function in healthy nonpsychiatric older adults, and even less studies have examined whether high levels of self-reported stress accelerate the cognitive decline found in normal late-aging populations. A group of older nonpsychiatric adults, ages 54 years and above, were asked to complete three measures assessing their self-perceived stress over the past month, past year, and their lifetime. Sixty-one adults between the ages of 54 and 88 (52% female) participated in a second phase in which neuropsychological tasks were administered to assess three cognitive domains; memory, learning, and executive functioning. A hierarchical regression examined each of the three domain scores to explore whether self-perceived acute and chronic stress, after covaring for state anxiety, was related to neuropsychological performance. No statistically significant regressions were found, which was predicted for the learning domain, but contrary to the hypotheses for the memory and executive functioning domain. The potential influence of age in this study was explored in a series of ANOVAs examining the interactions between the three stress measures with state anxiety and age on the three cognitive domains. A statistically significant interaction was found between age and perceived lifetime stress when examining the memory domain score. In the young-old participants an increase in stress showed a non-significant relationship with a decrease in memory performance, while in the older-old participants the opposite non-significant tendency was found. The current study also partially replicated an earlier report of a relationship between an increase in recent self-reported stress and a decrease in performance on a specific divided attention task, and extended this finding to include older adults. While the majority of the study's hypotheses were not supported, these preliminary findings provide the field with interesting areas to explore in future studies.

This dissertation is dedicated to my son who is my greatest teacher.

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INTRODUCTION

Stress has been a central issue in discussions of wellness for over a century, and is linked increasingly to physical and mental health due to the biopsychosocial perspective held by many health professionals (Cassidy, 1999). The biopsychosocial perspective posits that biological, social and psychological factors contribute to overall health and susceptibility to illness (Petersen & Spiga, 1982). There are a growing number of studies suggesting that a person's tolerance and predisposition for stress is a significant variable for healthy aging in all three factors (Cassidy, 1999).

Interest in aging research is gaining more prominence as life expectancy continues to rise, while fertility rates continue to decline. Global life expectancy has increased by almost twenty years between 1950 and 2000, while between 1950 and 1990 total global fertility has fallen from 6.54 to 5.54 children per woman (remaining below 2.0 in the developed world) (Andrews, 2001). The rapid aging of the population has spurred interest in discovering the factors that contribute to healthy aging and the factors that are detrimental. Chronic stress is implicated increasingly as a factor that could accelerate age-related decline in cognitive function (McEwen & Sapolsky, 1995; Sapolsky, 1996), and has been shown to adversely impact neurological structures involved in learning and memory (Lupien & Lepage, 2001; Lupien & McEwen, 1997).

Overview of the construct of stress

Stress is a term originating from the Latin *stringere* (to draw tight), and variations of the word have been used over centuries. Prior to the 1940's, however, the word stress was rarely

used outside of the engineering profession (Cooper & Dewe, 2004). Finding a current definition of the term that a majority of researchers can agree to is almost impossible - with the challenge being that stress is a "composite multidimensional concept" (Ursin & Olff, 1993). Definitions include: the nonspecific response of the body to any demand made upon it (Selye, 1979); a unique interaction between a person and the environment (Lazarus & Folkman, 1984); an adaptive biological response necessary for homeostasis and survival in a changing environment by mobilizing energy reserves (Levin & Ursin, 1991); and activity in the hypothalamic-pituitary-adrenal system caused by two general types of stressors – physical challenges (i.e., low temperature) and the interpretation of psychological challenges (McNaughton, 1993). The definition of stress that is used for the current study states that stress is a process through which environmental events are interpreted by people in relation to their own values and resources, and responded to psychologically, behaviorally, and biologically (Cohen, Kessler, & Underwood Gordon, 1995).

Stress and the interpretation of stressors are closely aligned to the construct of "anxiety," which are, together and separately, implicated in many psychiatric disorders (American Psychiatric Association, 2000; Glue, Nutt, & Coupland, 1993). A source of complication in research comes from the fact that sometimes the terms stress and anxiety are used interchangeably (Bushman, Vagg, & Spielberger, 2005). One description of the differences between the constructs states that if people perceive a stressful situation as threatening they will experience an anxiety reaction, and that overall process is referred to as stress (Spielberger, 1979). This description can be applied to many situations and variables, for example, academic or professional examinations. The objective stimulus properties of the testing situation, perceived

as stressful by most individuals, can be termed *examination stress,* whereas the subjective experience of that stimulus can be termed as *test anxiety* and is relative to the individual differences in anxiety proneness during examinations (Spielberger, Gonzalez, Taylor, Algaze, & Anton, 1978; Bushman, Vagg, & Spielberger, 2005). Thus, "stress" can be conceptualized as the reaction to a current or ongoing stressor (e.g., the effects of working intensely to meet a deadline), whereas "anxiety" primarily refers to the anticipation of a future stressor or the outcome of that stressor (e.g., concern about a future project or event, or the results of not meeting a project deadline). The allied nature of the terms has meant that stress levels have often been estimated through the use of anxiety and personality questionnaires that measure both state and trait components. Trait anxiety reflects an individual's relatively stable personality characteristic, whereas state anxiety assesses the apprehension level an individual is experiencing at that moment. The physiological reactions of the body from stress and anxiety follow similar biological pathways, which further complicates distinguishing their characteristics, as both are implicated in the stress response.

Neurobiological Correlates of Stress

Many advances have been made in the understanding of the biological mechanisms of the stress response. In the late 1960's researchers discovered that peripheral hormones could be recognized by the rodent brain (McEwen, Weiss, & Schwartz, 1968), which subsequently spurred research to replicate the findings in the human brain and map the neuro-circuitry of the stress response. The reaction begins with stress perception that is most likely modulated through the fast-acting inhibitory (i.e., gamma-aminobutyric acid; GABA) and excitatory (i.e., glutamate)

amino acids (Glue, Nutt & Coupland, 1993). The immediate response to the perception of stress is secretion of catecholamines (i.e., norephinephrine and dopamine) into the blood stream and rapid changes made by sympathetic neurons that increase heart rate, blood pressure, pupil dilation, and respiration (Ursin & Olff, 1993). Parvocellular neurosecretory cells in the periventricular area of the hypothalamus release hypophysiotropic hormones (corticotropin-releasing hormone; CRH) into a capillary bed on the floor of the third ventricle, which in turn act on the anterior lobe of the pituitary to release into the bloodstream adrenocorticotropic hormone (ACTH; Bear, Connors, & Paradiso, 2001). Neuroendocrine CRH acts to mediate the peripheral responses to stress, as the ACTH acts on the adrenal cortex located just above the kidneys to release cortisol, which is part of the slower and longer-term neurohormonal response to the stressor (Campbell, Reece, & Mitchell, 1999).

Non-endocrine CRH receptors (two known types mineralocorticoids and glucocorticoids; MRs & GRs) are located throughout the brain's limbic system and neocortex, and mediate the central responses of the system and the feedback loop that modulates or arrests the response (Hayden-Hixson & Nemeroff, 1993). Non-endocrine endogenous CRH exerts a neurotransmitter-like action (for a comprehensive overview see Hayden-Hixson & Nemeroff, 1993; and Sutanto & De Kloet, 1993). Human and animal studies reveal why these effects are posited to be deleterious in long term stress: chronic exposure to high levels of corticosteroids produce hippocampal dendritic atrophy and suppressive effects on neurogenesis (Lupien, et al., 1998; Shors, et al. 2001). In addition, research has shown that the prefrontal cortex is particularly receptive to the glucocorticoid hormone cortisol. This finding has been demonstrated in both rats (Diorio, Viau, & Meaney, 1993; Meaney & Aitken, 1985) and humans (Oei et al. 2007). Recent

studies examining rats have shown that exposure to either chronic (Liston et al, 2006; Cook & Wellman, 2004) or acute (Brown, Henning, & Wellman, 2005) environmental stress (restraint), results in dendritic changes in the medial prefrontal cortex. The stress response has been classified into acute and chronic states, with acute reactions seen as healthy and adaptive responding to the environment, and chronic states being linked to health problems (i.e., immune system inhibition, ulcers, and cardiovascular complications) and decreased overall functioning including cognitive decrements (Lundberg, 2005; Selye, 1973).

Cognitive decrements have also been thought to be related to increased levels of firing in the noradrenergic system, which is linked to the exaggerated attentional bias seen in anxiety disorders and the pronounced over-coding of specific stimuli (Glue, Nutt & Coupland, 1993). The main area of noradrenergic neurons in the brain is located in the locus coeruleus and serves to innervate forebrain regions - including the hippocampus and cerebral cortex that are both implicated in memory and attentional systems (Stanford, 1993). Activation of the locus coerulus neurons during the stress response results in an increase of norephinephrine in the structures they innervate, and can ultimately result in a depletion of the neurotransmitter in regions such as the hypothalamus and amygdala (Fillenz, 1990; Stanford, 1993). This depletion of norephinephrine has been linked to an increase for stress vulnerability by depriving the system of an essential coping mechanism (Anisman & Zacharko, 1991).

Normal Aging, Accelerated Aging, and Chronic Stress

Work with nonhuman species has shown increased susceptibility to the detrimental effects of glucocorticoids in later life, and is associated with disruption of electrophysiological

function, atrophy, and death of hippocampal neurons. When the neurological changes in non-human species are considered alongside the fact that negative feedback (to decrease/arrest the stress response) is impaired in aged rats (Lupien & Meaney, 1998), then the importance of studying the effects of stress in human aging becomes more apparent. Further, all of these findings in rats have been linked to producing severe cognitive deficits and are commonly cited as "unsuccessful" sequelae of central nervous system aging.

In humans, one of the diseases most often linked to unsuccessful aging has been Alzheimer's disease (AD). Cortisol levels in patients with AD have been found to be substantially higher than in normal controls (+30% to 52% in males and +57% to 102% in females) and inversely correlated with memory test scores (Lupien & Meaney, 1998). In early-stage AD patients, decreased glucocorticoid feedback sensitivity is apparent (Lupien & Meaney, 1998). More recent research has examined environmental and genetic risk factors for the development of (AD) that includes measuring prolonged stress and the apolipoprotein E4 (APOE4) genotype, and found interaction effects between the two variables. Elderly non-demented participants who reported higher stress and were positive for the APOE4 genotype, had higher cortisol concentrations and performed consistently worse on memory tasks than their lower stress or non-APOE4 genotype peers (Peavy et al., 2007).

Decline in cognitive performance in general has been shown to be associated with normal aging in tasks such as episodic memory and executive functioning (Buckner, 2004). Healthy older adults typically do less well than young adults on measures of delayed recall (Davis et al., 2003) and recognition (Huh, Kramer, Gazzaley, & Delis, 2006), although age-related change may not be as prominent with visual memory (Fjell et al., 2005). Older subjects also tend to

perform more poorly on measures of novel problem solving (Davis & Klebe, 2001), fluency (Brickman et al., 2005), and mental flexibility (Wecker, Kramer, Hallam, & Delis, 2005). Some researchers believe that many of these declines can be directly related to an overall decrease in processing speed that influences performance on a variety of memory, attention, and executive function tasks (Salthouse, 2001). In a major sequential study of aging, small declines in primary mental abilities (verbal meaning, inductive reasoning, word fluency) were seen in people in their 50's, increasingly noted during their 60's, with more rapid declines occurring during their 70's (Schaie, 1995). Large inter-individual differences are seen in cognitive performance during these decades, and the role of chronic stress could potentially contribute to accelerated age-related declines in aspects of cognition beyond that anticipated in normal healthy aging.

Relationship Between Self-Reported Stress and Cognitive Performance

Physiological arousal and the complex neurological system changes triggered by the stress response have long been implicated in decreased cognitive performance, but research has provided mixed results. The strongest data supporting cognitive impairments linked to the stress response come from research involved with aspects of memory. In particular, studies consistently show deficits with declarative memory (conscious recollection of previously learned material) that is postulated to be due to the actions of stress hormones in the hippocampus. A meta-analytic review of sixteen heterogenous memory studies found that cortisol given before recall impairs declarative memory retrieval, though effects varied depending on time of day (Het, Ramlow, & Wolf, 2005). The hippocampus is strongly implicated in the processes of declarative memory (Squire, 1992) and object recognition (Schacter et al., 1995) including the encoding of

novel faces (right hippocampus; Grady et al., 1995; Haxby et al., 1996). The hippocampus together with the prefrontal cortex was found to have greater activity during a PET study during the recognition of previously learned faces (Kapur, Craik, Jones, Brown, Houle, & Tulving, 1995). A later event-related potentials study examining the effects of hydrocortisone on 24 young adults revealed impairments in face recognition in a working memory task (Monk & Nelson, 2002). The memory impairments correlated with stress and stress hormones have been postulated to stem from the high density of corticosteroid receptors within the hippocampus that are activated during the stress response, which, when occupied, inhibit other hippocampal processes (Sauro, Jorgensen, & Pedlow, 2003).

Self-report of stress levels can be measured through clinical interview or subjective questionnaires that evaluate the level of self-perceived stress that an individual is experiencing. The cognitive appraisal of a stressor plays a major role in the interaction of the person and the stressful environment (Lazarus & Launier, 1978), and, for the most part, stimuli that are appraised as novel, unpredictable and threatening to the sense of self induce the stress response (Mason, 1968). There is a relative paucity of extant research on self-reported stress and cognitive performance, and most studies have used the related construct of anxiety to measure any effects. A study that measured self-reported anxiety in healthy adult males, using Spielberg's State and Trait Anxiety (STAI) scales, found no correlation between self-reported anxiety and performance on a neuropsychological battery assessing attention, learning, memory, and perceptuo-motor speed (Waldstein, Ryan, Jenning, Muldoon, & Manuck, 1997). A study that measured self-reported stress levels using the Perceived Stress Scale (PSS; a measure of perceived stress over the past month; Cohen, Kamarck, & Mermelstein, 1983) during examination stress found that

increased self-perceived stress was correlated with reduced performance on tasks of attention (Vedhara, Hyde, Gilchrist, Tytherleigh, & Plummer, 2000). Vedhara and colleagues administered the PSS during an exam and non-exam period with sixty university students. The PSS scores indicated significantly higher stress during the exam period than the non-exam. The cognitive assessment measures were given once during each period and differences in performance were examined. During the exam period, performance on a short-term memory task improved significantly, while significant decreases in performance were found on tasks of selective and divided attention. No differences were found in a task of auditory verbal working memory.

The differential association of everyday stress with decrements in episodic memory has also been examined in young, mid-life, and older adults (Vondras, Powless, Olson, Wheeler, & Snudden, 2005). Participants were administered a brief battery of memory tests, the PSS, and the Elders Life Stress Inventory (ELSI; Aldwin, 1990). Increased self-reported stress on both scales was related to poorer performance on a verbal narrative memory task (Logical Memory subscale from the Wechsler Memory Scale – Revised), but not on a measure of verbal associative memory (Verbal Paired Associates subscale from the Wechsler Memory Scale – Revised) or a task of attention and processing speed (Digit Symbol Substitution Test subscale from the Wechsler Adult Intelligence Scale-III). The relationship was marginally stronger for the more chronic scale of stressors experienced over the past year (ELSI). The participants who reported high levels of stress in the young and mid-life group performed at the level of the older adults with low stress on the narrative memory task. In other words, stress was associated with an apparent narrative memory performance decline that mimicked premature aging. However the study did not find an

interaction between age and narrative memory performance, suggesting that any narrative memory decline relating to stress occurred prior to age 20 (the earliest age group included in the study). This study was limited by several factors, as the authors examined age categories instead of a continuous range of age, included a limited memory test battery, and did not include any complex tests of prefrontal/executive functioning.

Another study examined the relationship between both self-reported stress and cortisol levels with cognitive performance in a sample of 139 older adults (65-80 years of age; Wright, Kunz-Ebrecht, Iliffe, Foese, & Steptoe, 2005). Participants were administered a brief cognitive battery (Verbal Paired Associates (VPA) subtest of the Wechsler Memory Scale - Third Edition and the Matrix Reasoning (MR) subtest of the Wechsler Adult Intelligence Scale-III) (Wechsler, 1997b; Wechsler, 1997a). Cortisol level, blood pressure, heart rate, and a question on subjective stress experienced throughout the experiment (1 = no stress to 7 = very high stress) were assessed at varying time points (e.g., baseline, task 1, task 2, task 3, and recovery). Participants with the highest cortisol levels recalled 29% fewer word pairs in the delayed recall of the VPA task, as compared with participants with low cortisol levels. This association between cortisol and memory was independent of age, gender, time of day, medication, chronic illness, and education. The subjective answer to the stress question during the tasks was not significantly related to higher cortisol levels or decreased cognitive performance, and, operationally, was more aligned with the construct of state anxiety. The possibility that state anxiety serves to temporarily increase task performance may help explain some of the disparate findings in the anxiety/stress literature. For example, examination stress, as measured by the STAI, was found to increase performance on the executive function tasks of the Stroop Neuropsychological

Screening Test (SNST) and a computer task-switching measure (Kofman, Meiran, Greenberg, Balas, & Cohen, 2006).

The Relationship between Stress and Prefrontal Functioning

"Executive functioning" tasks are tasks that are believed to assess high-level cognitive functions that are involved in planning, controlling, and coordinating lower level functions (Stuss & Levine, 2002). Tasks that are considered executive functioning measures are interchangeably known as frontal or prefrontal tasks, due to the neuroanatomical and neuroimaging data linking the increased activation of the frontal lobes during these tasks (particularly the dorsolateral prefrontal cortex; DLPFC; Gazzaley & D'Esposito, 2007; Goldman-Rakic, 1998; Stuss & Levine, 2002). Cognitive tasks labeled as "executive functions" include a diverse collection of complex processes, including working memory, flexibility of thought, set shifting, motor sequencing, regulation of goal directed behavior, and sustained and divided attention (Gazzaley & D'Esposito, 2007).

Two recent studies examined the relationship between executive functioning tasks and self-reported stress in undergraduate students. The performance time of eighty-one participants on a set shifting task (Trail 5, Comprehensive Trail Making Task) revealed a statistically significant positive relationship with self-reported stress, as measured by the PSS (Orem, Petrac, & Bedwell, 2008). A further study set out to examine the relationship between self-perceived stress and another task of prefrontal functioning after controlling for the state anxiety (Petrac, Bedwell, Renk, Orem, & Sims, 2009), as state anxiety had been found to increase performance on some executive functioning tasks (Kofman, Meiran, Greenberg, Balas, & Cohen, 2006). The

study revealed a statistically significant correlation between increased recent self-reported stress (as measured by the PSS) and reduced performance on a divided attention task after accounting for state anxiety in a sample of fifty-four young adults (Petrac et al., 2009). When the study examined the performance on the divided attention task after accounting for perceived stress, the opposite effect was found: an increase in state anxiety was related to a decrease in errors on the divided attention task. Complex divided attention tasks have been shown in previous neuroimaging research to primarily involve prefrontal regions (Vohn, et al., 2007), which is the area gaining increased focus in stress research.

Research with twenty male participants on a brief neuropsychological battery following ten days of either twice-daily administered hydrocortisone or a placebo (Young et al., 1999) indicated a reversible deficit on tasks that rely on prefrontal functioning (e.g., spatial working memory strategy) that was linked to the elevated cortisol. Another study examined the effects of acute hydrocortisone administration on working and declarative memory in 40 healthy young male adults (Lupien, Gillin, & Hauger, 1996). The participants received infusions of saline (placebo group) or hydrocortisone. Results revealed that, at the highest cortisol dose, cortisol selectively reduced performance on the task that placed relatively more demands on the prefrontal cortex - a working memory task, without impairing performance on vigilance tasks, or contrary to previous findings, a task of declarative memory. Elzinga & Roelofs (2005) found that only participants who responded to a stress-inducing task with an increase in cortisol levels (cortisol responders) showed decreases in working memory performance. The decreases in working memory only occurred when sympathetic autonomic activation occurred in the cortisol responders (as measured by elevations in heart rate and blood pressure). When sympathetic

activation returned to baseline levels working memory capacity improved, even though cortisol had not returned to baseline levels. Participants who experienced sympathetic autonomic activation without a change in cortisol levels (cortisol non-responders) had no change in working memory. This may help account for some of the disparate findings in the stress literature, and illustrates why the effects of stress on prefrontal tasks warrant further investigation.

Early research which examined the relationship between prefrontal tasks and stress emphasized visual attention and used different types of stressors (loud noise, heat, sleep deprivation). These studies reported that induced stress, as well as age, was related to decreased performance on sustained attention tasks such as pursuit meter task (tracking the movements of a pointer through poor visibility), and the serial reaction task (touching light bulbs as they illuminate randomly and sequentially; e.g., Broadbent, 1954; Lazarus, Deese, & Osler, 1952; Rodnick, Rubin & Freeman, 1943; Sarason, 1957). Based on these findings, researchers have suggested that decreases in complex attention capacity are a normal part of aging. However, one recent study found that divided attention performance was primarily reduced in older adults who also reported higher anxiety (Hogan, 2003). Other research that examined divided attention performance in older adults compared performance on nine tasks under single and dual task conditions (de Ribaupierre & Ludwig, 2003). The study found that once performance on single tasks was taken into account, decreased performance by the older adults was found in only four of the nine divided attention (dual) tasks. The study did not examine the potential influence of levels of recent or chronic stress, and further examination of these findings would provide valuable insight into the complex interactions of stress, aging, and cognition.

Current Aims & Hypotheses

Thus, recent research suggests a neurobiological mechanism for deleterious effects of chronic stress on cognitive functioning, particularly found in tasks associated with either hippocampal and prefrontal functioning. Consistent with this theory, several studies have revealed that both acute and chronic administration of cortisol impairs working memory, which relies on prefrontal functioning. However, relatively little research has examined the relationship between self-perceived chronic stress and cognitive measures of prefrontal functioning, particularly in the elderly, and have mainly explored the effects of cortisol. To date, decreased performance on memory tasks has been most frequently correlated with increased levels of cortisol, induced stress, and self-reported stress, but it appears that none of these studies have accounted for state anxiety in older adult populations.

The current study aimed to fill the gap in the literature, by investigating if the recent research with young adults that revealed a link between self-reported stress and performance on a task of divided attention, after controlling for state anxiety, (Petrac et al., 2009) would be replicated in an older adult sample (across a wide range of late aging). Other tasks that placed higher demands on prefrontal functioning, as well as several types of memory tasks, were used additionally to investigate if decreases in performance were related to increases of self-reported stress. Only one study to date has attempted to discover whether levels of self-reported stress are correlated with an accelerated cognitive decline, and no executive functioning tasks were used and the effects of state anxiety was not considered (Vondras et al., 2005). The current study examined the possibility of accelerated age-related decline in relationship to self-reported stress

across a continuum of late aging, with the inclusion of a broader range of memory and executive functioning tasks and accounted for state anxiety.

The relationship between different types of perceived stress was also examined. The global self-reported stress measure of the PSS examines the level of self-perceived stress experienced over the previous month (referred to from this point as PSS-M). A new global measure was created for this study by extending the time frame of the PSS-M to see if global stress perception during a lifetime would reveal greater correlations with decreased performance on cognitive tasks in an elderly population (PSS-L). To examine whether the total number of stressful events correlated with decreases in performance on the cognitive tasks, the ELSI (Aldwin, 1990) was used to count the number of significant negative life events (i.e., divorce, death of spouse, loss of job) that occurred during the previous year. The ELSI was included in the present study as it was found to have a marginally stronger relationship with performance on a verbal narrative task than the PSS-M (Vondras et al., 2005). However, Vondras et al., did not control for state anxiety that revealed the relationship between chronic stress and increased errors on task of divided attention reported in a previous study (Petrac et al, 2009).

Several tasks of memory and executive functioning were used to create memory, learning, and executive function domain batteries. The memory and the learning battery included three tasks taken from the Wechsler Memory Scale-III (Wechsler, 1997b) that represented broad aspects of memory divided into immediate (learning battery) and delayed (memory battery) conditions. The three tasks included assessment of prose memory, list learning, and memory for faces. Performance on the delayed prose memory task was anticipated to be most impacted by higher reported levels of stress. Simple immediate recall tasks have been found to improve

during periods of high self perceived stress (Vedhara, Hyde, Gilchrist, Tytherleigh, & Plummer, 2000), though the influence of state anxiety has not been accounted for in these relationships. Therefore, it was hypothesized that stress levels would have less negative impact on performance in immediate memory conditions (learning battery), though a greater negative impact would be revealed than in previous studies due to controlling for the effects of state anxiety.

The executive battery included a task of divided attention, a task of set shifting and rule inference, a measure of verbal fluency and a measure of verbal working memory. The four tasks had varying levels of complexity. Performance on the two most complex tasks, the divided attention and the set-shifting/rule inference tasks, were anticipated to reveal the poorest performance in relation to high levels of self-perceived stress. In a study that assessed whether anxiety was associated with poorer performance on cognitive and motor tasks it was found that older adults reporting high trait anxiety performed significantly worse in a task of divided attention than their non-anxious peers (Hogan, 2003). High trait anxiety is the personality characteristic that is most closely aligned to chronic stress, and it was hypothesized that the complex divided attention task in the current study would be the one showing the greatest relationship with self-perceived stress.

Practical Implications

In a variety of situations, healthy older adults have to deal with challenging situations and the need for proficient cognitive skills are paramount for life and death safety issues. This study assessed whether an older adult's subjective perception of their stress level correlated with accelerated age-related decline in performance on objective tasks of prefrontal functioning and

memory. Practically speaking, if a person is made aware that their feelings of stress can physiologically impact their ability to function well cognitively, then, perhaps, they may be more amenable to seek help to reduce that stress. Awareness that chronic stress in young adulthood may accelerate cognitive decline in later years, may be the impetus for a person to actively seek stress reducing circumstances. Active stress intervention may help circumvent conditions of cognitive impairment sometimes known as "pseudo-dementia," associated with high cortisol levels in depressed elderly (Lupien & Meaney, 1998). Further, in a longitudinal study of elderly men and women, accrued unremitting life stress was found to significantly impact the potential to experience positive well-being and life satisfaction (Smith, 2003). In the year 2000, it was estimated that 12.7% of the U.S. population was aged sixty-five or older, and in the 2010 census that figure is expected to rise to 13.2%. The Administration on Aging projects that by 2030, 20% of the U.S. population will be aged sixty-five or older (as reported in Spirduso, Francis, & MacRae, 2005). As the U.S. population continues to age, the need for research into the relationship between stress and aging become more pressing. The results of this research may have practical implications to stimulate the availability of interventions for people who experience high-stress in order to reduce the accelerated aging decline of cognitive functions.

Hypotheses

Main Effects Relating to Memory Performance

1) The PSS-Lifetime score was hypothesized to enter the model in predicting performance on the memory domain score. Planned post hoc comparisons for each memory test score that contributes to the overall memory domain score were hypothesized to reveal a large

effect size across all of the verbal memory scores and a medium effect size on the visual memory test score. All of these relationships were hypothesized to be statistically significant.

2) The PSS-Month score was hypothesized to enter the model in predicting performance on the memory domain score. Planned post hoc comparisons for each memory test score that contributes to the overall memory domain score were hypothesized to reveal a large effect size for the delayed prose verbal memory task, followed by medium effect sizes for the delayed list learning memory task, and the delayed visual memory task. All of these effect sizes were hypothesized to be statistically significant.

3) The ELSI score was hypothesized to enter the model in predicting performance on the memory domain score. Planned post hoc comparisons for each memory test score that contributes to the overall memory domain score was hypothesized to reveal a large effect size for the delayed prose verbal memory task (which will be statistically significant), followed by medium effect sizes for the delayed list learning memory task, and a small effect size for the visual memory task (which will not be statistically significant).

Main Effects Relating to Learning Performance

1) The PSS-Lifetime score was hypothesized to not enter the model in predicting performance on the learning domain score as any effect size found would be too small to be revealed by the sample size. There were no planned post hoc comparisons.

2) The PSS-Month score was hypothesized to not enter the model in predicting performance on the learning domain score, as any effect would be too small to be revealed by the sample size. There were no planned post hoc comparisons.

3) The ELSI score was hypothesized to not enter the model in predicting performance on the learning domain score, as any effect would be too small to be revealed by the sample size. There were no planned post hoc comparisons.

Main Effects Relating to Executive Functioning Performance

1) The PSS-Lifelong score was hypothesized to enter the model in predicting performance on the executive functioning domain score. Planned post hoc comparisons for each executive functioning test score that contributes to the overall executive functioning domain score were hypothesized to reveal large effect sizes across all executive functioning tasks that will be statistically significant.

2) The PSS-Month score was hypothesized to enter the model in predicting performance on the executive functioning domain score. Planned post hoc comparisons for each executive functioning test score that contributes to the overall executive functioning domain score were hypothesized to reveal a large effect size for the divided attention task, followed by medium effect sizes for the remaining executive functioning tasks, all of which will be statistically significant.

3) The ELSI was hypothesized to enter the model in predicting performance on the executive functioning domain score. Planned post hoc comparisons for each executive functioning test score that contributes to the overall executive functioning domain score were hypothesized to reveal a medium effect for the divided attention task (which will be statistically significant), and small, non-significant, effects for the remainder of the executive functioning tasks.

Interaction of Age and Stress on Cognitive Performance

In a series of nine ANOVA's, one for each of the three cognitive domain scores with each of the three stress measures and the STAI, it was hypothesized that there would be:

1) A statistically significant interaction between age and each of the three stress measures on predicting the memory domain test score, with the younger adults showing only a slight (non-significant) decline in memory performance with increasing reported stress and older adults showing a greater (statistically significant) decline in memory performance with increasing reported stress. This interaction was expected to be strongest for the PSS-L.
2) No statistical significance for the interaction between age and each of the three stress measures on predicting the learning domain test score.
3) A statistically significant interaction between age and each of the three stress measures on predicting the executive functioning domain test score with poorer performance with increasing age associated with increasing self perceived stress, with the younger adults showing only a slight (non-significant) decline in executive functioning performance with increasing reported stress and older adults showing a greater (statistically significant) decline in executive functioning performance with increasing reported stress. This interaction was expected to be strongest for the PSS-Lifetime.

METHODS

Phase I

Participants for Phase 1

Participants for this study were recruited from a population of healthy older adults who belong to Orlando, FL adult leisure groups and communities (The Learning Institute for Elders (LIFE) at the University of Central Florida (UCF); the Lutheran Haven retirement community; and the Whirl and Twirl Dance center). Participants completed questionnaires that included stress scales, demographic information, and validity scales (see section on Phase I measures) either online or in paper and pencil. A link to the questionnaires was posted on the LIFE website. A total of 200 participants were sought for this initial screening phase to allow sufficient variability and range of stress levels and age to be gathered. Participants who were over the age of 49 were invited to participate, with no upper age limit. This was to ensure that a range of young-old to the oldest-old adults was represented.

Measures for Phase I

Demographic Information (Appendix A). The demographic section of the questionnaire included contact information, gender, age, race, previous employment history, education level, a screen for: vision/auditory problems, history of stroke, history of brain tumors, history of traumatic brain injury, current or past dementia diagnosis, past traumatic experiences, and current prescribed medications.

Perceived Stress Scale (PSS-M; Appendix B). The PSS-M is a 10-item questionnaire and is one of the most common measures of self-perceived stress (Cohen, Kamarck, & Mermelstein,

1983). The Cronbach alpha coefficients reported for this scale ranges from 0.84 to 0.86, and was calculated to be .81 for this study. The items reflect a person's perception of the intensity of situational stressors they have experienced during the month prior to completing the questionnaire. Items in the PSS-M measure the extent that individuals report their lives as unpredictable, uncontrollable, and overloaded (Cohen, Kamarck, & Mermelstein, 1983). The format of the PSS-M is a Likert Scale with five rating choices, ranging from "never" to "very often" that respondents use to gauge the frequency of feelings they have experienced such as "control of irritations" and "confidence in ability to handle personal problems."

Perceived Stress Scale - Lifetime (PSS-L; Appendix C). The PSS-M 10-item questionnaire (Cohen, Kamarck, & Mermelstein, 1983) was adjusted by the author of the current study to examine self-perceived stress over the lifetime. Specifically, the content of each item on the PSS-M was retained, but the text at the beginning of each question was changed from "In the last month" to "Reflecting on your lifetime." Currently, there are no Cronbach alpha coefficients to report for this lifetime version other than the one calculated from this study's sample, which was strong at .86. Items on the PSS-L measure the extent that individuals reported perceiving their entire lives as unpredictable, uncontrollable, and overloaded. The response choices and format were the same as on the PSS-Month.

Elders Life Stress Inventory (ELSI; Appendix D). The ELSI is a 31-item self-report measure that is used to assess stressful life events that have occurred during the previous year (Aldwin, 1990). The events include general stressful occurrences (e.g., death of a friend, being burglarized), as well as events that are more likely to occur in later adulthood (e.g., death of a

spouse, retirement). The Cronbach alpha coefficients reported for this scale ranges from 0.69 to 0.70 (Vondras, Powless, Olson, Wheeler, & Snudden, 2005).

The Marlowe-Crowne Social Desirability Scale (MC; Appendix E). An abbreviated 13-item scale (Reynolds, 1982), designed from the 33-itemed Marlowe-Crowne Social Desirability Scale (Crowne & Marlowe, 1960), was used to assess perception of social support and whether participants answered according to what they perceive to be socially appropriate responses. The 13-item form has been found by others to have acceptable internal consistency reliability (r = .76) comparable to the standard form and other short forms (Reynolds, 1982). The 13-item version of the Marlowe-Crowne Social Desirability Scale was also found to have strong reliability with the Marlowe-Crowe Standard form (r = .93). Items in the MC are answered as true or false.

The State-Trait Anxiety Inventory (STAI; F). Only the "trait" portion of the STAI (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was administered in Phase I. This is a 20-item questionnaire that is one of the most common measures of long-term characterological (trait) anxiety. The items in the "trait" portion reflect an individual's perception of how he or she feels "in general," and not how he or she at that moment.

Procedure - Phase I

Participants who chose to complete the questionnaires online were directed to an informed consent webpage after they volunteered for the study. The webpage informed participants about the study and they were asked to read the informed consent carefully (Appendix G) and then give an electronic signature of understanding prior to proceeding.

Participants who chose to complete the questionnaires in paper and pencil received an informed consent sheet stating that they should only fill out the questionnaires if they were consenting to be a participant in the study.

After providing informed consent, participants completed the demographic questionnaire that included a question asking permission from the participants to allow the investigator to contact them directly for future research studies. The demographic section was followed by questions from the Phase 1 measures (described previously). The questions appeared in a fixed order: the original 10-item PSS-M, the 31 items from the ELSI, the lifetime 10-item PSS-L, and the 13-item MC. The average completion time for the 64 questions was approximately 20 minutes. Following the completion of all items on the questionnaire, the participants received a debriefing form (Appendix H), which included additional information about the purpose of the study as well as researcher contact information.

Phase II

Participants for Phase II

Participants from Phase I were invited to participate in Phase II after a process of screening out participants who reported issues that may have confounded Phase II results. Participants were excluded for self-report of significant uncorrected visual or auditory impairments, as this may have affected their performance on the cognitive measures. In addition, participants were excluded for self-report of a history of strokes, brain tumors, or traumatic brain injury. Participants who indicated exposure to a psychological trauma (e.g., rape) were not

invited to Phase II because of the potential for Posttraumatic Stress Disorder, which could confound responses on the stress measures.

Other participants were excluded due to their partial completion of the Phase I measures. For example, some participants only completed one side of the two sided paper and pencil packets, and others began the online questionnaires and never completed the last measures. Participants were also excluded for the following: if any of the questions from the two 10-question PSS measures was missing; if two or more questions were missing from the STAI; if three or more questions were missing from the ELSI; or if they scored more than two standard deviations above the mean on the MC scale. Missing questions were given the most conservative responses possible (a non-report of symptoms) when calculating the measure scores. After exclusion criteria were applied a total of 147 participants were eligible for recruitment into Phase II. In this sample of 147, there was a wide range of PSS-month stress scores (0 - 23, mean = 12.77; SD = 4.59) and ages (53 - 97).

In accordance with Cohen's (1992) recommendations for power analysis, it was estimated that a minimum sample size of 43 participants was needed for sufficient statistical power in Phase II. This estimate was based on an alpha level of .05, an estimated a Pearson's *r* of .36 (medium effect size), and power of .80 for a two-tailed test. The effect size used in this power analysis was based on earlier research results (Petrac et al., 2009), which showed a positive statistically significant relationship between the PSS scores and an auditory omission error change score (errors in dual task condition minus errors in single task condition) in a dual task continuous performance test, a task used in the current study. However, the earlier study only included young adults and did not investigate the interaction of PSS with age on predicting

the cognitive performance. There does not appear to be any published studies that use a similar design as the current study to estimate a related effect size from. Therefore, to be conservative, we expected at least a medium effect size as was found in the earlier study with younger adults, although we predicted that this effect size may be somewhat larger in an older adult sample.

A total of 61 participants took part in the Phase II testing, 29 males and 32 females with an age range of 54 to 88 years of age, with a mean age of 72.87 years (SD = 6.5). All Phase II participants were Caucasian, with a mean education of 16.06 years (SD = 2.57) and a range of 12 - 21 years of education. Phase II participants' socioeconomic status (SES) was able to be calculated for 59 of the participants using a four factor index of social status (Hollingshead, 1975). The index requires information about education and current/past occupation of participants that is then used to calculate totals (using factor weights) that result in computed social strata scores. Hollingshead (1975) ranked five possible social stratas, with the highest strata equivalent to major business and professionals (scores of 66-55) and the lowest strata equivalent to unskilled laborers and menial service workers (scores of 19-8). The mean SES score of Phase II participants equaled 57.85 (SD = 7.37) with a range of 37 – 66, overall, 74.6% fell into the highest strata, 22% the next highest, and 3.4% into the middle strata. No participants were in the two lowest strata.

Measures for Phase II

Executive Function Battery

Visual Continuous Performance Test (V-CPT). The V-CPT task was created using the Vigil/W v. 1.3.0 software package (ForThought, 1995). Stimuli were presented using a 22-inch

NEC Multisync FP 2141^{SB} monitor and PC computer, and responses were collected using a standard keyboard. The CPT task was modeled after the A-X version (Wohlberg & Kornetsky, 1973), in which a series of random single letters is presented and the participants are asked to press the spacebar after observing a target sequence of two letters. In the present study, the target consisted of the number "1" followed by the number "6." This sequence occurred 20% of the time. Stimuli was presented in the center of the monitor at a constant rate of 1400 ms, with the target appearing for 50 ms followed by the blank screen appearing for 1350 ms. Each number was approximately 1.5 cm wide and 1.5 cm high.

The task began with one 30 second practice block consisting of 30 stimuli and 10 targets. The practice session did not have decoys (i.e., a number other than "1" followed by "6" or "6" followed by a letter other than "1"). White noise on the background was automatically generated by the software package. During the practice session, participants were given oral feedback from the experimenter regarding their accuracy. Following the practice session, the full task was administered, consisting of 3 consecutive blocks. Each block contained 24 targets and 12 decoys randomly occurring within 120 total stimuli. Non-target stimuli consisted of random numbers. A response was marked as a correct detection when the participant responds to target trials ("1" followed by "6"). Responses to non-targets were marked as a commission error while failure to respond to a target was marked as an omission error. The V-CPT was performed twice, one time alone and one time simultaneously with the Auditory Continuous Performance Test in a divided attention trial. For all CPT tasks, participants were oriented towards the computer screen by means of a chin/forehead rest positioned 18 cm from the monitor.

Auditory Continuous Performance Test (A-CPT). The A-CPT task was created using theVigil/W v. 1.3.0 software package (ForThought, 1995). Stimuli were presented using a second PC computer with stereo speakers. The A-CPT task was modeled after the V-CPT described above, with several modifications. A series of random single letters were presented audibly (with a recorded male voice on the computer), and the participant was asked to respond orally with the word "hit" when a target was heard ("K" followed by "A"). The researcher pressed a keyboard spacebar to enter the participant's oral response into the computerized accuracy monitoring software. Auditory stimuli were presented at a constant rate of 1400 ms by the computer (85 ms = target, 1315 ms = interstimulus interval). The A-CPT mirrored the same practice and full task protocols as described in the V-CPT section. The primary differences were: 1) the stimuli were letters instead of numbers; 2) stimuli were presented audibly instead of visually; and 3) the participant indicated a response orally instead of pressing a keyboard spacebar.

Divided Attention Continuous Performance Test (DA-CPT). The DA-CPT consisted of the simultaneous performance of both the V-CPT and the A-CPT on the two computers. Both the V-CPT and the A-CPT were the same versions of the tasks that were used when administered individually, and were administered using the same procedures as described previously. The format of the programs necessitated that they were run on two computers, and this required that the examiner tap the space bar of the second computer when the participant verbally responded "hit." This precluded recording the participant's reaction time during the A-CPT. The DA-CPT began with the simultaneous presentations of the practice sessions from the individual V-CPT and A-CPT. Then the DA-CPT full task was administered with the simultaneous presentations of

the individual V-CPT and A-CPT. The individual visual and verbal stimuli were not synchronized due to slight differences in the presentation times of the visual and auditory stimuli.

Performance on the DA-CPT was assessed by calculating a total change score in both omission and commission errors (separately). This score was calculated by summing the errors on the DA-CPT from both modalities (auditory and visual) and then subtracting the summed errors made on the single conditions from the dual condition. Change error scores were also calculated within each modality (i.e., dual condition auditory omission score minus single condition auditory omission score).

Wisconsin Card Sorting Test: Computerized Version 4 (WCST: CV4). A computer-based version of the Wisconsin Card Sorting Test (WCST) was administered using standard instructions (Psychological Assessment Resources, 2003). The chinrest was not used during this task and participants were seated at a comfortable distance from the screen. This task included four stimulus cards and 128 response cards that contained various figures. The cards varied on color (red, green, blue, or yellow), type of figure (crosses, circles, triangles, or stars), and number of figures (1-4). Four key cards remained across the top of the screen throughout the task in the following left-to-right order: one with a red triangle, one with two green stars, one with three yellow crosses, and one with four blue circles. The participant was asked to match each of the response cards (presented one at a time on bottom of screen) to one of the four key cards on the top of the screen. The participant used the computer mouse to click on one of the key cards that they believed was the correct match. Feedback was provided after each selection by a computerized female voice that stated "correct" or "incorrect." Prior to starting the task, the

participant was told that the rules for matching cannot be given and that they should attempt to make the correct match based on the feedback provided by the computerized response. After the participant made a predetermined number of consecutive correct matches using the initial arbitrary rule, the sorting rule was changed by the computer without notice. The test progressed in this way through five shifts of three possible rules.

Letter Number Sequencing (LNS). The version of the LNS used was from the Weschler Adult Intelligence Scales-III (WAIS-III; Wechsler, 1997a), and is a component of the Working Memory Index of that test. Lists of random letters and numbers were read aloud, and participants were asked to rearrange them and repeat them back with numbers first, in order, followed by the letters alphabetically arranged. LNS is thought to better assess working memory than simpler digit span tasks that are posited to assess immediate memory span (Lezak, Howieson, & Loring, 2004).

Controlled Oral Word Association (COWA). This task required participants to generate as many words as possible (excluding proper nouns or variations of a previously said word) in one minute beginning with a designated letter (Benton & Hamsher, 1989). There were three word generating trials using the letters F, A, and S. The task is a widely-used measure of verbal fluency, and is used extensively to assess executive function.

Memory Battery

Logical Memory II (LM II). Story recall was used to measure memory for meaningful auditory material (Wechsler Memory Scale-III; Wechsler, 1997b). Two stories were read, one at a time, and participants were asked to remember each one. They were asked to immediately

recall the first story prior to being read the second story that was read to them twice. The delayed recall condition is given approximately thirty minutes after the immediate recall (LM I; learning), and the score used for the memory domain is the total number of words remembered during free recall.

Word Lists II (WL II). Word Lists assesses immediate memory, efficiency of learning, effects of interference, and recall following short and long delay periods (Wechsler Memory Scale-III; Wechsler, 1997b). Twelve words are read aloud during four learning trials, and participants are instructed to remember as many words from the list as they can. A second list is then read aloud, and immediately after recalling the second list participants are asked to freely recall the words from the first list (without hearing that list again) (WL I; learning). The delayed recall condition is given thirty minutes after the immediate recall. The number of words remembered during the delayed free recall was used for the memory domain.

Faces II (F II).This task was designed to measure complex and meaningful information presented visually (Wechsler Memory Scale-III; Wechsler, 1997b) that is considered a visual analog to the Logical Memory subtest. Twenty four colored photographs of diverse human faces were presented visually for 3 seconds each, and participants were instructed to remember each face. Their recognition (using the original 24 actual faces and 24 new faces) was then assessed in immediate (learning) and delayed recall conditions (memory).

Learning Battery

Logical Memory I (LM I). Story recall was used to measure learning for meaningful auditory material (Wechsler Memory Scale-III; Wechsler, 1997b). Two stories were read, one at

a time, and participants were asked to remember each one. They were asked to immediately recall the first story prior to being read the second story that was read to them twice. The total score of the immediate recall for all three stories was used for the learning domain.

Word Lists I (WL I). Word Lists assesses immediate memory, efficiency of learning, effects of interference, and recall following short and long delay periods (Wechsler Memory Scale-III; Wechsler, 1997b). Twelve words are read aloud during four learning trials, and participants are instructed to remember as many words from the list as they can. A second list is then read aloud, and immediately after recalling the second list participants are asked to freely recall the words from the first list (without hearing that list again). The total number of words remembered during the four trials of immediate recall was used for the learning domain.

Faces I (F I). This task was designed to measure complex and meaningful information presented visually (Wechsler Memory Scale-III; Wechsler, 1997b) that is considered a visual analog to the Logical Memory subtest. Twenty four colored photographs of diverse human faces were presented visually for 3 seconds each, and participants were instructed to remember each face. Their recognition (using the original 24 actual faces and 24 new faces) was then assessed in immediate (learning) and delayed recall conditions (memory).

Anxiety and Stress Measures

The State-Trait Anxiety Inventory (STAI; Appendix J). Only the "state" portion of the STAI (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was administered. This is a 20-item questionnaire that is one of the most common measures of transient current (state) anxiety. The items in the "state" portion reflect an individual's perception of how he or she feels "right

now, at the moment," and not how he or she generally feels. The STAI was used to help separate recent ongoing perceived stress (over the last month or lifetime) from immediate situational anxiety.

Perceived Stress Scale - Lifetime (PSS-lifetime; Appendix C). The PSS 10-item questionnaire (Cohen, Kamarck, & Mermelstein, 1983) was adjusted by the author of the current study to examine lifetime self-perceived stress. Specifically, the content of each item on the PSS was retained, but the text at the beginning of each question was changed from "In the last month" to "Reflecting on your lifetime." Currently, there are no Cronbach alpha coefficients to report for this lifetime version other than the one calculated from this study's sample, which was strong at .86. Items measure the extent that individuals reported perceiving their entire lives as unpredictable, uncontrollable, and overloaded. The response choices were the same as with the PSS-Month.

Procedure for Phase II

Research was conducted in the Clinical Cognitive Neuroscience Laboratory located on the campus of UCF. The research appointment began with a detailed informed consent procedure (Appendix I), and then the participants completed a new PSS-M (paper version), to measure their perception of their level of stress over the previous month, and then the STAI-state was given, to measure the amount of anxiety they were experiencing at that exact time (Appendix J). Then they were administered the memory and executive functioning batteries in a counterbalanced fixed order. The average time for each battery was one hour, including practice trials. Following the test administration, the participants were given a debriefing form (Appendix K), which also

gave the opportunity request receiving study results. The debriefing forms included information about the purpose of the study as well as the researchers' contact information.

Statistical Analyses

The memory domain score was created by transforming the three raw scores of the three delayed memory tasks (LM-II Total Recall Score; WL-II Total Recall Score; F-II Total Recall Score) into z-scores and deriving the mean z-score. The learning domain score was created by transforming the three raw scores of the three immediate memory tasks (LM-I Total Recall Score; F-I Recall Total Score; WL-I Total Recall Score) into z-scores and deriving the mean z-score. The executive domain score was created by transforming four raw scores from the four executive functioning tasks (DA-CPT Auditory Omission Error Change Score, WCST Total Number of Errors, LNS-Total Correct Score, COWA Total Score) into z-scores and deriving the mean z-score.

To examine the relationships between the stress measures and cognitive measures, three hierarchical regressions were conducted using each individual cognitive domain scores (learning, memory, & executive functioning) as the dependent variables. All three regressions used the same predictors and followed the same procedure. In the first step, the state anxiety score was entered in order to control for this factor in the second step. In the second step, the three stress scores the PSS-M (from Phase II), the PSS-L, and the ELSI were entered using the stepwise method. Results were examined to evaluate which (if any) stress measure(s) entered the model in predicting the cognitive performance in any of the three domain areas. If a particular cognitive domain (memory, learning, or executive functioning) showed a statistically significant

relationship with a stress measure, further exploratory regressions were planned to be conducted in a similar fashion using each subtest score (within that domain) as the dependent variable.

To examine the relationships between the stress measures and age on the three cognitive domains, three sets of three ANOVA's were conducted. Each ANOVA examined whether the interactions of each of the stress measures (PSS-M, PSS-L, and the ELSI) with age had an effect on any of the three dependent domain variables (memory, learning, and executive functioning). Finally, exploratory correlations were planned using the variables that comprised each domain score to see if any of the sub-tests approached significance. This exploratory statistic was planned to gain insight and ideas for future directions examining this research area.

RESULTS

The results were conducted using SPSS for Windows version 16.0. All variables were screened for normality, using a Kolmogrov-Smirnov statistic with Lilliefors significance correction. Results of this normality check suggested that the only variable not normally distributed was the ELSI. The kurtosis value for this variable was 3.14 suggesting that the shape of the distribution would not have a significant influence on the regression analyses, which are relatively robust to minor variations in the normality assumption.

A hierarchical regression analysis with $p_{in} = .05$ and $p_{out} = .10$ was used to assess whether, after controlling for the STAI score, any of the three stress measures were significant predictors of the score on the Memory Domain. It was found that one participant's score was missing the ELSI, so only 60 participants were included in the regression model for the ELSI. The STAI was entered first in the model and by itself was not found to be a significant predictor of variance in the Memory Domain score, $F(1,58) = 0.53$, $p = 0.47$, $r = -.095$. In step 2, the PSS-M, PSS-L, and the ELSI were added to the model, using the stepwise entry model. None of the variables entered into a model to be significant predictors of variance in the Memory Domain score (see Table 1).

The second hierarchical regression analysis with $p_{in} = .05$ and $p_{out} = .10$ was used to assess whether, after controlling for the STAI score, any of the three stress measures were significant predictors of the score on the Learning Domain. The STAI was entered first in the model and by itself was not found to be a significant predictor of variance in the Learning Domain score $F(1, 58) = 2.87$, $p = 0.09$, $r = -.217$. In step 2, the PSS-M, PSS-L, and the ELSI

were added to the model, using the stepwise entry model. None of the variables entered into a model to be significant predictors of variance in the Learning Domain score (see Table 2).

The third and final hierarchical regression analysis with $p_{in} = .05$ and $p_{out} = .10$ was used to assess whether, after controlling for the STAI score, any of the three stress measures were significant predictors of the score on the Executive Functioning Domain. One participant's score was missing from the LNS subtest, and four other participant's scores were missing from the WCST, so their executive functioning scores were calculated separately using three variables, and not the four used for other participants. The STAI was entered first in the model and by itself was not found to be a significant predictor of variance in the Executive Functioning Domain score $F(1, 58) = 1.92$, $p = 0.17$, $r = -.179$. In step 2, the PSS-M, PSS-L, and the ELSI were added to the model, using the stepwise entry model. None of the variables entered into a model to be significant predictors of variance in the Executive Function Domain score (see Table 3).

To examine the relationships between the stress measures and age on the three cognitive domains, three sets of three between-subject ANOVAs were conducted. In the first set of three ANOVAs, the cognitive domain of memory was explored with each of the three stress measures; the ELSI, PSS-L, and the PSS-M. In the first ANOVA, the independent variables of the STAI, ELSI, and age were entered along with the interaction between ELSI and age. No main effects or interaction effects were found. In the second, the independent variables of the STAI, PSS-L, and age were entered along with the interaction between PSS-L and age. A statistically significant interaction was found for PSS-L*Age, $F(1,60) = 4.637$, $p = .036$ partial $\eta^2 = .076$. The simple effects of this interaction were examined by dividing participants into two age groups, one below the median age split (young-old; 54 to 73 years of age) and the other above (older-old; 74 to 88

years of age) (see Figure 1). No significant relationship was found between the groups $F(1,60) = .327$, $p = .569$, partial $\eta^2 = .006$. Finally, the independent variables of the STAI, PSS-M, and age were entered along with the interaction between PSS-M and age. No main effects or interaction effects were found (see Table 4).

In the second set of three similar ANOVAs, the cognitive domain of learning was explored. No main effects or interaction effects were found for any of the three stress measures (see Table 5). In the third and last set of similar ANOVAs, the cognitive domain of executive functioning was explored. Similar to the learning domain, no main effects or interaction effects were found for any stress measure (see Table 6).

For descriptive purposes, three sets of partial correlations were conducted. After controlling for the STAI, a partial correlation was conducted for each of the three cognitive domains, using all subtest scores from that domain, along with all stress measures, age, and years of education. The correlations among the variables are shown in Tables 7-9. The main correlations found were in predictable areas – the stress measures correlated with each other, and the tasks used within each of the three cognitive domains tended to correlate within the domain. However, one correlation was consistent with the a priori hypothesis posited while creating this study - the stress measure ELSI showed a positive relationship ($p < .01$) with the auditory omission change score from the CPT task (greater stress related to more omission errors during the more difficult dual task condition). The ELSI was also correlated with the number of errors from the WCST ($p < .01$). However, this relationship did not survive a conservative Bonferroni for the multiple comparisons.

DISCUSSION

This study aimed to expand the knowledge base in the complex area of self-perceived stress and cognition, by examining whether there was a relationship between increased self-perceived stress and an accelerated decline in cognitive function in an older adult population. Further, this research set out to examine if a negative relationship between self-perceived stress and aspects of cognitive functioning would be increased after accounting for state anxiety. The results of the hierarchical regressions of this study (which did not account for age) showed that there were no significant models. This had been a predicted finding for the learning domain; however, this was not predicted for the hierarchical regressions for the memory and executive functioning domains. Research examining the interactions between stress and cognitive performance has previously produced contradictory results, and the complex variables that are involved in this area may account for the lack of findings in the current study.

The relationships between the three stress measures and the learning domain was predicted to be the least strong of the three domain areas, and to not be statistically significant, due to fewer consistent research findings reported in this cognitive domain (Lupien & Lepage, 2001). Results from previous studies have found contradictory results that include no relationship between stress and learning performance, a positive correlation between the two, or a negative correlation between the two. There have only been a very limited number of studies that have examined naturalistic stress, without endogenous or exogenous induction of the HPA stress axis, with immediate learning and self-report of stress levels using the PSS-M. Two of the studies that have examined this question of naturalistic stress with immediate memory found

opposite effects. Vedhara et al. (2000) found that immediate recall of a list of 20 words increased during times of higher self-reported stress on the PSS-M, while divided attention decreased. Vondras et al. (2005) found that participants reporting higher stress performed worse on task requiring recall of a prose passage in both immediate memory and delayed memory conditions. They found in two separate hierarchical regressions that an increase in self-perceived stress on the PSS-M or ELSI score predicted a decrease in performance in immediate memory when using one of the same tasks (LM I) that is incorporated in the learning domain in this current study. However, these authors reported small effect sizes (*partial* R^2 = .04). In the current study, the related effect sizes for the learning domain were even smaller (*partial* R^2 < .02 for all stress measures). In contrast with the Vondras et al. study, the statistical power in the current study did not allow detection of small effect sizes. Therefore, the lack of statistical significance in the relationship between the stress measures and the learning domain scores was predicted and consistent with our hypothesis.

A more unexpected finding was the lack of relationship between the stress measures and scores on the memory domain. This was contrary to some of the more robust findings in the stress and cognition literature. This lack of findings indicates that this sample of participants may have had some unusual characteristics. A common problem encountered in research is the reliance of volunteers to participate in studies, as the sample becomes self-selected. In the area of aging this problem has been shown to result in self-selected samples that are more educated, have higher socio-economic status, and who have better physical health (Lupien & Lecours, 1993). These three factors have been shown to be important for maintaining or optimizing cognitive functioning in old age (Jürges, 2009; Johnson et al., 2010; Schaie, 1993), as well as

having less stress-related illnesses (Marmot, et al., 1991; Sapolsky, 2004). While information on physical health was not collected for this study, the sample had higher education (mean = 16.06 years) than the general population, and higher SES - 97% participants fell in the highest two social strata levels of Hollingshead's (1975) five social strata. The main groups who agreed to have their members contacted for possible participation in this study also possessed other characteristics, like the likelihood of greater physical health and rich social networks, that may have further influenced this presents study's findings.

A recent study of leisure activities in late life found that not only a rich social network was related to a lower risk of dementia (Fratiglioni, Wang, Ericsson, Viitanen, & Winblad, 2000), but mental and physical components were also significantly associated (Paillard-Borg, Fratiglioni, Winblad, & Wang, 2009). The latter study showed that participation in a broad spectrum of activities in more than one of the three components was more beneficial. Informal conversation and observation of participants in this current study suggested that all were active in at least two of the components indicated by Paillard-Borg and associates. Non-development of dementia has been one of the many factors posited in the definition of successful aging. A comprehensive review of the many definitions and studies of successful aging concluded that over one third of older adults could be classified as aging successfully with the main variables being lack of physical disability and psychosocial factors (Depp & Jeste, 2006). The possibility exists that the sample of participants in this study may be more representative of the one third of older adults classified as successful agers, who may have been able to combat some of the more toxic effects of stress exposure.

The neurotoxic effects of chronic stress have been most reliably found in the reduction of hippocampal volume (due to dendritic atrophy and suppression of neurogenesis) and more recently in the medial prefrontal cortex (dendritic atrophy). The plasticity of the hippocampus has been well documented (Gould, Tanapat, Rydel, & Hastings, 2000), and the connections from the hippocampus to the medial prefrontal cortex well researched (Morris, 2007). When neurogenesis occurs in the hippocampus then the connections with the medial prefrontal cortex (MPC) are concomitantly strengthened. Though neurogenesis has not been found in the MPC region, the increase in signaling from the hippocampus has been shown to stimulate dendritic sprouting increasing the efficiency of the region and thereby counteracting any previous negative cognitive effects. Impairments in cognition have been found six months after recovery from putative stress-related illness (O'Brien, Lloyd, McKeith, Gholkar, & Ferrier, 2004), though this may well be associated with inter-individual differences of hippocampal volume (smaller hippocampi as a putative predisposition to stress related disorders; Gilbertson et al., 2002). Lupien et al. found that hippocampal volume returned to baseline size after individuals with chronic depression underwent treatment, in a subgroup of depressive individuals who had hypercortisolism (2004). The current findings may indicate that any neurotoxic effects of chronic stress in the brain may have already been reversed in the current sample due to hippocampal plasticity. Further some of the variables included in the new successful aging paradigm may be factors in activating or increasing this plasticity.

The most complex tasks in this study were in the executive functioning domain (working memory, set shifting/rule inference, and divided attention tasks), which involved tasks placing greater demands on prefrontal functioning. This area has been linked to the stress axis more

recently than the hippocampus, and is less well researched than the other two cognitive domains examined in this study. However, due to the tasks high demands on the prefrontal region and the evidence that this is an area deleteriously affected by the stress reaction, main effects relating to the stress measures were posited to enter the model in predicting performance on the executive functioning domain score. However, in the current study, none of the stress measures entered the regression model in relation to the executive functioning domain score.

Post-hoc comparisons were predicted to reveal that the complex task of divided attention (CPT) would have the largest effect size due to the recent finding on a task of divided attention in an undergraduate sample (Petrac et al., 2009). Exploratory post-hoc analyses revealed a significant negative correlation between the ELSI and the CPT divided attention variable (auditory omission errors). This particular CPT variable was the same one to show a relationship to stress in the earlier study with undergraduate students (Petrac et al., 2009); therefore we had an *a priori* hypothesis that this particular executive functioning variable would show a relationship to recent stress. However, in the previous study, the relationship was found with the PSS-M (the only stress measure examined in that study), while it was only found with the ELSI (stressful events over past year) in the current study. While there are differences in the particular measure of recent stress, the partial replication of this finding from a younger to older adult sample suggests that this particular task may be a promising measure of executive functioning as it relates to recent self-reported stress. The negative partial correlation between the ELSI and WCST accuracy was not predicted, as we were not aware of previous research that examined these two variables. Therefore, we applied a Bonferroni correction to this alpha level on this relationship, due to the multiple exploratory correlations, and this correlation was no longer

considered statistically significant. However, it provides a useful lead for future studies in this area of research.

The other two executive functioning measures, the LNS and FAS, showed non-significant correlations with the ELSI in the opposite direction to the CPT and WCST variables. This may explain why the predicted findings were not found in the regression as the opposing effects of the LNS and FAS counteracted the relationship effects of the CPT and WCST when they were combined in the executive functioning domain. The LNS and FAS are significantly less demanding executive functioning tasks than the CPT and WCST, and the highly educated sample of participants were likely not as challenged by these tasks (Brickman et al., 2005).

Other developments in neuroendocrine research may also account for why the regression model for the executive functioning domain was non-significant, and perhaps explain some of the contradictory findings in the stress/cognition literature in general. Elzinga & Roelofs (2005) found that only participants who responded to a stress-inducing task with an increase in cortisol levels (cortisol responders) showed decreases in working memory performance. However, the decrease in working memory performance only occurred when sympathetic autonomic activation occurred in the cortisol responders (as measured by elevations in heart rate and blood pressure). When sympathetic activation returned to baseline levels, working memory capacity improved, even though cortisol had not returned to baseline levels. No change in working memory occurred in participants who experienced sympathetic autonomic activation without a change in cortisol levels (cortisol non-responders). If Elzinga and Roelofs' hypothesis is true (deficits in working memory only occur in cortisol responders), then future stress research needs to explore the characteristics of cortisol responders and incorporate cortisol and other physiological measures

in predicting reduction in working memory deficits. If more cortisol responders exist in a student population than in an elderly population it may help to clarify the relatively low effect size found both with the dual task CPT used in this study and in the stress literature in general.

One of the most enduring theoretical viewpoints of stress began with Yerkes and Dodson, from their research with discrimination learning in mice, who proposed that moderate levels of anxiety were beneficial for performance, and that both high and low levels impede performance (1908). The inverted U-shaped curve they proposed, which subsequently became known as the Yerkes-Dodson Law (variously described as task performance efficiency, performance anxiety, or stress arousal), is now used to explain a variety of cognitive and mental processes from the actions of plasma levels of neurotransmitters and hormones to noise level interference and electric shock responses in animal learning (Teigen, 1994). Elevated levels of catecholamines are considered an essential factor in coping with stress, but hyporesponses and hyperesponses both have an adverse effect that adds to the assertion that there is an optimal physiological arousal state (Stanford, 1993).

Evidence for the inverted U-shaped curve in stress response has been found in both animal and humans, and in humans it is believed to be influenced by different rates of MR and GR receptor occupation (Lupien & Lepage, 2001). The difference between the neurobiological consequences of chronic versus acute stress may help elucidate this finding. Chronic cortisol elevation (from chronic stress) has deleterious effects, including hippocampal dendritic atrophy and suppressive effects on neurogenesis (Lupien, et al., 1998; Shors, et al., 2001); while acute stress (acute cortisol spike; top of inverted U function) appears to acutely enhance memory and attention (Diamond, Bennett, Fleshner, & Rose, 1992). The first hormone replacement study to

look at these effects found that the inhibition of corticosteroids significantly impacted delayed memory performance, and that performance was returned to baseline measures after hydrocortisone replacement (Lupien, Wilkinson, Briere, Menard, Kin, & Nair, 2002). This study used young male participants, and inhibition studies in older adults have shown that the picture is more complex.

No significant changes in cognitive tasks were found in a group of older adults (69-82 years of age) after administration of 20 mg hydrocortisone (Porter, Barnett, Idey, McGuckin, & O'Brien, 2002). When an inhibition of corticosteriods study examined suppression and replacement with hydrocortisone in an elderly population, the results showed a differential effect. In a longitudinal study tracking cortisol levels in the elderly, those with a history of moderate cortisol levels revealed that suppression of cortisol yielded similar results to that of the young adults: a reversible deficit in memory (Lupien, Wilkinson, Briere, Kin, Meaney, & Nair, 2002). However, when the same procedure involved older adults with a history of high cortisol levels, who already were demonstrating memory deficits, the suppression of cortisol had no effects and the subsequent replacement revealed significant decreases in delayed memory (Lupien et al., 2002). The samples in these studies were small, and presented as pilot data, but the authors speculate that in an elderly population the variability of response to glucocorticoids is dependent on the volume and length of time and needs further study (Lupien et al., 2002). These studies also suggest that with age there is even greater individual variability to the inverted U-shaped curve of the HPA axis and the subsequent effects on cognition.

To examine the potential influence of age in this study, the interactions between the three stress measures and age on the three cognitive domains were explored in a series of ANOVAs.

Main effects and interaction effects were only found in the ANOVA that examined the memory domain with the PSS-L and not for the ANOVAs that examined the PSS-M and ELSI, or any of the other cognitive domains. A main effect was found in the memory domain for the PSS-L and age, and a statistically significant interaction effect was found between the two variables (Figure 1). The simple effects of this interaction were examined by dividing participants into two age groups, one group above the age median split and the other below. This analysis revealed that, in the younger participants (young-old; 54 to 73 years of age), an increase in lifetime stress was related to a decrease in memory performance, while in the older participants (older-old; 74 to 88 years of age), the opposite pattern was found – an increase in lifetime stress was related to an increase in memory performance. Neither of these relationships was statistically significant within each group, but the opposing direction of the relationship between groups likely accounted for the interaction.

This interaction was unexpected, and appears not to have been found in the few previous studies that looked at self-perceived stress, cognition and aging. For example, Vondras et al. (2005) found no interaction in their study, and reported that the groups tended to run parallel - all adults who reported higher stress, no matter which age group, had an associated decrease in memory. However, they used only the PSS-M to measure stress and not a lifetime measure, and their sample included young and middle age adults compared with a group of older adults ages 60-89 years. There are several possible explanations for the interaction found in the current study including that this may be a spurious statistical finding due to the multiple analyses that took place. Another possible explanation is that the age groupings in this sample have unique characteristics that created a cohort effect, for example the young-old group (below the median

split) included participants who are were born during World War II, as well as in the time afterwards in the well known Baby Boom Generation. This cohort effect could be related to many differences including personality styles or emotional coping styles that may potentially moderate or mediate the relationship between stress and cognitive performance. For example, this could mean that there are differences between the age groups in the ability to reduce cognitive interference generated by subjective emotional stress. A study that examined the PSS-M and a measure of stress-related cognitive interference, the Impact of Event Scale (IES; Horowitz, Wilner, & Alvarez, 1979) found that in older adults it was not necessarily the level of perceived stress that was associated with poorer performance on cognitive tasks, but the amount of rumination associated with the stress (Stawski, Sliwinski, & Smyth, 2006).

The cohort effects could also lead to a higher prevalence of certain personality styles in one of the age groups that are related to better coping ability. For example, Maddi (2006) suggests that certain individuals have a hardiness trait that leads them to grow through stressful situations, while other research indicates that high self-esteem can ameliorate some age-related decline in cognition (Pruessner, Lord, Meaney, & Lupien, 2004). This theory lends itself to the possibility that in this study the oldest-old adults' perception of higher lifetime stress was accurate, but that they had the ability to adapt and grow through the stress. Therefore, the neurological impact of the stress of earlier years may have had time to recover through effective coping mechanisms in the older-old adult group. Recent neuroimaging research supports this theory, as one study showed that the disruptive influence of psychosocial stress on prefrontal processing and attentional control can be reversed after the stress has passed (Liston, McEwen, & Casey, 2009). Other research has revealed that affirming personal values buffers

neuroendocrine responses to stress (Creswell, Welch, Taylor, Bower, & Sherman, 2007), and it is possible that the group of oldest adults in this study had found more time for activities that reinforced personal values. Alternatively, it could be that those individuals who survive to the oldest of ages possess resilient psychological and physiological characteristics that have contributed to their longevity. Finally, no other research can be directly compared with this result, as the 10-item PSS-L was created specifically for this study.

The PSS-L was hypothesized to be the measure that would reveal the most effects, as this measure assessed the perception of participants' perception of chronic stress over their entire lifetime. The ELSI has "life" in the title of the measure, but only explores the number of stressful events over the last year, which can be limiting as it does not measure a person's reaction to the events. Future studies may want to examine this new PSS-L measure in a larger population to see if the reliability and validity can be enhanced. Some of the newer theories postulate that significant stress during early development may affect the development of the HPA axis, making an individual in later life more vulnerable to the negative effects of stress (McDonald, 2002). The current study did not explore the participants' experiences in early childhood, and this could be a contributing factor to the null findings of this study.

A number of other limitations of the current study warrant consideration. The study participants were all self-selected, and were mainly highly educated, high socioeconomic status, non-disabled, and were all Caucasian. These sample traits limit generalizability of the findings to other populations (Herbert & Cohen, 1996). A sample that includes minority participants and a wider range of SES, education, and physical health will be particularly useful to find whether the sample characteristics in the present study restricted the range of possible relationships. Another

limitation is reliance on the self-report measure of chronic stress. Self-report measures often have inherent problems with construct validity and potential for over- or under-reporting distress. The use of repeated cortisol measurements over an extended period of time (e.g., 1 - 2 months) may provide a more objective measure of biological chronic stress that is theoretically more directly related to changes in cognitive function. The long known challenge with the negative impact of the stress hormones on the brain is the lack of understanding of the precise length of time that it takes for elevated levels of cortisol to result in structural deficits in the brain and the time for those changes to recover fully (Hoschl & Hajek, 2001). This ultimately maybe the most crucial and difficult question to answer in the investigation of stress and healthy aging.

With the dramatic increase in life expectancy over the last century, the factors that contribute to healthy aging have become important to understand, in particular when trying to understand why approximately 65% of older adults are not classified as successful agers (Depp & Jeste, 2009). Faster recovery times from acute stress become essential, as the beneficial acute effects of cortisol on the system are known to become toxic when chronic (Sapolsky, 2000). There remains to be discovered not only the length of time required for elevated levels of cortisol to become toxic in humans, but whether genes such as apolipoprotein E4 (APOE4) influence this toxicity. Research that has examined environmental and genetic risk factors for the development of Alzheimer's disease, found an interaction between prolonged stress and the apolipoprotein E4 (APOE4) genotype. Elderly non-demented participants who reported higher stress and were positive for the APOE4 genotype, had higher cortisol concentrations and performed consistently worse on memory tasks than their lower stress or non-APOE4 genotype peers (Peavey et al., 2007). There may be other, as yet undiscovered variables in this complex area.

In a meta-analytic review and synthesis of 208 studies of acute laboratory based stressors and cortisol responses (Dickerson and Kemeny, 2004), tasks that were uncontrollable or had a strong social evaluative component elicited the most frequent and highest cortisol responses. Cortisol levels also took longer to return to baseline with these types of tasks. The motivation to preserve the physical self has been well established to elicit activation of the HPA axis and the psychological, physiological, and behavioral responses necessary to cope, but the clear finding of this meta-analysis reveals that threats to social esteem or social status activates the "social self-preservation system." This finding warrants the inclusion of social esteem and self-perceived social status questionnaires in future stress assessment measures. It is interesting to hypothesize that this is a possible explanation of why the effects of stress may be more damaging in children and younger adults as the social self is not yet fully developed. Future stress measures may also evaluate more precisely a person's belief in their ability to recover from stressful events.

An overarching goal of this study was to try to clarify some of the contradictory findings in the stress literature by accounting for state anxiety. Some studies report that acute state anxiety enhances memory and attention and it is possible that increased moderate arousal during laboratory tasks has masked the more chronic effects of stress on cognition in previous studies. However, a relationship between stress and cognition after statistically controlling for state anxiety as hypothesized was not found, and it is possible that the self-report measures of stress and state anxiety used may not have accurately captured these constructs in an older population. Alternatively, it is possible that these constructs were adequately captured and simply were not related to cognitive performance in this sample. Future studies may want to consider formulating a new measure of stress that includes social esteem and perceived social status based on the

meta-analytic findings of Dickerson and Kemeny (2004). Further, future research examining an individual's baseline physiological functioning, including diurnal cortisol, blood pressure, noradrenaline and heart rate, could determine if continued exploration of this studies' hypotheses are warranted. At this time, the conclusions that Dickerson and Kemeny (2004) reached remain unchanged, that psychological stressors are capable of activating the HPA axis, but the enduring effects of psychological stressors are highly variable within individuals and events. The goal of this study to clarify those variables was not reached, but has instead generated more research pathways to explore in this important, complex and fascinating research area.

APPENDIX A: ONLINE DEMOGRAPHIC QUESTIONAIRE

Online Demographic Questionnaire

Name:
Home address:
Telephone numbers:
Gender: M / F
Date of Birth:
Race:

1. Which hand do you write with?
2. How many total years of education do you have?
3. What was/is your major life occupation?
4. If you volunteer, how many hours a week do you spend volunteering (not paid)?
5. Do you have significant difficulty reading printed material (i.e., text books), even with the use of corrective lenses?
6. Do you have significant difficulty hearing (e.g., normal conversation, television) even with the use of hearing aid?
7. What is your current work situation?
8. What is your primary language?
9. Have you recently experienced (within the last 12 months) and event that was traumatic (for example, but not limited to: death of a loved one, serious injury in an accident, rape)?

If yes, do you: have recurrent and distressing recollections of the event?
have distressing dreams of the event?
find yourself acting or feeling as it the event were recurring?
feel significant distress when something reminds you of the event?

Please check all that apply of your current medical conditions and past medical events:

1. Congestive heart failure		13. Diabetes	
2. Heart attack, coronary attack, or MI		14. Epilepsy (seizures)	
3. High blood pressure or hytertension		15. Chronic obstructive pulmonary disease	
4. High cholesterol		16. Traumatic brain injury	
5. Coronary artery disease		17. Hepatitis or liver disease	
6. Angina		18. Thyroid disease	
7. Coronary bypass surgery (CABG)		19. Dementia diagnosis	
8. Placement of STENT in an artery		20. Parkinson's disease	
9. A pacemaker installed		21. Schizophrenia or psychosis	
10. Carotid endarterectomy		22. Currently being treated for Depression	
11. Stroke, cerebral hemorrhage, CVA		23. Treatment for Depression in the past	
12. TIA (mini-stroke)		24. Cancer	

Please write any current medications you are prescribed:

APPENDIX B: PERCEIVED STRESS SCALE – MONTH

Perceived Stress Scale - Month

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

Name _____ Date _____

Age _____ Gender (Circle) M / F

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?.....0 1 2 3 4
2. In the last month, how often have you felt that you were unable to control the important things in your life?.....0 1 2 3 4
3. In the last month, how often have you felt nervous and "stressed"? 0 1 2 3 4
4. In the last month, how often have you felt confident about your ability to handle your personal problems?.....0 1 2 3 4
5. In the last month, how often have you felt that things were going your way?……0 1 2 3 4
6. In the last month, how often have you found that you could not cope with all the things that you had to do? ……...0 1 2 3 4
7. In the last month, how often have you been able to control irritations in your life?.....0 1 2 3 4
8. In the last month, how often have you felt that you were on top of things?...0 1 2 3 4
9. In the last month, how often have you been angered because of things that were outside of your control? …….0 1 2 3 4
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?..... 0 1 2 3 4

APPENDIX C: PERCEIVED STRESS SCALE – LIFETIME

Perceived Stress Scale - Lifetime

The questions in this scale ask you about your feelings and thoughts during your lifetime. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

Name _____ Date _____

Age _____ Gender (Circle) M / F

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1. Reflecting on your lifetime, how often have you been upset because of something that happened unexpectedly?..... 0 1 2 3 4
2. Reflecting on your lifetime, how often have you felt that you were unable to control the important things in your life?..... 0 1 2 3 4
3. Reflecting on your lifetime, how often have you felt nervous and "stressed"? 0 1 2 3 4
4. Reflecting on your lifetime, how often have you felt confident about your ability to handle your personal problems?..... 0 1 2 3 4
5. Reflecting on your lifetime, how often have you felt that things were going your way?……... 0 1 2 3 4
6. Reflecting on your lifetime, how often have you found that you could not cope with all the things that you had to do? ……0 1 2 3 4
7. Reflecting on your lifetime, how often have you been able to control irritations in your life?..... 0 1 2 3 4
8. Reflecting on your lifetime, how often have you felt that you were on top of things?0 1 2 3 4
9. Reflecting on your lifetime, how often have you been angered because of things that were outside of your control? …… 0 1 2 3 4
10. Reflecting on your lifetime, how often have you felt difficulties were piling up so high that you could not overcome them?.....0 1 2 3 4

APPENDIX D: ELDER LIFE STRESS INVENTORY

Elders Life Stress Inventory

The questions in this scale ask you about events that you have experienced during the last year. Please circle yes or no to each question.

1. Deterioration of memory	Y	N
2. Death of a friend	Y	N
3. Major deterioration in health or behavior of a family member	Y	N
4. Major decrease in activities that you really enjoy	Y	N
5. Major personal injury or illness	Y	N
6. Death of other close family member	Y	N
7. Child's divorce or marital separation	Y	N
8. Decrease in responsibilities or hours at work or where you volunteer	Y	N
9. Increase in your responsibilities or hours at work or where you volunteer	Y	N
10. Loss of a very close friend due to a move or break in friendship	Y	N
11. Death of a spouse	Y	N
12. Worsening in relationship with a child	Y	N
13. Worsening in relationship with your spouse	Y	N
14. Other worsening relationship that affects you	Y	N
15. Major deterioration in financial state	Y	N
16. Retirement	Y	N
17. Spouse retired	Y	N
18. Being burglarized or robbed	Y	N
19. Loss of prized possessions due to move	Y	N
20. Marriage	Y	N
21. Institutionalization of a parent	Y	N
22. Assuming major responsibility for a parent	Y	N
23. Institutionalization of a spouse	Y	N
24. Move to a less desirable residence	Y	N
25. Deterioration in living conditions	Y	N
26. Marital separation	Y	N
27. Divorce	Y	N
28. Death of a grandchild	Y	N
29. Change to a less desirable line of work	Y	N
30. Troubles with boss or co-workers	Y	N
31. Death of a son or daughter	Y	N

APPENDIX E: ABBREVIATED MARLOW-CROWNE SOCIAL DESIRABILITY SCALE

Abbreviated Marlowe-Crowne Social Desirability Scale

Instructions: If the statement is true or mostly true, as applied to you, click true (T). If a statement is false or not usually true, as applied to you, click false (F).

True False 1. It is sometimes hard for me to go on with my work if I am not encouraged.

True False 2. I sometimes feel resentful when I don't get my way.

True False 3. On a few occasions, I have given up doing something because I thought too little of my ability.

True False 4. There have been times when I felt like rebelling against people in Authority even though I knew they were right.

True False 5. No matter who I'm talking to, I'm always a good listener.

True False 6. There have been occasions when I took advantage of someone.

True False 7. I'm always willing to admit it when I make a mistake.

True False 8. I sometimes try to get even rather than forgive or forget.

True False 9. I am always courteous, even to people who are disagreeable.

True False 10. I have never been irked when people expressed ideas very different from my own.

True False 11. There have been times when I was quite jealous of the good fortune of others.

True False 12. I am sometimes irritated by people who ask favors of me.

True False 13. I have never deliberately said something that hurt someone's feelings.

APPENDIX F: STATE TRAIT ANXIETY INVENTORY - TRAIT

STAI Y-2

A number of statements which people used to describe themselves are given below. Read each statement and then click the appropriate circle to the right of each statement to indicate how you *generally* feel.

	Not at all	Some-what so	Moder-ately	Very much so
1. I feel pleasant …….....	(1)	(2)	(3)	(4)
2. I feel nervous and restless……..	(1)	(2)	(3)	(4)
3. I feel satisfied with myself…….	(1)	(2)	(3)	(4)
4. I wish I could be as happy as others seem to be…….....	(1)	(2)	(3)	(4)
5. I feel like a failure……	(1)	(2)	(3)	(4)
6. I feel rested…….	(1)	(2)	(3)	(4)
7. I am "calm, cool, and collected"……	(1)	(2)	(3)	(4)
8. I feel that difficulties are piling up so that I cannot overcome them…….	(1)	(2)	(3)	(4)
9. I worry too much over some thing that really doesn't matter ……..…….	(1)	(2)	(3)	(4)
10. I am happy……	(1)	(2)	(3)	(4)
11. I have disturbing thoughts……..	(1)	(2)	(3)	(4)
12. I lack self-confidence……	(1)	(2)	(3)	(4)
13. I feel secure……	(1)	(2)	(3)	(4)
14. I make decisions easily……	(1)	(2)	(3)	(4)
15. I feel inadequate……	(1)	(2)	(3)	(4)
16. I am content……	(1)	(2)	(3)	(4)
17. Some unimportant thought runs through my mind and bothers me…….……	(1)	(2)	(3)	(4)
18. I take disappointments so keenly that I can't put them out of my mind……..	(1)	(2)	(3)	(4)
19. I am a steady person……	(1)	(2)	(3)	(4)
20. I get in a state of tension or turmoil as I think over my recent concerns and interests ……	(1)	(2)	(3)	(4)

APPENDIX G: CONSENT FORM PHASE I

Consent Form

CONSENT TO PARTICIPATE IN AN EXPERIMENTAL STUDY

I agree to participate in the research entitled "Does Chronic Stress Accelerate Late-Aging Cognitive Decline in Memory and Executive Functioning?" The research is being conducted by Diane Petrac, a graduate student, as part of a doctoral dissertation under the supervision of Dr. Jeffrey S. Bedwell, an Assistant Professor in the Department of Psychology at the University of Central Florida. I understand that this participation is entirely voluntary and I can withdraw at any time without giving a reason or being penalized. I can ask to have information related to me removed from the research records or destroyed. The following information has been made available to me:

- Purpose: I will be one of approximately 400 participants in this phase of the research study, and I understand that the purpose of this study is to investigate the relationship between self-reported stress and cognitive performance, and the researchers hope that a better understanding of this relationship will provide information about how stress and anxiety can affect cognitive performance.

- Duration and Location: My participation in this phase of the study will last approximately twenty minutes and will be completed online immediately following this consent form acceptance. I understand that the length of completion time will vary from person to person. I understand that my participation in the first session does not guarantee the opportunity to participate in the second session, which will only include a small percentage of session one participants who will be invited by the investigator.

- Procedure: During the first session of the study I will answer basic demographic questions, give contact information, and then complete a 64-item questionnaire about stress and other experiences/thoughts.

- Exclusions: I may not participate in this study if I am under 18 years of age.

- Risks and Discomforts: I have been informed that no risks are expected, beyond possible transient psychological discomfort due to the personal nature of some of the questions. I do not have to answer every question or complete every task and I will not be penalized for refusing to do so.

- Benefits: I will not benefit directly from this research study, besides learning more about how research is conducted. However, my participation in this research may lead to information that could lead to a greater understanding in the relationship between chronic stress and cognitive performance.

- New Findings: I will be given any new information gained during the course of this study that may affect my willingness to continue my participation.

- Confidentiality: Every effort will be made to protect my identity. My answers to the online questionnaire will be stored in a separate file from my contact information and name, once they are exported from the online server. The online server has security measures to prevent access to the information from outside parties. I will not be identified in any publication or report of this study or its results.

- Payment to Participants: There are no payments in for participating in this study, and your volunteering is greatly appreciated.

- Offer to Answer Questions: I have the opportunity to ask, and have answered, any questions I may have about this research at any point during the study. If I have such questions, I may call Diane Petrac at (407) 823-5435, or e-mail her at PetracResearch@gmail.com. I may also contact her supervisor, Dr. Jeffrey Bedwell, if I wish. He can be reached at (407) 823-5858, or by e-mail at jbedwell@mail.ucf.edu.

- Permission for Future Contact: I agree that the investigator can contact me, by phone, mail, or by e-mail, to request my participation in the second phase of this study or for future research projects. I understand I may decline any additional participation without penalty.

- Research at the University of Central Florida: I understand that all research involving human participants is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to:
  UCFIRB Office, University of Central Florida Office of Research,
  Orlando Tech Center, 12443 Research Parkway, Suite 301, Orlando, FL 32826
  Telephone number: (407) 823-2901

If I believe I have been injured during participation in this research project, I may file a claim against the State of Florida by filing a claim with the University of Central Florida's Insurance Coordinator, Purchasing Department, 4000 Central Florida Boulevard, Suite 360, Orlando FL 32816 (407) 823-2661. The University of Central Florida is an agency of the State of Florida, and its and the State's liability for personal injury is extremely limited under Florida law. Accordingly, the university's and the state's ability to compensate me for any personal injury or property damage suffered during this research project is very limited.

I have read the information provided above and I voluntarily agree to participate in this study.

In addition, I certify that I am over 18 years of age, and by completing the online survey I am providing my informed consent.

[Button here on online form stating "**I Agree**"]

"**If you do not wish to participate after reading this information, please close your web browser at this point**"

APPENDIX H: DEBRIEFING STATEMENT PHASE I

Debriefing Statement (Phase I)

Subsets of the questions in this online survey were designed to measure self-reported stress experienced over the past month, year, and lifetime. For the purpose of this research project, individuals scoring in the lowest and highest range, as well as those scoring close to the mean score may be asked to undergo further testing (this is on a voluntary basis). We are hoping that this research (including both Phases) will provide information that may improve the understanding of factors that are related to successful aging. Thank you for your participation.

APPENDIX I: LABORATORY INFORMED CONSENT PHASE II

CONSENT FORM TO PARTICIPATE IN AN EXPERIMENTAL STUDY

I, _____, agree to participate in the research entitled "Does Chronic Stress Accelerate Late-Aging Cognitive Decline in Memory and Executive Functioning?," which is being conducted by Diane Petrac (Tel: 407-823-5435), a student in the graduate program of clinical psychology, under the supervision of Dr. Jeffrey S. Bedwell (Tel: 407-823-5858), an Assistant Professor in the Department of Psychology, University of Central Florida. I understand that this participation is entirely voluntary; I can withdraw my consent at any time without giving reason, and without penalty. I can ask to have information related to me removed from the research records or destroyed. The following information has been made available to me:

I will be one of approximately 50 participants in this phase of the research study.

Purpose: The purpose of this study is to investigate the relationship between stress and cognitive processes. It is hoped that a better understanding of this relationship will provide information about how stress may interfere with cognition, in particular memory and executive functioning.

Duration and Location: My participation in this phase of this study will last approximately 2 hours and will be completed in one continuous session, located in the Clinical Cognitive Neuroscience Laboratory (Psychology Building, room 137). I understand session times will vary to some extent from person-to-person.

Procedures: During this session of the study, the following will occur:

1. I will complete two brief paper-and-pencil measures of stressful situations and anxiety I have experienced in recent months.
2. I will be administered a variety of memory and executive functioning (both computer and paper-and-pencil) designed to assess specific abilities.

Exclusions: I should not participate in this study if I am under age 18.

Risks and Discomforts: No risks are expected. I do not have to answer every question or complete every task and I will not be penalized for refusing to do so.

Benefits: I will not benefit directly from this research, besides learning more about how research is conducted. However, my participation in this research may lead to information that could lead to greater understanding of the processes that may impede successful aging.

New Findings: I will be given any new information gained during the course of this study that might affect my willingness to continue my participation.

Confidentiality: Every effort will be taken to protect my identity. Only a code number will be used on testing forms and computer databases. My full name will be linked to my code number on this form, but this form will be kept in a separate file cabinet from the rest of the data. I will not be identified in any report or publication of this study or its results.

Payment to Participants: There is no payment offered to participants in this study. I agree that I will not receive compensation for my participation in this study.

Offer to Answer Questions: I have the opportunity to ask, and to have answered, any questions I may have about this research at any point during the study. If I have such questions, I may call Diane Petrac at 407-823-5435 or e-mail her at PetracResearch@gmail.com. In addition, I have the option to contact Dr. Jeffrey Bedwell at 407-823-5858 or e-mail him at jbedwell@mail.ucf.edu.

Permission for Future Contact: I agree that the investigator may contact me in the future for an additional potential study. I realize that I may decline such a request without penalty.

Research at the University of Central Florida: I understand that all research involving human participants is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to:

UCFIRB Office, University of Central Florida Office of Research,
Orlando Tech Center, 12443 Research Parkway, Suite 301, Orlando, FL 32826
Telephone number: (407) 823-2901

If I believe I have been injured during participation in this research project, I may file a claim against the State of Florida by filing a claim with the University of Central Florida's Insurance Coordinator, Purchasing Department, 4000 Central Florida Boulevard, Suite 360, Orlando FL 32816 (407) 823-2661. The University of Central Florida is an agency of the State of Florida, and its and the State's liability for personal injury is extremely limited under Florida law. Accordingly, the university's and the state's ability to compensate me for any personal injury or property damage suffered during this research project is very limited.

I have read the information provided above and my questions have been answered to my satisfaction.

I voluntarily agree to participate in this study. After this consent form has been signed I understand that I will receive a copy.

_____ _____
Signature of Research Participant Date

_____ _____
Signature of Researcher Date

APPENDIX J: STATE TRAIT ANXIETY INVENTORY – STATE

STAI Y-1

A number of statements which people used to describe themselves are given below. Read each statement and then click the appropriate circle to the right of each statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

	Not at all	Some-what so	Moder-ately	Very much so
1. I feel calm ……....	(1)	(2)	(3)	(4)
2. I feel secure…….	(1)	(2)	(3)	(4)
3. I feel tense …….	(1)	(2)	(3)	(4)
4. I feel strained……..	(1)	(2)	(3)	(4)
5. I feel at ease……	(1)	(2)	(3)	(4)
6. I feel upset …….	(1)	(2)	(3)	(4)
7. I am presently worrying over possible misfortunes……	(1)	(2)	(3)	(4)
8. I feel satisfied…….	(1)	(2)	(3)	(4)
9. I feel frightened …….	(1)	(2)	(3)	(4)
10. I feel comfortable ……	(1)	(2)	(3)	(4)
11. I feel self-confident……..	(1)	(2)	(3)	(4)
12. I feel nervous ……	(1)	(2)	(3)	(4)
13. I feel jittery……	(1)	(2)	(3)	(4)
14. I feel indecisive ……	(1)	(2)	(3)	(4)
15. I feel relaxed ……	(1)	(2)	(3)	(4)
16. I feel content ……	(1)	(2)	(3)	(4)
17. I feel worried ……	(1)	(2)	(3)	(4)
18. I feel confused ……..	(1)	(2)	(3)	(4)
19. I feel steady……	(1)	(2)	(3)	(4)
20. I feel pleasant ……	(1)	(2)	(3)	(4)

APPENDIX K: DEBRIEFING PHASE II

Debriefing Statement for Phase II

Thank you for participating. During the study, you answered paper-and-pencil measures designed to assess recent perceived stress and anxiety. One of the questionnaires was designed to measure the physiological symptomology of anxiety, while the other assessed emotions experienced during chronic stress. The other tasks were designed to test different areas of memory and attention. Previous studies have found some indications that these cognitive processes may be affected by chronic stress. In particular, we believe that the delayed memory recall tasks (when you had to remember previously learned stories) will be the most related to self-reported recent stress. We are hoping that this research (including both Phases) will provide information that may help the understanding of the role of chronic stress on the processes of memory and executive functioning.

If you have any further questions about this research study, please contact Jeffrey Bedwell, Ph.D. by email (jbedwell@mail.ucf.edu) or phone (407-823-5858) or Diane Petrac by email (PetracResearch@gmail.com) or phone (407-823-5435). Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to: UCFIRB Office, University of Central Florida Office of Research, Orlando Tech Center, 12443 Research Parkway, Suite 301, Orlando, FL 32826. The phone number is (407) 823-2901.

Table 1 Summary of Hierarchical Regression Analysis for Scores on Three Stress Measures Predicting Results on the Memory Domain after Accounting for State Anxiety (N=61)

Variable	B	SE B	β	Partial *r*	*t*	*p*
Step 1						
STAI-state	-.009	.013	-.095	-.095	0.730	.468
Step 2*						
PSS-M				.164	1.255	.215
PSS-L				.040	0.304	.762
ELSI				-.071	0.539	.592

Note: STAI = State Trait Inventory; PSS-M = Perceived Stress Scale, month; PSS-L = Perceived Stress Scale, life ELSI = Elder Life Stress Scale

* No variables entered the model in the stepwise second step

Table 2 Summary of Hierarchical Regression Analysis for Scores on Three Stress Measures Predicting Scores on the Learning Domain after Accounting for State Anxiety (N=61)

Variable	B	SE B	β	Partial *r*	*t*	*p*
Step 1						
STAI-state	-.021	.012	-.217	-.217	1.695	.095
Step 2*						
PSS-M				.168	1.290	.202
PSS-L				.038	0.287	.775
ELSI				-.045	0.342	.733

Note: STAI = State Trait Inventory; PSS-M = Perceived Stress Scale, month; PSS-L = Perceived Stress Scale, life
ELSI = Elder Life Stress Scale * No variables entered the model in the stepwise second step

Table 3 Summary of Hierarchical Regression Analysis for Scores on Three Stress Measures Predicting Scores on the Executive Functioning Domain after Accounting for State Anxiety (N=61**)**

Variable	B	SE B	β	Partial *r*	*t*	*p*
Step 1						
STAI-state	-.012	.009	-.179	-.179	1.386	.171
Step 2*						
PSS-M				.064	0.485	.630
PSS-L				.218	1.683	.098
ELSI				-.032	0.241	.811

Note: Note: STAI = State Trait Inventory; PSS-M = Perceived Stress Scale, month; PSS-L = Perceived Stress Scale, life ELSI = Elder Life Stress Scale * No variables entered the model in the stepwise second step

Table 4 Analysis of Variances for Memory Domain

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Partial* η^2	*p*
STAI	0.049	1	0.049	0.087	.002	.769
ELSI (n=60)	0.980	1	0.980	1.751	.031	.191
Age	1.675	1	1.675	2.994	.052	.089
ELSI*Age	0.947	1	0.947	1.693	.030	.199
Error	30.777	55	0.560			
STAI	0.495	1	0.495	0.947	.017	.335
PSS-L (n=61)	2.331	1	2.331	4.456*	.074	.039
Age	2.898	1	2.898	5.539*	.090	.022
PSS-L*Age	2.426	1	2.426	4.637*	.076	.036
Error	29.297	56	0.523			
STAI	1.168	1	1.168	2.140	.037	.149
PSS-M (n=61)	0.228	1	0.228	0.418	.007	.521
Age	0.557	1	0.557	1.020	.018	.317
PSS-M *Age	0.311	1	0.311	0.569	.010	.454
Error	30.569	56	0.546			

Note: STAI = State Trait Inventory; PSS-M = Perceived Stress Scale, month; PSS-L = Perceived Stress Scale, life
ELSI = Elder Life Stress Scale

Table 5 Analysis of Variance for Learning Domain

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Partial* η^2	*p*
STAI	1.082	1	1.082	2.028	.036	.160
ELSI (n=60)	0.065	1	0.065	0.122	.002	.728
Age	0.571	1	0.571	1.071	.019	.305
ELSI*Age	0.062	1	0.062	0.117	.002	.733
Error	29.333	55	0.533			
STAI	1.636	1	1.636	3.144	.037	.149
PSS-L (n=61)	0.236	1	0.236	0.453	.007	.521
Age	0.465	1	0.465	0.893	.018	.317
PSS-L*Age	0.261	1	0.261	0.501	.454	.010
Error	29.146	56	0.520			
STAI	2.299	1	2.299	4.501*	.074	.038
PSS-M(n=61)	0.001	1	0.001	0.961	.000	.961
Age	0.063	1	0.063	0.123	.002	.727
PSS-M*Age	0.002	1	0.002	0.955	.000	.955
Error	28.602	56	0.511			

Note: STAI = State Trait Inventory; PSS-M = Perceived Stress Scale, month; PSS-L = Perceived Stress Scale, life
ELSI = Elder Life Stress Scale

Table 6 Analysis of Variance for Executive Functioning Domain

Source	*Sum of Squares*	*df*	*Mean Square*	*F*	*Partial* η^2	*p*
STAI	0.358	1	0.358	1.268	.023	.265
ELSI (n=60)	0.044	1	0.044	0.156	.003	.695
Age	0.103	1	0.103	0.365	.007	.548
ELSI*Age	0.042	1	0.042	0.148	.003	.702
Error	15.526	55	0.282			
STAI	0.960	1	0.960	3.657	.061	.061
PSS-L (n=60)	0.063	1	0.063	0.240	.004	.626
Age	0.148	1	0.148	0.564	.010	.456
PSS-L*Age	0.108	1	0.108	0.412	.007	.524
Error	14.698	56	0.262			
STAI	.477	1	0.477	1.724	.030	.195
PSS-M (n=60)	.033	1	0.033	0.118	.002	.733
Age	.009	1	0.009	0.031	.001	.860
PSS-M*Age	.025	1	0.025	0.091	.002	.764
Error	15.477	56	0.276			

Note: STAI = State Trait Inventory; PSS-M = Perceived Stress Scale, month; PSS-L = Perceived Stress Scale, life
ELSI = Elder Life Stress Scale

Table 7 Pearson correlations among the Stress Measure Scores, Demographic Variables, and the Memory Domain Measures, after controlling for STAI

	PSSM	PSSL	ELSI	Age	Edu	LMII	FCII	WLII
PSS-M	--	.484**	.344**	.055	.002	.133	.046	.188
PSS-L		--	.199	.058	.174	.181	-.130	.042
ELSI			--	.173	.020	-.016	-.221	.079
Age				--	.061	-.056	-.138	-.166
Edu					--	.012	.185	-.025
LMII						--	.386**	.399**
FCII							--	.217
WLII								--

Note: * Statistically significant r at $p < .05$ (two-tailed), **statistically significant r at $p < .01$ (two-tailed); df=57; STAI = State Trait Inventory (state); PSS-M/L = Perceived Stress Scale (month/ life); ELSI = Elder Life Stress Index; LMII, FCII, WLII = delayed recall tasks from the Wechsler Memory Scales-III, Logical Memory/Faces/Word Lists

Table 8 Pearson correlations among the Stress Measure Scores, Demographic Variables, and the Learning Domain Measures after controlling for STAI

	PSSM	PSSL	ELSI	Age	Edu	LMI	FCI	WLI
PSS-M	--	.484**	.344**	.055	.002	.088	.117	.161
PSS-L		--	.199	.058	.174	.087	-.148	.145
ELSI			--	.173	.020	-.040	-.044	-.014
Age				--	.061	-.091	.024	-.317*
Edu					--	-.142	.202	-.314
LMI						--	.158	.437**
FCI							--	.255*
WLI								--

Note: * Statistically significant r at $p < .05$ (two-tailed), **statistically significant r at $p < .01$ (two-tailed); df=57; PSS-M/L = Perceived Stress Scale (month/ life); ELSI = Elder Life Stress Index; LMI, FCI, WLI = immediate recall tasks from the Wechsler Memory Scales-III, Logical Memory/Faces/Word Lists

Table 9 Pearson correlations among the Stress Measure Scores, Demographic Variables, and the Executive Functioning Domain Measure, after controlling for STAI

	PSSM	PSSL	ELSI	Age	Edu	LNS	FAS	CH_AO	WCSTER
PSS-M	--	.547**	.331*	.016	.019	-.070	.214	.263	-.047
PSS-L		--	.194	.009	.135	.226	.199	.003	.057
ELSI			--	.140	.010	-.146	-.080	.324**	.313*
Age				--	-.018	-.233	-.257	.060	.277*
Edu					--	.036	.139	.076	-.070
LNS						--	.237*	-.241	-.392**
FAS							--	-.217	-.321*
CH_AO								--	.267*
WCSTER									--

Note: * Statistically significant *r* at p < .05 (two-tailed), **statistically significant *r* at p < .01 (two-tailed); df= 52; STAI = State Trait Inventory (state); PSS-M/L = Perceived Stress Scale (month/ life); ELSI = Elder Life Stress Index; LNS = letter number sequencing; FAS = verbal fluency; CH_AO = CPT dual task auditory omission change score; WCSTER = Wisconsin Card Sort Task

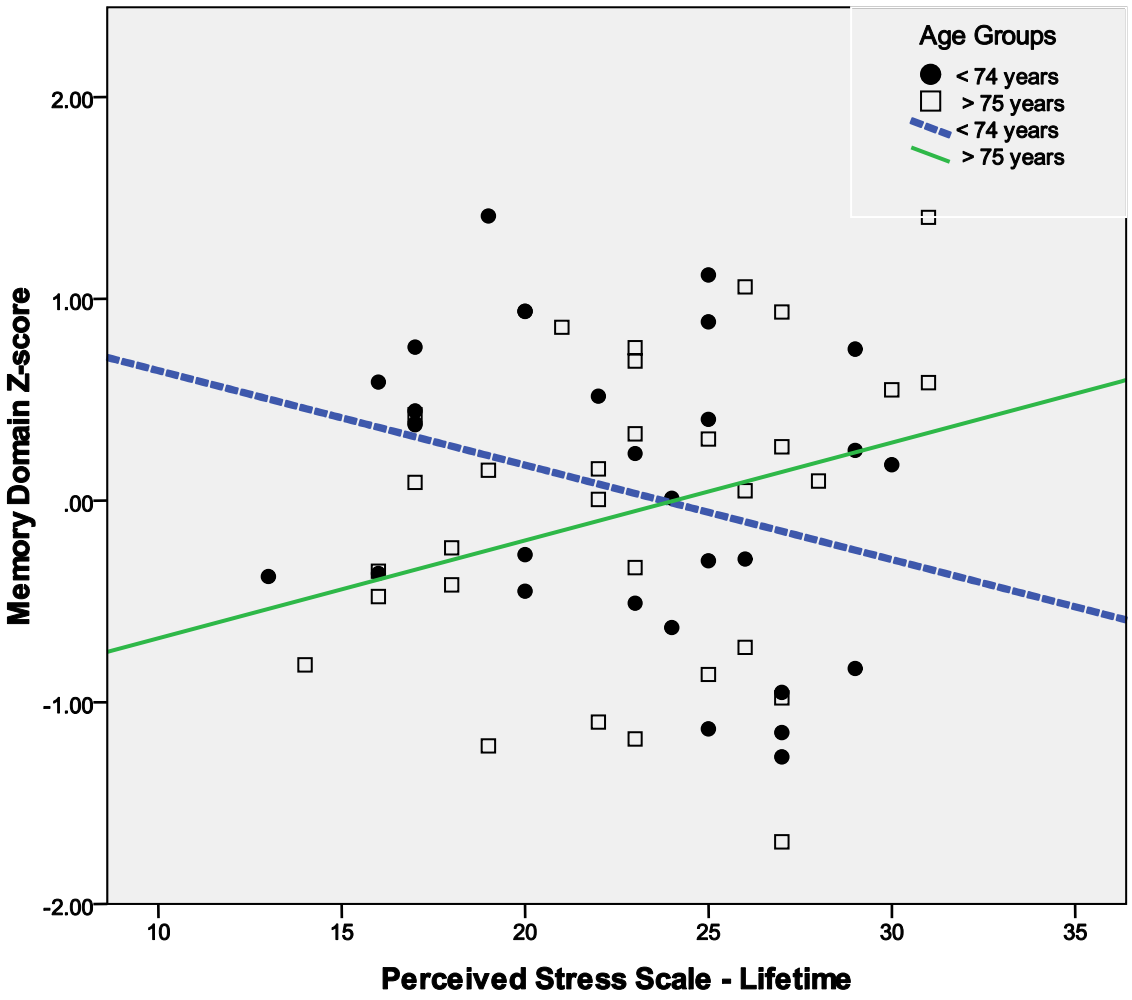

Figure 1 Interaction Effect between Young-Old and Older-Old participants for the Memory Domain and the Perceived Stress Scale - Lifetime

Note: Young-old = 54 to 73 years of age; Older-old = 74 to 88 years of age

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