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AN EXAMINATION OF VARIATIONS OF VERBAL MEMORY PERFORMANCE IN A POPULATION OF CHILDREN WHO HAVE BEEN MALTREATED

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the School of Education (School Psychology).

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ABSTRACT

Rachel Kitson: An Examination of Variations of Verbal Memory Performance in a Population of Children who have been Maltreated

(Under the direction of Steve E. Knotek, Stephen R. Hooper, and Michael D. De Bellis)

This research examined the consequences of maltreatment on children's verbal memory, as measured by the California Verbal Learning Test (CVLT-C). The data were collected through an NIMH funded study at Duke University titled "Life Events & Childhood Brain Development" (funded under the title "PTSD & Childhood Sexual Abuse: Psychobiology," Principal Investigator: Michael De Bellis). The analytic sample for this study consisted of 96 children who served as controls, and 91 children who had been maltreated.

This study addressed the following research questions: 1) Do children who have been maltreated differ significantly from a control group on an overall measure of verbal memory performance? 2) Do children who have been maltreated differ significantly from a control group across five verbal memory factors? 3) Within the group of children who have been maltreated, are the total numbers of PTSD symptoms manifested predictive of variation in performance across the five verbal memory factors? 4) Within the group of children who have been maltreated, is the diagnostic status of PTSD predictive of variation in performance across the five verbal memory factors? Structural equation modeling was used to analyze these questions. Covariates such as attention, intelligence, race, gender, age, socioeconomic status, and type of maltreatment were included as predictors in the models.

Overall, these findings suggest that PTSD symptomatology is not a significant contributor to variation in verbal memory performance.

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CHAPTER 1

INTRODUCTION

Overview

This dissertation examined verbal memory performance in children who have been exposed to maltreatment. Reviews of the literature on child maltreatment and the biology of memory suggest that verbal memory is a cognitive domain that is significantly and uniquely impacted by trauma exposure, however, there is limited research on this phenomenon in children. The purpose of this research was to examine how trauma exposure disrupts the physiological pathways in the body and the ways in which this may lead to the development of posttraumatic stress symptoms. It was then investigated how exposure to maltreatment and the development of posttraumatic stress disorder negatively impact a child's ability to retain and processes verbal information. The implications for such consequences are particularly grave given the necessity of verbal memory for academic, social, and occupational success.

Child Maltreatment.

Child maltreatment is chronic and severe by definition and includes physical, sexual, or emotional mistreatment or neglect of a child. Legally, it has been defined as an act, or failure to act, on the part of a parent or caretaker that results in death, serious physical injury, emotional harm, sexual abuse, or exploitation of a child, or which places the child in imminent risk of serious harm (42 U.S.C.A. § 5106g).

The most common subgroups for child maltreatment include: neglect, emotional maltreatment, physical abuse, and sexual abuse. Neglect involves the failure to provide for the child's basic physical needs for adequate food, clothing, shelter, and medical treatment; or extreme failure to carry out important aspects of care (also called failure to provide). This often results in significant impairment of the child's health or development, including non-organic failure to thrive. In addition to inadequate attention to physical needs, another form of neglect is a lack of supervision (also called failure to supervise), subtypes include moral-legal neglect, and educational neglect (Department of Health, 1999). Emotional maltreatment involves persistent or severe thwarting of the child's basic emotional needs for psychological safety and security, acceptance and self-esteem, and age appropriate autonomy. Emotional maltreatment may negatively impact and disrupt the emotional and behavioral development of a child (Department of Health, 1999). All abuse consists of some emotional ill treatment; therefore, this category should be used where it is the main or sole form of abuse. Physical abuse involves the non-accidental infliction of physical injury on the child and ranges from 'minor' to 'physically disfiguring' (Department of Health, 1999). It also includes the actual or likely physical injury to a child or failure to prevent physical injury (or suffering) to a child, including deliberate poisoning, suffocation, and Munchausen's syndrome by proxy (Department of Health, 1999). Sexual abuse involves attempted or actual sexual contact between the child and perpetrator for purposes of sexual satisfaction or financial benefit (Department of Health, 1999). Examples of sexual abuse range from exposure to pornography or adult sexual activity to touching, fondling, to forced intercourse and actual or likely exploitation of a child or adolescent. Consequences have been found to include over dependence and/or developmental immaturity.

Typically rates of neglect and emotional maltreatment outnumber sexual and physical abuse; with sexual abuse rates being less than those of physical abuse. Children in maltreated populations typically experience multiple subtypes of maltreatment including both abuse and neglect (e.g., Bolger, Patterson, & Kupersmidt, 1998; Manly, Kim, Rogosch, & Cicchetti, 2001). This makes it difficult to separate out the effects of each and providing support for the study of maltreatment as a study of chronic and severe stress in childhood.

Verbal Memory.

In terms of construct definition, verbal memory is conceptualized as the type of memory people use in day-to-day life to hold verbal material for long enough to sufficiently put it to short-term use (e.g., a postal code or unfamiliar name) so that it can potentially be stored or integrated into our long-term memory (Caplan & Waters, 1999). This flexible capacity to store and manipulate information termed short-term or working memory is important to our cognitive functioning, and is made possible by our verbal and visual memory systems. In general, studies of verbal spans (e.g., digit word and letter spans) have shown that development improvement follows a negatively accelerated trajectory (Gathercole, 1999). Over the course of childhood these skills should develop exponentially, but as we age, our ability to recall and rehearse verbal information, while still gradually increasing, appears to plateau. Changes in memory span are typically interpreted in terms of Baddeley's model (e.g., Baddeley & Hitch, 1974; Baddeley, 1983, Smith & Jonides, 1997; Alloway, Gathercole, & Pickering, 2006). He postulated two functionally independent subsystems specialized in handling verbal and nonverbal information that he coined the *phonological loop* and the *visuospatial sketchpad*. These systems are overseen by an attentional control system he called the *central executive*, which amongst other functions,

assists in the coordination of cognitive operations. Researchers have studied whether these three systems improve as a child ages or whether independent components develop throughout maturation. Overall, data support that this subsystem is intact in children as early as the age of four (e.g., Alloway, Gathercole, & Pickering, 2006). Children under the age of eight or nine, however, tend to rely more heavily on visual information when trying to remember items over a short period of time than older children, who shift to a focus on verbal information (for review see, Gathercole & Baddeley, 1993). Verbal memory is more readily called upon for day-to-day life as well as academic and social functioning. After separating executive functioning from working memory in children Tillman et al. (2009) found that visuospatial and verbal executive functioning both contribute independently to intelligence. Verbal memory performance therefore is likely strongly impacted by age and is highly correlated with cognitive performance.

Children who display deficits in verbal memory are more likely to demonstrate poor academic performance leading to overall deleterious effects on school functioning and achievement that can eventually impact their quality of life as adults. Furthermore, verbal memory is accepted as a vital component to successful development and adaptive functioning for human beings (e.g., Alloway, Banner, & Smith 2010). Based on verbal memory's importance in such essential domains, of interest was how verbal memory performance was affected by maltreatment exposure. Children who have been exposed to maltreatment, and the extent to which this exposure may threaten the appropriate neurobiological development of verbal memory and subsequent academic achievement, has thus far been largely neglected in research. There are very few studies of verbal memory in children who have been

maltreated, and the studies published to date are of very small sample sizes (Moradi et al., 1999; Beers and De Bellis 2002; Yasik, Saigh, Oberfield, & Halamadaris, 2007).

Research regarding components of memory has resulted in several camps of thought. While the subsystems of verbal and visual or visual-spatial memory are considered separate systems with unique pathways and involved brain regions, there are shared underlying mechanisms for how memories are processed, recalled, and stored. Generally speaking, these mechanisms are referred to as short-term, long-term, and working memory. The California Verbal Learning Test (CVLT-C) measures both short-term (e.g., the short- and long- term recall indices) and working verbal (e.g., Trial 1) memory processes (Numan, Sweet, & Ranganath, 2000; Strauss, Sherman, & Spreen, 2006). Both are required, and thus precursors, for potential graduation of verbal memory to long-term storage. Working memory specifically refers to the capacity for holding a small amount of information in a readily available state for a short amount of time and short-term memory refers to the structures and processes used for temporarily storing and manipulating information (Erricson & Kitsch, 1995). Due to their interrelatedness, Baddeley and Hitch (1974) proposed that short-term memory be conceptually incorporated in to the framework of working memory. In a study where the CVLT-C was used to measure verbal memory in a population of individuals with traumatic brain injury, the authors conclude that the CVLT-C measures 'recency effect,' which "reflects recall from short-term memory (i.e., working memory)" (pg. 558). For these and the following reasons, the CVLT-C was chosen as the verbal memory measure.

California Verbal Learning Test.

There are a number existing measures of verbal memory. The California Verbal Learning Test (CVLT-C; Delis, Kramer, Kaplan, & Ober, 1994), Wechsler Memory Scale (WMS, WMS-R; Wechsler and Stone, 1974), and Rey Auditory Verbal Learning Test (AVLT; Lezak, 1983; Rey, 1941) are among the most commonly used assessments of verbal memory amongst practitioners (Rabin, Barr, & Burton, 2005). The CVLT-C was chosen as the verbal memory measure in this study. The CVLT-C is among the top three verbal memory assessment instruments used by neuropsychologists (Rabin, Barr, & Burton, 2005). The CVLT-C was designed to assist in identifying children with mild to severe learning and memory impairments and provide test results that specify how a child fails to store and remember information. The CVLT-C was developed based on a model of encoding, storing, and retrieving information that requires a host of memory-related skills. It also takes under consideration the fact that children can employ different learning strategies in an attempt to encode information into memory, and the extent to which these strategies enhance or impede performance. Learning and memory impairments are especially prominent in clinical populations of youth, and the CVLT-C allows a clinician to assess not only the overall ability, but the learning strategies, processes, and errors. The CVLT-C measures the multiple aspects of how verbal learning occurs or fails to occur, as well as the amount of verbal material learned. The components of the CVLT-C will be provided in Appendix C.

As the authors of the CVLT-C note (Delis et al., 2000), there are many tests available to measure the amount of verbal memory remembered and their instrument additionally offers an assessment for how the information is learned and retrieved (verbal learning *and* verbal memory). Furthermore, it offers the most component scores of any verbal memory assessment (up to 42 scores) and thus the potential to examine additional neuropsychological

functions underlying verbal memory and learning. The CVLT-C allows for clinicians and researchers to parse the multiple components of learning and memory and to characterize distinctive memory profiles as they are associated with different disorders. Thus, the CVLT-C potentially offers a more extensive examination of the various components of verbal memory than other existing measures.

Previous Research

Consequences of Child Maltreatment.

Current theories regarding the consequences of child maltreatment hold that maltreatment in childhood likely contributes to a wide range of short- and long-term effects associated with behavioral, emotional, physical, cognitive, and psychological deficits; also conceptualized as aberrant developmental trajectories. Intuitively such consequences do not bode well for school performance or academic achievement. Research supports this intuition; children who have been maltreated are more likely to receive school disciplinary referrals and suspensions (Eckenrode, Laird, & Doris, 1993) and are more likely to be less engaged in academic work. Lack of engagement may mediate the relationship between maltreatment and academic maladjustment (Shonk & Cicchetti, 2001). The disciplines of developmental science and psychology emphasize the importance of developing a secure attachment between the child and adult caregiver during infancy. This is negatively impacted when there is child maltreatment (as reviewed by Cicchetti, 2004). Disruptions in this proximal relationship have the potential to significantly impact the child's development and disrupt a number of developmental functions leading to long-term consequences (Cicchetti, 2004).

Child maltreatment is additionally associated with physical injuries, delayed physical growth, and neurological damage (Butchart & Harvey, 2006). It is also associated with psychological and emotional problems such as aggression, depression, and post-traumatic stress disorder (PTSD) (American Academy of Child and Adolescent Psychiatry [AACAP], Official Action, 2010). Child maltreatment has also been linked to increased risk of substance abuse, eating disorders, obesity, suicide, and sexual promiscuity later in life (AACAP, 2010). Research supports that the timing and type of abuse will impact the long-term consequences of child maltreatment (e.g, Hoffman-Plotkin & Twentyman, 1984; Lynch & Cicchetti, 1998). For example, there is research that has found victims of child maltreatment may be more likely to engage in deviant or criminal behavior as juveniles or adults (Widom, 1995). There is also research that suggests males and females may differ in their responses to maltreatment, with males showing greater impact (e.g., McGloin & Widom, 2001; De Bellis, 2003).

Maltreatment and the Developing Brain.

Maltreatment is a form of stress and trauma, and such exposure in childhood may impact neurobiological development. The stress response elicited through exposure to maltreatment may lead to structural changes in the neurobiological systems involved in adaptations to stress and overall cognitive abilities. The consequential functional changes stand to be broad sweeping (e.g., De Bellis et al., 1999; De Bellis, Keshavan, et al., 2002; Carrion, Weems, & Reiss, 2007). It is important to understand how these neurobiological systems are designed to function in response to normal stressors in order to compare their adaptive functioning to their functioning in children exposed to chronic stress and trauma, defined in this dissertation as child maltreatment experiences. It is also important to consider

the functional breadth of these biological stress systems in order to anticipate the scope of the consequences elicited through childhood maltreatment.

Research suggests that exposure to maltreatment in childhood may act through modification of neural development and influence attention span, behavior, and information processing (as reviewed by De Bellis, 2001; Perry & Pollard, 1998). Alterations in neural functioning resulting from maltreatment may cause developmental delays in children leading to their reportedly lower readiness for school (Hoffman, Plotkin, and Twentyman, 1984) and inability to keep up with peers or meet teachers' expectations (e.g., Martin & Rodeheffer, 1976). Studies that have examined how children who have been maltreated function as adults indicate these adults often have lower IQ's and do worse academically when compared to adults who did not report maltreatment (e.g., Perez & Widom, 1994; Kaplow & Widom, 2007; Yanos, Czaja, Widom, 2010).

Furthermore, memory consolidation involves biological stress chemicals and certain brain structures such as the hippocampus (e.g., Bremner, Vermetten, Afzal, & Vythilingam, 2004), which stress has been shown to damage in both humans and animals (e.g., Luine Villegas, Martinez, & McEwen, 1994). The same brain structures damaged through exposure to prolonged exposure to stress are also associated with, and important for, a number of domains associated with new learning, particularly verbal memory encoding (e.g., Kirschbaum, Wolf, May, Wippich, & Hellhammer, 1996; Keenan & Kuhn, 1999). Disruptions in cognitive development and verbal memory in children stand to potentially lead to a cascade of dysfunctions in the development of adaptive and academic skills.

Psychiatric Outcomes resulting from Trauma Exposure.

One of the concerning long-term consequences of maltreatment during childhood is the potential likelihood of the victim developing psychopathology that may also impact memory processes. Posttraumatic Stress Disorder (PTSD) is one of the most common diagnoses assigned to children who have been maltreated (e.g., Browne & Finkelhor, 1986). To meet diagnostic criteria for PTSD, individuals must demonstrate symptoms representative of three "clusters" (i.e., Cluster B, Cluster C, and Cluster D) resulting from trauma exposure, as was stipulated by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV). Childhood maltreatment is also a risk factor for depression, attention deficits, anxiety, behavioral problems, and mood disorders (e.g., Eisen et al., 2007). These types of psychopathology are associated with the underlying neurological structural and functional changes that occur through exposure to stress resulting from maltreatment (e.g., De Bellis 2001; Jackowski, Araujo, Lacerda, Mari, & Kaufman, 2009). When a child is exposed to maltreatment this triggers a biological reaction that leads to a cascade of biochemical and neurological responses, similar to the biological response triggered by other types of stress people encounter in their everyday environments (Wilson, Hansen, & Li, 2010). Maltreatment during childhood is uniquely detrimental in that it is more likely to be chronic and occurs in an immature and underdeveloped neurosystem that would serve as a protective defense in an adult. Research increasingly supports children who have been maltreated are rarely unscathed as adults (e.g., Widom, DuMont, & Czaja, 2007).

Adult patients with PTSD often report a wide range of cognitive problems in memory, concentration, attention, planning, and judgment (e.g, Yasik et al., 2007). There is a paucity of such work in children and adolescents whose cognitive systems are undergoing neuro-maturation. In adults, much of the trauma research focuses primarily on those who

have developed PTSD as a consequence of combat exposure (e.g., war veterans). In comparison to other types of memory and cognitive domains (i.e., visual memory and IQ), research on verbal memory in adults with PTSD suggests that it may be uniquely adversely affected by the biological stress response elicited during exposure to chronic stress (i.e., maltreatment, war combat exposure) (e.g., Bremner et al., 1993; Vasterling, Brailey, & Sutker, 1993; Bremner et al., 1995; Yehuda et al., 1995; Jenkins, Langlais, Delis, & Cohen 1998; Vasterling, Brailey, Constans, & Sutker, 1998; Moradi, Taghavi, Doost, Yule, & Dalgleish 1999; Uddo et al., 2002). Verbal memory has been examined across multiple adult trauma populations (e.g., war veterans, rape victims, survivors of natural disasters) using a variety of standardized measures. A number of qualitative reviews of the adult literature indicate verbal memory impairment is the most consistent cognitive impairment related to PTSD (Buckley, Blanchard, & Neill, 2000; Vasterling & Brailey, 2005; Isaac, Cushway, & Jones, 2006). These studies were conducted in adults when the brain has fully developed, as opposed to children, whose brains are still maturing, thus offering unique windows of vulnerability.

Current Study

One goal of this study is to examine verbal memory performance in children and adolescents who have been maltreated compared to a group of non-maltreated peers. Data were examined from an existing database collected on a sample of children in North Carolina who were recruited to participate in a study at Duke University led by Principal Investigator, Dr. Michael De Bellis. Maltreatment status was determined through referral from state agencies and mental health clinics that specialize in the assessment and treatment of maltreated children. The comparison group was recruited within the same catchment area.

Data included outcome measures of verbal memory, attention, intelligence, adaptive behavior, and psychopathology from a neuropsychological battery and semi-structured interview (Appendix B). Demographic and other related variables collected via parent interview and questionnaire were also examined (Appendix B).

Statement of Purpose

This dissertation will examine the effects of child maltreatment, a national epidemic, on children's verbal memory performance as measured by the California Verbal Learning Test (CVLT-C; Delis, Kramer, Kaplan, & Ober, 1994). It was hypothesized that the experience of maltreatment during the developmental years will negatively impact a child's memory processes through maladaptive biological changes in the body resulting from stress. Childhood maltreatment has the potential to disrupt any number of critical stages of development, where growth and development are occurring quickly and are more susceptible to biological stress related insults. The structural and functional neurological changes may alter the course of, and generalize beyond reactions to, stress and retention of memory across the lifespan. Disruptions in memory, and specifically verbal memory, are hypothesized to impact a child's adaptive functioning in broad sweeping ways. Of primary concern for school-aged children is how these disruptions might impact academic achievement, one of many domains that are highly dependent on verbal memory.

Verbal memory was examined in particular because it is an essential component of adaptive academic and social development. Other variables such as the type of abuse, PTSD symptoms, attention, and socio-demographic factors were also considered for their potential contribution to verbal memory performance. Verbal memory was conceptualized as being

made up of a number of latent abilities that may be affected uniquely based on the severity of psychopathology. This study seeks to examine whether PTSD symptoms resulting from childhood maltreatment impact verbal memory, similarly to what the adult trauma data suggest.

This is the largest study to date to examine verbal memory performance (via the CVLT-C) in children who have been maltreated.

Research Questions and Hypotheses

Based on the review of the relevant literature and the scope of the variables in the existing data set, the following questions and associated hypotheses have been developed:

Research Question 1. Is verbal memory significantly different in children who have experienced maltreatment than matched controls as measured by the CVLT-C? This question will be addressed by controlling for selected demographic variables (i.e., age, socioeconomic status, sex, and race) and other covariates (e.g., attention, intelligence) as needed.

Hypothesis Associated with Research Question 1. After controlling for other potential covariates, it was predicted that verbal memory performance in children who had been maltreated would be significantly lower compared to those children who have not been maltreated. The Total Recall Score was compared between groups, as it is the best overall measure of short-term verbal memory provided by the CVLT-C.

Research Question 2. Do children who have been maltreated perform differently on specific factors of the CVLT-C (i.e., Attention Span, Learning Efficiency, Free-Delayed Recall, Cued-Delayed Recall, and Inaccurate Recall) than the matched control group?

Hypothesis Associated with Research Question 2. After controlling for other potential covariates, it was predicted that children who had been maltreated would perform significantly lower across the Attention Span, Free-Delayed Recall and Cued-Delayed Recall, Learning Efficiency, and Inaccurate Recall factors of verbal memory performance compared to those children who have not been maltreated.

Research Question 3. Within the sample of children who had been maltreated, how do the number of PTSD symptoms a child exhibits contribute to verbal memory performance on the factors of the CVLT-C above and beyond the specific covariates of attention (Conners' CPT Variability), trauma type (i.e., Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Hypothesis Associated with Research Question 3. After controlling for potential covariates, it was predicted that the more PTSD symptoms a child who has been maltreated displayed, the lower their performance would be across the five latent factors of the CVLT-C.

Research Question 4. Within the sample of children who had been maltreated, how do the three diagnostic categories of either having no PTSD symptoms, exhibiting PTSD symptoms but not meeting criteria for diagnosis, and meeting diagnostic criteria for a PTSD diagnosis contribute to variance in performance on the CVLT-C factors above and beyond the covariates of attention (Conner's CPT Variability), trauma type (i.e., Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Hypothesis Associated with Research Question 4. After controlling for all other potential covariates, it was predicted that children with PTSD symptoms would demonstrate lower scores on the five latent factors of the CVLT-C than children who had not developed

PTSD symptoms. Furthermore, it was predicted that children who had PTSD symptoms but did not meet diagnostic criteria for PTSD would demonstrate higher scores on the latent factors compared to the children had been diagnosed with PTSD. As follow-up to Research Question 3, this question sought to investigate whether diagnostic status was related to deficits in verbal memory performance, as it has been found to be in adult populations (e.g., Vasterling et al., 1997; Saigh et al., 2006).

The following literature review will outline the support for these questions and hypotheses.

CHAPTER II

LITERATURE REVIEW

Introduction

This review will begin with an examination of the research on maltreatment, including the consequences of child maltreatment, prevalence rates of child maltreatment, types of child maltreatment, and the aversive outcomes associated with child maltreatment. Following that review, consideration will be given to the research on neurobiology and trauma; the biological stress systems; the effects of stress on memory, brain structure, and function in adults and children; and a review of the neurocognitive studies of stress and trauma in adults and children. Additionally the neurocognitive findings related to verbal memory in trauma victims will be described. The limited literature that examines verbal memory in childhood will be summarized. Finally a review of other factors which have been found to contribute to verbal memory performance in children who have been maltreated including sociodemographic factors, cognitive factors, and psychopathology associated with maltreatment, and how they relate or may relate to memory functions, will be provided. Subsequent research questions and hypotheses will be outlined based on the reviewed literature. Following this review, the third chapter will provide a description of the study participants, the assessment measures used, and the statistical analyses and research methods. The final chapters present the results of the data analysis and a discussion of the findings, implications, limitations, and directions for future research.

Maltreatment and the School-Aged Child.

As suggested there is a significant body of research which examines the relationships between child maltreatment and adaptive outcomes, particularly with regard to academic achievement and learning disabilities. Sullivan and Knutson (2000) sought to examine the relationships between maltreatment and children receiving special education services with a diagnosed learning disability. They found children needing disability services were 3.41 times more likely to be maltreated than those children found not to be in need of services. While the most prevalent form of maltreatment was found to be neglect, most students experienced more than one form of maltreatment (Sullivan & Knutson, 2000). Furthermore, abused children with a disability were more likely to experience more than one form of maltreatment and multiple episodes of abuse than were other abused children without a disability (Sullivan & Knutson, 2000). Children with disabilities were 3.88 times more likely to be emotionally abused, 3.79 times more likely to be physically abused, 3.76 times more likely to be neglected, and 3.14 times as likely to be sexually abused as children without disabilities. More than one-half of children with behavior disorders and more than one-third of children with speech and language disorders had confirmed histories of maltreatment (Sullivan & Knutson, 2000). Their data and findings do not confirm whether children who have been maltreated are more likely to develop developmental disabilities or children with developmental disabilities are more likely to be maltreated; there may be causation in both directions. Among children without disabilities, maltreatment is associated with verbal and nonverbal achievement test scores that were about 1.5 standard deviations below those for non-abused children (Sullivan & Knutson, 2000). They noted children who would likely perform academically at or above normal under ideal circumstances are likely to perform at lower, but still normal, academic levels if maltreated. A study from Spain found similarly

that maltreatment was 7.7 times more common in children with learning disabilities compared to controls (Vergugo, Bermejo, & Fuertes, 1995).

Perez and Widom (1994) sought to follow-up and improve upon previous research investigating the relationship between maltreatment and school performance. To improve upon prior studies' methodologies, the authors included a matched control group (n=286), a large sample size, and a prospective assessment of long-term intellectual and academic outcomes in a sample of previously abused and neglected individuals (n=413). Perez and Widom sought to expand upon the research conducted by Wodarski, Kurtz, Gaudin, & Howing (1990), which found child maltreatment to have a persistent effect on school performance. To do so, the authors identified a large number of children who had been maltreated and then re-evaluated them a number of years later. Their findings suggested this "persistence," as noted by Wodarski et al., extends into adulthood.

Perez and Widom (1994) were able to contact 699 out of 1,575 individuals who had been originally identified between 1967 and 1971 in county juvenile or adult criminal court, when they were 11 years old or younger, as victims of sexual or physical abuse, and/or neglect. The authors noted that many of the individuals were found to lead "transient lives," were homeless, and many of the "harder to find" individuals had warrants by the police (Perez & Widom, 1994). Sixty-three people in the maltreated group were contacted but refused to participate, 26 were deceased, and 6 were "incapable of being interviewed." The authors contacted the maltreated group approximately 20 years after the abuse when the individuals averaged 28 years of age. Those who participated in the study completed a two hour follow-up interview, semi-structured and structured questions and rating scales, a psychiatric assessment, and measures of cognitive and reading ability. Cognitive ability was

assessed using the Quick Test (QT; Ammons & Ammons, 1962) and reading ability was assessed using the Wide Range Achievement Test-Revised Edition (Justas & Wilkinson, 1984). This prospective study found the effects of maltreatment on reading ability and cognitive functioning continued well into young adulthood (Perez & Widom, 1994). The study did not exclude participants with medical or neurological disorders.

Veltman and Browne (2001) reviewed three decades (1966-1999) of empirical research on the effects of child maltreatment and found consistent results indicating significant developmental delays for the school-aged child in the following domains across studies: intellectual development, 49/65 (75%); language development, 36/42 (86%); and academic achievement 31/34 (91%). Only 24 out of 92 studies (26%) used a control group, however, and 84 out of 92 (91%) were carried out in North America. Only English language, empirical studies reporting cognitive development, and/or intellectual status, and/or language level, and/or academic achievement were included. The majority of the studies did not exclude children with medical or neurological disorders. The majority of reviewed studies concluded that child maltreatment led to delayed cognitive development, lower intelligence, delayed language, and poor academic performance. They also found that children who have been maltreated demonstrated higher levels of acting-out, poor self-esteem, poor self-image, social incompetence, emotional immaturity, aggression, self-injurious behaviors, withdrawal, antisocial and destructive behavior, and difficulty with peer-group interactions. As early as 1984, Hoffman-Plotkin and Twentyman found physically abused and seriously neglected children demonstrated lower cognitive functioning across all measures when compared to matched controls. Overall, they found that neglected and physically abused children were

more aggressive, less mature, and less ready to learn; in addition they also displayed significant social and cognitive deficits (Hoffman-Plotkin & Twentyman 1984).

Based on an analysis of data from the National Survey of Child and Adolescent Well-Being, a national probability study of children receiving child welfare services due to alleged child maltreatment, Crozier and Barth (2005) found that children who have been maltreated scored significantly below national norms on standardized tests of cognitive functioning and academic achievement. Path analysis indicated the accumulation of risk factors (i.e., family poverty, prior involvement with child welfare services, caregiver mental health problems, and two measures of clinical behavior problems) decreased cognitive and academic functioning. They did not find that type of maltreatment affected the test scores. It is possible that some cognitive disabilities in children who have been maltreated may arise from subclinical 'shaken baby syndrome,' as only one third of shaken babies die and large numbers do not come to clinical attention (Duhaime, Christian, Rorke, & Zimmerman, 1998). The present study will exclude children with neurological disorders and abnormal MRI scans to address these confounds in the field.

As these studies suggest, child abuse and neglect represent significant risk factors for poor long-term intellectual and academic outcomes. However the specific components within these domains require further elucidation. Of particular interest for the present study is the impact of child maltreatment on verbal memory. This dissertation will examine the effects of maltreatment on verbal memory, and explore how other factors affect this relationship.

Prevalence.

Child maltreatment is defined by law as physical abuse, sexual abuse, emotional abuse or neglect. Neglect is further divided into failure to provide or supervise. Child maltreatment is tracked through a national statistical system which counts children as victims if an investigation by a state child welfare agency classifies their case as either "substantiated" or "indicated" child maltreatment. Substantiated cases are those in which an allegation of maltreatment or risk of maltreatment was supported or founded according to state law or policy. Indicated cases are those in which an allegation of maltreatment or risk of maltreatment could not be substantiated, but there was reason to suspect maltreatment or the risk of it (U.S. Department of Health and Human Services, Administration on Children, Youth and Families, 2008). Of the reported cases, approximately 30% are able to demonstrate proof of abuse. From these cases the National Center for PTSD has calculated that the type of abuse can be broken down as follows: approximately 65% neglect, 18% physical abuse, 10% sexual abuse, 7% psychological/verbal/mental abuse. Approximately 3-10 million children witness family violence each year, and approximately 40-60% of those cases involve child physical abuse (National Center for PTSD, 2008). It has also been estimated that approximately two-thirds of child abuse cases are not reported (National Center for PTSD, 2008).

In 2008, U.S. state and local child protective services (CPS) received 3.3 million reports of children being abused or neglected. Between 1990 and 1996 the number of children for whom child abuse or neglect was substantiated or indicated rose from 860,577 to 1,011,973 (approximately 15 out of every 1,000 children under age 18). This trend reversed between 1996 and 1999 to a rate of approximately 12 out of every 1,000 children; and has remained fairly constant through 2008. Among children who have been maltreated, the

proportion reported as neglected increased from 49% in 1990 to 71% in 2008, while those reported as sexually abused declined from 17 to 9 percent, and the proportion reported as physically abused declined from 27 to 16 percent (less frequent types of maltreatment, including those classified as "unknown," accounted for the balance). Young children are more likely than older children to be victims of child maltreatment. In 2008, children ages 3 and younger had a maltreatment rate of 14.7 per 1,000 compared to a 5.5 per 1,000 rate in children ages 16 to 17. African American (16.6 per 1,000), Native American (13.9 per 1,000), and Pacific Islander (11.6 per 1,000) children have higher rates of reported child maltreatment than children in other racial groups. White children (8.6 per 1,000), Hispanic children (9.8 per 1,000), and Asian children (2.4 per 1,000) generally are reported less for maltreatment. Reported rates of neglect are higher than those for other types of maltreatment. In 2008, 7.4 per 1,000 children were reported victims of neglect, compared with 1.7 for physical abuse, 1.0 for sexual abuse, and 0.8 for psychological or emotional abuse (as reported in Child Maltreatment Child Trends Database). Overall rates of victimization were slightly higher for girls (10.8 per 1,000 children) than boys (9.7 per 1,000 children).

Outcomes Associated with Type of Abuse.

Children who have been maltreated differ in emotional and behavioral regulation from children who have not been maltreated. There is also evidence that different forms of child maltreatment (i.e., neglect, physical abuse, sexual abuse, and emotional abuse) may result in different social, emotional, and behavioral outcomes; influencing the development of the types of psychopathology associated with trauma and maltreatment.

Children whose primary form of maltreatment has been neglect, have demonstrated a significant difficulty in trusting others (Cicchetti, 1987; Houck & King, 1989), which has shown to propagate feelings of helplessness, depression, despair, low self-esteem, and limited motivation (e.g., Egeland & Sroufe, 1981; Crittenden, 1985, 1988, 1992; Jean-Gilles & Crittenden, 1990). Neglected children and adults with neglect histories have demonstrated lower IQ, delays in academic achievement and neurocognitive function, antisocial behaviors, and impairing psychopathology (Eckenrode, Laird, & Loris, 1993; Perez & Widom, 1994; McGloin & Widom, 2001; Widom et al., 2007). Neglected children have demonstrated various limitations in their cognitive development, such as delays in development when compared to non-abused peers and poorer performance on standardized cognitive and language assessments (e.g., Hoffman-Plotkin & Twentyman, 1984; Allen & Tarnowski, 1989; Eckenrode et al., 1993; De Bellis, Hooper, Spratt, & Woolley, 2009). Furthermore, in terms of types of maltreatment, research has indicated that neglect may produce the worst outcome in terms of academic achievement (Allen & Oliver, 1982; Eckenrode et al., 1993). Neglect is also more likely to be co-morbid with other forms of abuse (Farmer & Owen, 1995), and combinations of maltreatment are generally associated with more serious outcomes (Wolfe & McGee, 1994; Lynch & Cicchetti, 1998).

Children who have experienced maltreatment in the form of physical abuse tend to be aggressive toward peers and adults, have difficulty with peer relationships, and are less able to empathize (Peacock, & Forrest, 1985; Zimrin, 1986; Mrazek & Mrazek, 1987; Oates, Tong, Oates, & McDowell, 1987; Dodge, Bates, & Petit, 1990; Wolfe & McGee, 1994;). Physical abuse may result in aggressive behaviors, learned helplessness, ineffectiveness, anxiety, depression, worthlessness, internalizing problems, negative self-perceptions, and

low self-esteem (Kinard, 1980; Allen & Tarnowski, 1989; Vondra, Barnett, & Cicchetti, 1990; Pelcovitz, Kaplan, Goldenberg, Mandel, Lehane, & Guarrera, 1994; Toth, Manly, & Cicchetti, 1992; Lynch & Cicchetti, 1998). Such behaviors may stand in the way of optimal school performance. Trickett and McBride-Chang's review (1995) found infants and very young children who experienced physical abuse displayed more insecure attachments. These children were also found to be more aggressive, non-compliant, demanding (especially boys), withdrawn and wary (especially girls); they demonstrated poor social problem solving, less pro-social behaviors with peers, and low cognitive maturity compared to healthy controls. Extending into adolescence, physically abused children demonstrated the same behaviors as the younger children in this maltreatment subtype, as well as more pessimism, atypical social networks, low peer status, and peer ratings, low empathy, stimulant drug use, low cognitive maturity and school competence, low school grades and test scores, being more likely to repeat a grade, ADHD and developmental disabilities, and lower IQ and reading scores (Trickett & McBride-Chang1995).

Like physical abuse, sexual abuse is linked with increased aggression and externalizing behaviors (Kendall-Tackett, Williams, & Finkelhor, 1993), although the link may be less consistent than in physical abuse. Children who have been sexually abused have been found to suffer from low self-esteem, depression, and anxiety (Koverola, Pound, Heger, & Lytle, 1993; Trickett & Putnam, 1993; Oates, O'Toole, Lynch, Stern, & Cooney, 1994; Swanston, Tebbutt, O'Toole, & Oates, 1997; Bolger et al., 1998). Children with and without learning disabilities who had been sexually abused were found to be more likely to display aggressive and dominant behavior, episodes of inappropriate anger, and self-injury (Mansell, Sobsey, & Moskall, 1998). This subgroup is also more likely to demonstrate maladaptive

behaviors such as excessive guilt, learning difficulties, sexual promiscuity, sexualized behavior, runaway behavior, somatic complaints, regression, hysterical seizures, phobias, nightmares, compulsive rituals, and self-destructive behaviors (e.g., Livingston, 1987; White, Halpin, Storm, & Santilli, 1988; Taussig & Litrownik, 1997). Among these studies, findings were based on non-standardized reports or record reviews as opposed to standardized assessments. Those studies examining sexually abused children that used specific measures to assess neurocognitive functioning and academic achievement include a study that found sexually abused children had lower verbal ability, lower ratings of learning and social competency, and high school avoidance (Trickett, McBride-Chang, & Putnam, 1994).

Emotional abuse is considered a core issue in child maltreatment and underpins all other forms of abuse (Brassard, Germain, & Hart, 1987; Navarre, 1987; Garbino, Guttman, & Seeley, 1986; Jaffe, Wolf, & Wilson, 1990; Browne & Fereti, 1996). These children demonstrate a limited tolerance for frustration, poor impulse control, martyr-like long suffering, and tendencies to internalize or externalize their anger (Summit, 1983; Jaffe, Wolfe, Wilson, & Zak, 1986; Rosenberg, 1986; Holden & Ritchie, 1991; O'Keefe, 1994 Sternberg, Lamb, & Dawud-Noursi, 1998; Graham-Berman & Levendowsky, 1998). They also commonly demonstrate or experience clinically significant levels of sadness, depression, psychosomatic complaints, absences from school, and pre-delinquent and delinquent behavior (Jouriles, Barling, & O'Leary, 1989; Carroll, 1994; McCloskey, Figueredo & Koss, 1995; Falshaw, Browne, & Hollin, 1996). Results from studies examining this population implied that emotionally abused children become emotionally blunted, socially unresponsive, passive, apathetic, inattentive, more likely to suffer from psychiatric disorders, emotional-

behavioral problems, suicidal ideation, and engage in suicide attempts (e.g., Silverman, Reinherz, & Giaconia, 1996).

Overall, these studies suggest specific deficits in monitoring and regulation of memory information, which may be the result of type of trauma experienced. In many ways, it still remains unclear how stress, trauma, and maltreatment impact the course of normal memory functions as well as memory for the traumatic experiences themselves in children.

Summary.

Child maltreatment is a national health concern due to its prevalence and the extent to which is negatively impacts children across cognitive, emotional, behavioral, and physical domains. Some children literally do not survive maltreatment, and many others go on to develop debilitating psychopathology. While the more observable consequences of child maltreatment have been reviewed in this section, the underlying neurological mechanisms related to the development of these symptoms are important to consider in understanding, anticipating, and treating psychopathology associated with trauma and stress.

As the literature suggests, all forms of abuse are associated with aversive social, emotional, behavioral and cognitive outcomes. There is some evidence, however, that neglect may produce the worst outcomes in terms of academic achievement. Neglect is also typically co-morbid with other types of abuse, and there is evidence that combinations of maltreatment are generally associated with worse outcomes. Additionally, there is research that has found sexual abuse may result in deficits related to verbal memory. These considerations will provide support for the hypotheses related to the current study.

The ways in which maltreatment may contribute to depression, PTSD, or poor academic functioning is predominately through the body's response to the chronic

environmental stress the child's developing nervous system is being exposed to. Research has indicated that the developing nervous system is vulnerable to the negative physiological effects of stress hormones, especially during the critical developmental periods (e.g., Bachevalier & Vargha-Khadem, 2005). Therefore, physiogically, children are uniquely susceptible to the neurocognitive disruptions that result from maltreatment. Such alterations in development during critical periods of growth necessitate further research on the effects of maltreatment on neurocognitive development and functioning. Thus far, clinical studies that examined children subjected to maltreatment without neurological injury suggest the stress response may lead to deficits in central executive functioning, memory, attention, visual-spatial ability, language, and motor speed; and, in some cases they exhibit accompanying significant cerebral atrophy (e.g., Cicchetti, 2003; Savitz, van der Merwe, Stein, Solms, & Ramesar, 2007). The following section will detail the neurological and physiological pathways associated with the body's response to stress, and review the research associated with the functional and structural changes that result.

Neurobiology of Maltreatment and Trauma

The ways that people respond to stress, trauma, and maltreatment are related to one another through a neurobiological feedback system designed to aid an organism's reaction to and understanding of threatening environments. Research on neurobiological reactions to traumatic stress, in both adults and children, has demonstrated there are specific systems involved in this maladaptive response. These systems include the hypothalamic-pituitary-adrenal axis (HPA-axis), the prefrontal cortex, and the limbic system (for review of support for these structure's involvement, see Wilson, Hansen, & Li, 2010). These systems can be more broadly referred to as the neurotransmitter, the sympathetic nervous, and the immune

systems. Their function is to act acutely to aid survival. This section will review the biological response elicited through exposure to stress, the structural and functional changes that are impacted by exposure to chronic stress, and how this stress response affects the brain and memory.

Biological Stress Systems.

The biological stress system refers to the combined efforts of the body's neurotransmitter system, sympathetic nervous system, and immune system in reacting to and coping with environmental stress. These systems provide organisms with crucial survival skills for avoiding threats to physical and emotional well-being and are essential for a number of other adaptive behaviors and functions.

The neurotransmitter system of particular interest in maltreatment and PTSD studies is the elicited functioning of the hypothalamus-pituitary-adrenal (HPA) axis, which plays a key role in this negative feedback system. This part of the stress response involves secretion of many neurotransmitters (e.g., norepinephrine and dopamine). The HPA-axis is a physiological pathway that connects the brain to the adrenal cortex. The hypothalamus, which is in the frontal lobe of the brain, is activated when an organism encounters stress and secretes corticotropin-releasing hormone (CRH). CRH then stimulates the anterior pituitary gland, which releases adrenocorticotropic hormone (ACTH). ACTH then enters the blood stream and when it reaches the adrenal gland, stimulates the cortex to release cortisol. Cortisol is the primary hormone used to monitor and assess the stress response. This hormone provides the feedback for the negative feedback loop: as organs in the body are exposed to increasing amounts of cortisol, messages are sent back to the adrenal gland to decrease cortisol secretion. Cortisol is part of a class of steroid hormones called

glucocorticoids. Glococorticoids are released minutes after exposure to a stressor and it can take hours before they reach their full effect. Studies have found extreme stress results in an increase in cortisol levels in human subjects (e.g., Howard, Olney, & Frawley, 1955). Base levels of cortisol are necessary for normal neurobiological growth and for the support of metabolic activity necessary to sustain general functioning (McEwen, 1998). Brief elevations of cortisol in response to environmental stress can aid people in managing their circumstances competently. Chronic elevations of cortisol may lead to a number of negative biological and physiological outcomes such as the loss of hippocampal neurons and impaired affective and cognitive functioning (as reviewed by Glaser, 2000; Teicher et al., 2003). Cortisol levels can be measured through saliva and urine, and in normal circumstances vary diurnally: levels are highest in the mornings and decrease throughout the day.

In chronically traumatized or maltreated individuals, this system is found to become overloaded and blunted, so individuals actually appear to have less than typical levels of cortisol (e.g., Hart et al., 1995; De Bellis, Chrousos et al., 1994; Golier & Yehudi, 1998). For example, children who have been maltreated, those with and without a diagnosis of PTSD, have been found to have elevated stress response chemicals (i.e., catecholamines and cortisol) when compared with adults who have been maltreated. This supports the hypothesis when exposed to chronic stress this biological system is exacerbated and essentially bottoms-out (De Bellis, Chrousos, Dorn, 1994; De Bellis, Lefter, Trickett, & Putnam, 1994; De Bellis, et al., 1999; Carrion et al., 2002).

In addition to its role in managing the stress response, cortisol also influences the central neural processes that are involved in cognition, emotion, and memory (Gunnar & Vazquez, 2006). With regard to memory, low levels of cortisol can help with memory

formation and with retrieval of stored memories. Exposure to very low levels (as in some cases of adult PTSD) or very high levels (as in cases of chronic stress or pediatric PTSD (De Bellis 1999) of cortisol has been found to interfere with the brain's ability to store new memories and recall old ones (Het, Ramlow, & Wolf, 2004). Chronic exposure to elevated levels of glucocorticoids (e.g., cortisol) is accompanied by cognitive problems including impairment of declarative memory and visual episodic memory (for reviews, Heffelfinger & Newcomer, 2001; Howe, Toth, & Cicchetti, 2006), as well as new learning (Luine et al., 1994). Studies in normal human subjects show glucocortoids have direct effects on memory function; and administration of glucoctoroids, such as cortisol, has resulted in impairments in verbal declarative memory function (Keenan, Jacobson, Soleyman, & Newcomer, 1995; Kirschbaum et al., 1996). Research examining traumatized children has tended to rely on less intrusive exploration of neurological dysregulation such as salivary assays of cortisol, or social, emotional, cognitive, and behavioral assessments. Cortisol sampling has been used to research anxiety, stress, and the traumatic stress response because it is easy to sample and reflects functioning of the HPA and limbic system.

In addition to the neurotransmitter system involved in the stress response, the sympathetic nervous system (SNS) and limbic systems also play important roles in how humans have evolved to respond to stress. These systems are stimulated through a combined effort of the neurotransmitter system and several brain regions including the medulla of the brain stem, the amygdala, and the hippocampus. In comparison to the glucocorticoids, which are released through the HPA-axis and take hours to have a full effect, the SNS component of the stress response is responsible for the more fast acting catecholamines (i.e., adrenaline/epinephrine and noradrenaline/norepinephrine). Exposure to prolonged stress and

elevated levels of dopamine and norepinephrine has additionally shown to contribute to prefrontal cortex dysfunction (Arnsten, 1998; Arnsten & Goldman-Rakic, 1998), and therefore to symptoms of inattention and impairment in executive functions, new learning, and memory.

As noted, the brain region referred to as the amygdala plays a role in the normal and healthy stress response. Along with the hypothalamus, the hippocampus, and several nearby brain regions, the amygdala makes up part of the brain's limbic system that modulates the expression of emotion through integration of sensory information from the outside world for storage and retrieval from memory. Essentially, the amygdala "attaches" an emotional response with the stimuli that activates other body systems to elicit an adaptive response. When the emotional valence is stress, it activates those body systems involved in reacting to stress. The locus ceruleus initiates the noradrenergic (norepinephrine) stress response (the paraventricular nucleus of the hypothalamus that initiates stress sensitive HPA axis) to the vagus nerve and medulla of the brain, which are responsible for the stress induced increases in heart rate and blood pressure. This then stimulates the parabrachial plexus, which leads to increased respiratory rate during stress. This activates the central gray matter of the brain that is involved in conditioned fear (the phenomenon of freezing during acute stress and stress induced analgesia) that then signals the nucleus reticularis pontis caudalis that controls fear related heightening of the startle reflex. Thus, the amygdala serves as the initial screening center for sensory input. If the input is deemed stressful, it triggers a cascade of physiologic and psychologic responses (i.e., increased blood pressure and heart rate, sweating).

The amygdala is also neurally connected to the medial prefrontal cortex, an area of the brain associated with planned behaviors, working memory, motivation, and distinguishing between internally versus externally derived models of the world (Knight, Grabowecky, & Scabini, 1995). The anterior cingulate, part of the medial prefrontal cortex, is important in extinguishing learned fear responses and attention regulation. The medial prefrontal cortex releases several neurotransmitters including dopamine, norepinephrine, and serotonin that result in negative feedback (inhibitory effect to limit further reaction from the organ) to the amygdala. This constitutes the neurobiological explanation for the psychological flight or fight phenomenon and consequently influences memory formation and retrieval. High levels of noradrenaline and dopamine are related to prefrontal cortex dysfunction (Arnsten, 1999). The prefrontal cortex is considered to be the brain region associated with planning, organizing, working memory, and attention to distractions (i.e., executive functions).

Overall, these neurobiological systems associated with perceiving and reacting to stress and trauma are also extremely important for memory retrieval and formation; and in particular, verbal memory functioning. The following sections will outline, in greater detail, how under chronic conditions, the biological stress system impacts the associated brain structures and thus, the adaptive cognitive, behavioral, and emotional associates of brain functioning.

Functional and Structural Brain Changes.

As noted, human beings have developed systems to adapt to stressful or aversive changes in the environment. Adaptive functioning of the stress response system is somewhat dependent on the chronicity and intensity of the environmental stressors. Aversive events,

such as maltreatment or combat exposure occur outside of the experience-expectant developmental process and evoke a response from the biological stress system that may become maladaptive. Researchers who have studied the maladaptive stress response have found the chemical and behavioral reactions to prolonged stress manifest in both structural and functional neurological changes with long-term consequences. The developing brain areas most vulnerable to early stress include the prefrontal cortex, hippocampus, and corpus callosum (Teicher et al., 1997). These structures are influenced by the biological stress system, which will impact their functioning (De Bellis, 2001). Based on an understanding of the stress response system, the following sections will review the research findings in both adults and children that illustrate how the chronic influence of these systems negatively impacts brain functioning through structural changes.

Adults: Functional and Structural Brain Changes.

As reviewed, conditions of chronic stress the body's biological responses become maladaptive, resulting in the very biological mechanisms that work to maintain homeostasis to act in ways that contribute to, maintain, or even cause disease (Selye, 1973). Such a chronic and heightened response has been observed to lead to structural and functional brain changes in adults, specifically with regard to volume reduction and functional changes in the hippocampus and amygdala, as well as abnormal frontal-temporal electrical activity (De Bellis, 1999; Carrion et al., 2002; Teicher et al., 2004; Teicher, Talmud, & Anderson, 2006). Adults who meet diagnostic criteria for PTSD are the most common population of study in terms of the consequences of trauma, due in part that PTSD is the psychopathological manifestation of severe trauma exposure and is most readily identified in adults. Therefore

this population warrants focus for gaining some understanding about the neurobiology of trauma.

With regard to the HPA-axis in people with PTSD, the hippocampus is one of the most important brain areas mediated and affected by stress as it is particularly susceptible to the neurotoxic effects of increased cortisol (Heim & Nermeroff, 2001) due to its rich concentration of receptors for glucocorticoids (McEwen, de Kloet, & Rostene, 1986) and its capacity to integrate cognitive, neurochemical, and neurohormonal responses to stress. The hippocampus also plays an important role in new learning and memory, as it works as part of the stress response in assessing potential threat (Zola-Morgan, Squire, & Amaral, 1980). Increased levels of glucocortoids in the context of stress have been shown to damage the hippocampus (Luine et al., 1994). Therefore, it has been speculated that the hippocampus likely plays a role in stress-related psychiatric disorders (Bremner, 1999). Research examining the hippocampal volume following trauma in adults has reported reduction in volume. Bremner and colleagues (2003) found a comparative reduction in hippocampal volume within a group of women who had been sexually abused as children and had PTSD, as compared to women who had been sexually abused and had no PTSD, as well as controls (Bremner, Vythilingam, Vermetten, Southwick, McGlashan, Nazeer, Khan, Vaccarino, Soufer, Garg, Staib, Duncan, & Charney, 2003). Gilbertson, Shenton, Ciszewski, Kasai, Lasko, Orr, and Pitman (2002) and Bremner and colleagues (1995) also observed reduced hippocampal volume among adults with PTSD. Reduced hippocampal volume was also found to be associated with verbal memory deficits among veterans with PTSD (Bremner, Randall, Capelli, Scott, McCarthy, and Charney, 1995). The finding of reduced hippocampal volume in PTSD has not been consistently demonstrated in all studies of children and in

some studies of adults (De Bellis, 2001; Pederson et al., 2004) and has not been consistently associated with impaired memory (Gurvits et al., 1996; Neylan et al., 2004). The hippocampus is a brain region associated with long-term and episodic memory, which will be discussed in more detail later on. If episodic memory, or memory for events within a context, is dysregulated, a person may not be able to remember the context of a memory and thus overgeneralize its source as demonstrated in adults with PTSD. In contrast, a longitudinal study of trauma survivors, some of whom developed PTSD, did not find reductions in hippocampal volume (Bonne, Gilboa, Gomori, Shenton, Pitman, 2001). The amygdala, part of the HPA-axis that serves as the initial screener for sensory input and as gatekeeper to retrieving past experiences, has also been found to become hyper-responsive in the context of stress, possibly leading to recurrent and intrusive traumatic memories and excessive fear associated with traumatic reminders that are symptoms of PTSD (Bremner, 1999). Overall, the hippocampus and amygdala are brain regions deserving of further inquiry in relation to memory and functional impairments related to stress.

The prefrontal cortex is another area of the brain considered to be susceptible to the consequences of trauma exposure, and is linked to executive functioning abilities, such as planning and controlling behavioral responses. The medial prefrontal cortex in particular may also become under-reactive in people with PTSD; as less blood flow and neural activity was evidenced in adults with PTSD than adults without PTSD (Bremner, 1999; Shin et al., 1999). Shin et al. (2004) examined prefrontal cortex blood flow in the amygdala and medial prefrontal cortex in Vietnam veterans with PTSD and found decreased blood flow and atrophy in these brain regions in veterans as compared to control participants without PTSD symptoms. In a review of the relevant research, Shin, Rauch, and Pitman (2006), noted a

trend in diminished volumes, neuronal integrity, and functional integrity of the hippocampus in adults with PTSD across studies. The medial prefrontal cortex has been identified as smaller and hyporesponsive during symptomatic states and performing emotional cognitive tasks in adults with PTSD (Hamner, Frueh, Ulmer, & Arana, 1999; Elzinga & Bremner, 2002; Layton & Krikorian, 2002).

Through functional magnetic resonance brain imaging (fMRI) and regional cerebral blood flow analysis (rCBF) of the brain, researchers have begun to examine the neurocognitive changes and brain mechanisms associated with trauma in adults. In conjunction with rCBF studies, which have found trauma scripts (using the Clinician-Administered PTSD Scale for Children and Adolescents; CAPS-CA, 1995) tend to trigger dissociative experiences while at the same time increasing blood flow to areas of the brain associated with non-verbal patterns of recall in adult female survivors of sexual trauma, researchers have begun to make hypotheses regarding memory disintegration resulting from trauma experiences (Weems, Saltzman, Reiss, & Carrion, 2003). Furthermore, blood flow dysregulation has been found in the medial prefrontal cortex, hippocampus, and visual association cortex as well as increased activation in the posterior cingulate and motor cortex of adult women with PTSD (Bremner, 1999). The blood flow dysregulation has been speculated to be a symptom of an altered stress response in reaction to inescapable predation that engages the brain areas associated with non-verbal, bodily arousal awareness, and episodic recall of memories; essentially eliciting behavioral immobilization (Frewen & Lanius, 2006).

The adult brain is clearly susceptible to the influence of a chronically activated stress response. Many of these brain regions appear to function maladaptively subsequent to this

exposure. Because emotion (including the fear response) and memory are adaptively linked through certain regions of the brain, it becomes understandable how dysfunction in both domains may be related.

Children: Functional and Structural Brain Changes.

The fact that traumatized adults evidence significant neurobiological changes begs the question of what trauma exposure might do to a child's maturing brain and nervous system. While humans are born with most of the brain cells and structures that will be present once they have fully matured, development and functioning varies across the lifespan. As the child's brain grows there are sensitive periods of development during which environmental influences may impact the brain's development to reach certain capacities in the future (Wilson et al., 2010). These external influences have been referred to as "experience-expectant developmental phenomena" (Greenough, Black, & Wallace, 1987) and are part of typical brain development within the typical expectable environment. These experiences allow for and contribute to the process of brain maturation including neuronal overproduction, synaptic pruning, and myelination (Wilson et al., 2010). Maltreatment falls outside of the realm of the experience-expectant social developmental processes and alters the developmental trajectory in a deleterious manner. Maltreatment activates a stress response in a chronic way which the child would not be exposed to otherwise, and deprives the child of needed experiences for proper development resulting in cognitive and emotional deficits (Heim & Nemeroff, 2001). De Bellis (2005) found evidence that myelinated areas of the developing brain are particularly susceptible to chronic stress. In addition to the states of hyperarousal or avoidant behaviors resulting from elevated levels of catecholamines and cortisol elicited through the stress response, these hormones stand to adversely impact

neuronal growth, pruning, and myelination (for review see De Bellis, 2003), and consequent long-term cognitive functioning in children who have been maltreated. Understanding the complexities of dysregulated or hyperactive biological stress responses in children who have been maltreated will aid understanding their cognitive development.

Magnetic Resonance Imaging (MRI) studies of children who have been maltreated suggest that child abuse-related PTSD is associated with global adverse brain development. In two separate studies conducted by De Bellis et al. (1999, 2002), children who had been maltreated were found to have smaller intracranial, cerebral, and prefrontal cortex, prefrontal cortical white matter, right temporal lobe volumes and areas of the corpus callosum when compared to non-maltreated controls. However the right, left, and total lateral ventricles and frontal lobe cerebral spinal fluid volumes were larger in the maltreated group compared to the controls. One study found decreased cerebral volumes and attenuation of frontal lobe asymmetry (Carrion et al., 2001). In particular, maltreated boys, with related PTSD, tended to have a smaller corpus callosum (Teicher et al., 1997; De Bellis et al.,1999, 2002;) and smaller cerebral and frontal cortices, less prefrontal white matter, and reduced temporal lobe volumes (De Bellis et al., 2002).

Other studies have also provided evidence that maltreated males with PTSD may show more evidence of adverse brain development, and therefore be more vulnerable to the effects of stress, than maltreated females with PTSD (De Bellis & Keshavan, 2003). Males who have been maltreated and developed PTSD may also be more vulnerable to the long-term consequences of childhood trauma (McGloin & Widom, 2001). Based on an examination of age of onset of PTSD trauma, these studies suggest that traumatic stress is associated with disproportionately negative consequences if it occurs during early childhood,

that it has global and adverse influences on brain development, and that these may be cumulative (De Bellis et al., 1999, 2002). Other research has found children who have been maltreated and adolescents with PTSD or sub-threshold PTSD showed no anatomical differences in limbic (hippocampal or amygdala) structures cross-sectionally (De Bellis, et al., 1999; Carrion et al., 2001; De Bellis et al., 2002) or longitudinally (De Bellis et al., 2001). While the hippocampus clearly plays a role in the sympathetic stress response, the research is largely mixed with regard to hippocampal volume increasing, decreasing, or remaining the same prior to maltreatment and/or trauma exposure. Researchers have further noted differences in total brain tissue and cerebral gray volumes, as well as cortisol secretion in youth aged 10-16 years old who had been maltreated when compared to same-aged controls (e.g., Carrion et al., 2010). Such changes most likely negatively impact cognitive functioning. These studies suggest maltreatment associated PTSD has some adverse consequences for neurobiological development, particularly myelination, leading to overall structural and volumatic changes in the brain. There are also specific structures, with distinct roles in neurocognitive functioning that seem particularly susceptible to stress.

The results have been mixed with regard to the research that has examined hippocampal volume and brain development in children who have been maltreated. As noted, the hippocampus plays an important role in the formation of new memories about experienced events (i.e., episodic memory, which will be defined), and detecting novel events and stimuli, as well as part of the larger medial temporal lobe memory system responsible for memories that can be explicitly verbalized and include memory of facts as well as episodic memory (e.g., Squire, 2004; VanElzakker, Fevurly, Breindel, & Spencer, 2008). The hippocampus is therefore of interest to PTSD research due to its role in archiving

memories and attending to stimulation. De Bellis and (2005) examined a group of 61 youth with malteratment-related PTSD and 122 controls, and found significantly lagrer hippocampal volume in the youth with PTSD as compared to the controls. The increased volume was also positively related to age of trauma onset and the level pf psychopathology, particularly externalizing psychopathology (De Bellis & Tupler, 2005). Another study found no differences between groups' hippocampal volume at baseline, follow-up, or across time; and larger amounts of grey matter (De Bellis et al., 2001). The latent effects of hippocampal reduction may be accounted for, in part, by the chronicity and chronology of the maltreatment, as well as the type of maltreatment. Furthermore, Carrion et al. (2010) found a sample of 27 youth, who experienced interpersonal trauma and displayed Posttraumatic Stress Symptoms (PTSS), exhibited decreased hippocampal activity during a verbal memory task (Carrion, Haas, Garrett, Song, & Reiss, 2010). In this study, the group with PTSS demonstrated reduced right hippocampal activation during the retrieval portion of the task; however, increasing severity of the PTSS symptoms of avoidance and numbing correlated with reduced left hippocampal activation retrieval.

Participants in research studies have typically experienced some early identification, intervention, and treatment of child maltreatment as opposed to the unstudied population of unidentified and/or untreated children who have been maltreated. Furthermore, the hippocampal cell loss may be overcome if it occurs during a sensitive developmental period (De Bellis et al., 2001). Teicher and colleagues (2003) further extrapolated on this theory and noted sensitive periods of neurogenesis and pruning vary by age and gender (Teicher Andersen, Polcari, Anderson, Navalta, & Kim, 2003). For example, adolescence is a period of pruning, post-neurogenesis; thus maltreatment experienced during this developmental

stage is considered more detrimental to hippocampal volume than children who are pre- or post-pubescent (Teicher et al., 2003). Sensitive periods for myelination also differ by gender in that boys are more vulnerable for reduced myelination earlier than girls (Teicher et al., 2004). Therefore, neglected boys are more likely to demonstrate reduced hippocampal volume (since this type of abuse typically occurs earlier in life), as are sexually abused girls (since this type of abuse typically occurs later in life) than boys and girls who fall into other maltreatment type categories (Teicher et al., 2004). Teicher et al. (2006) has most recently found children who have been sexually abused earlier in life develop reduced hippocampal volume, while children who have been sexually abused later in life are more likely to show decreased prefrontal cortex volume. These findings suggest the vulnerability of different regions of the brain is somewhat dependent on the growth stages and critical periods they are in when the child is exposed to abuse.

The prefrontal cortex, found to be structurally altered in adults with PTSD, has an extended developmental period from childhood into early adulthood, as compared with other brain structures. It therefore has an extended period of vulnerability, especially within the context of maltreatment, making it worth examining in children. One study that compared 23 children (ages 7-14) with a history of trauma and PTSD symptoms with 24 same-aged children who had not been maltreated found differences in prefrontal cortex grey matter volume in children with PTSD (Richert, Carrion, Karchemskiy, & Reiss, 2006). Changes in prefrontal cortex size and/or functioning have been identified in children who have encountered traumatic experiences and demonstrated poorer executive functioning (e.g., De Bellis et al., 2002; Levin & Hanten, 2005). Therefore, trauma likely impacts prefrontal cortex development, and may lead to functional shortcomings in executive functioning

capacities (Wilson et al., 2010). Dysregulation in executive functioning may also disrupt cognitive and emotional appraisals of experiences, including maltreatment, resulting in some of the psychological sequelae noted in maltreated populations (e.g., depression). Sowell, Thompson, Tessner, and Toga (2001), reported that maturation of the frontal lobe was significantly associated with verbal and spatial memory among typically developing children aged 7 to 16, suggesting that trauma with associated PTSD may result in deficiencies verbal memory development.

The corpus callosum, a structure in the brain that connects the two hemispheres, has also been found to be susceptible to the effects of childhood maltreatment. This region of the brain allows for effective communication between, and integration across, the two brain regions. It is not typically studied as a structure of interest in populations of adults with PTSD; however the effects of maltreatment during sensitive periods of brain development have been linked to differences in structure and function of the corpus callosum (e.g., Teicher et al., 2006). In a review of the research, duration of maltreatment has been linked to corpus callosum size and IQ in children (see Cohen & Mannarino, 2002). In a study of 115 children admitted to a hospital, 51 were admitted for psychiatric reasons, and 28 of these had a history of maltreatment and corpus callosum size was found to be maltreatment and gender specific (Teicher et al., 2004). Neglect resulted in the greatest corpus callosum reduction for boys, and sexual abuse resulted in the greatest reduction for girls. PTSD symptoms and diagnoses were not related to this finding; rather the dysregulated corpus callosum development was resultant of prevented myelination, through the deleterious effects of maltreatment, during sensitive periods of growth (Teicher et al., 2006). Disseth (2005) speculated that the stunted

development of the corpus callosum inhibits communication between the brain regions and prevents adequate integration of sensory stimuli.

Summary: Functional and Structural Brain Changes.

The neurobiological feedback system reviewed in this section provides an organism the means to respond to stress in the environment. The cascade of chemical and neurological changes serves an adaptive purpose when the stress is contained, allowing neurobiological structures to develop and function appropriately. As is the case with many neurobiological pathways and structures in the body, the components of the biological stress system also play imperative roles in other adaptive functions; namely, neurocognitive functioning. When the HPA-axis is activated for too long or flooded, it can lead to a number of health problems and result in structural and functional changes. Thus, the overall neurocognitive functioning of the organism is put at-risk through chronic exposure to stress (e.g., maltreatment). Furthermore, the effects of chronic stress, as experienced by children who have been maltreated, on neuropsychological development may vary by age and become stronger based on the duration and timing of the exposure (e.g., Crozier & Barth, 2005). The following sections will review the domain of neurocognition, and how it is impacted by the structural and functional changes resulting from maltreatment in adults and children.

Neurocognitive Findings from Maltreatment: General.

Neurocognitive refers to how the structure and the function of the brain relate to thought and behavior. Various components of memory, attention, and intelligence fall under the realm of neurocognition, and deficits in these domains lead to disruptions in adaptation and functioning. Of particular interest for this study are the neurocognitive deficits associated with child maltreatment trauma. Research indicates children who have been

maltreated are more likely to demonstrate difficulties with neurocognition, which will negatively impact academic achievement. The neurobiological feedback system enlisted when an organism is exposed to stress also exerts influence on many of the brain structures involved in memory. For example, the stress hormone cortisol has demonstrated widespread effects on memory through its impact on many of the critical brain structures implicated in memory function (e.g., Bremner, 2005). Additionally and as noted, the limbic system, which is the primary area of the brain that deals with stress, plays an important role in emotions and memory (Sapolsky, 2003). Within the limbic system, the amygdala is responsible for determining what memories are stored and where memories are stored, and the hippocampus is thought to be responsible for long-term storage and retrieval of memories (e.g.,Van der Kolk, 1994). Damage to the hippocampus has been found to result in an inability to produce new memories. Hence, the adaptive functioning of the stress response system and memory is highly correlated.

The literature reviewed thus far suggests an understandably growing interest in the relationship between exposure to psychological trauma and deficits in memory function (Buckley, Blanchard, & Neill, 2000; Elzinga & Bremmer, 2002). The following sections will review the research that has been conducted regarding neurocognitive functioning adult survivors of adult trauma, adult survivors of childhood trauma, and cognitive functioning in traumatized children. A more detailed review of research that focuses on or includes specific examination of verbal memory functioning will be described following the review of these general neurocognitive findings.

Adults: Neurocognitive Findings.

A growing body of research suggests PTSD is associated with a broad range of neurocognitive deficits, including attention (e.g., Dalton, Pederson, Blom, & Besyner; 1986; Uddo et al., 1993; Sutker, Vasterling, Brailey, & Allain, 1995), executive functioning (e.g., Sutker et al., 1995), and memory (e.g., Bremner et al., 1993; Uddo et al., 1993; Yehudi et al., 1995). Furthermore, in addition to the core PTSD symptoms, adult patients with PTSD report difficulties with new learning, memory, and attention (e.g., Thygesen, Hermann, & Willanger, 1970; White, 1983). It should be noted that most of these studies examined adult men who had been exposed to war combat. Additionally, a PTSD diagnosis has been generally correlated with a lower full scale IQ in adults; including studies of with populations of combat veterans, adult rape victims, and adult survivors of child sexual abuse (Gil, Calev, & Greenberg, 1990; Gurvits, Lasko, & Schachter, 1993; Vasterling, Brailey, Constans, Borges, & Sutker, 1997; Brandes, Ben-Schachar, Gilboa, Bonne, Freedman, & Shalev, 2002; Vasterling et al., 2002). Researchers have sought to assess neuropsychological functioning in patients with PTSD and found they display poorer performance on several tests of learning and memory. These studies, their measures, and findings will be reviewed in this section.

Uddo et al. (1993) compared a group of Vietnam veterans with PTSD to a group of Army National Guard enlistees with no reported trauma histories on measures of attention, concentration, new learning, and memory. They found PTSD veterans performed more poorly than the comparison sample on a measure of verbal learning, exhibiting less proficient cumulative acquisition across repeated exposures, greater sensitivity to proactive interference, more perseverative errors, and impairments in word fluency and visual/tracking attention abilities (Uddo et al., 1993). Also in 1993, Bremner and colleagues compared Vietnam veterans with PTSD (n=26) to comparable but non-traumatized control group

(n=15) on a battery of assessments measuring memory and intelligence, including the Russell revision of the Wechsler Memory Scale, the Selective Reminding Test, and subtest of the of the WAIS (Wechsler Adult Intelligence Scale-Revised; Wechsler, 1981). Patients with PTSD scored significantly lower than controls on WMS Logical Memory measures for Immediate Recall and Delayed Recall (Bremner et al., 1993). Furthermore, participants with PTSD demonstrated significant impairments on the Total Recall, Long-Term Storage, Retrieval, and Delayed Recall measures for the verbal component of the Selective Remind Test, and on the Recall, Long-Term Storage, Long-Term Retrieval, and Continuous Long-Term Retrieval measures for the visual component of the Selective Reminding Test (Bremner et al., 1993). There were no significant differences between subjects in prorated IQ as measured by the WAIS-R (Bremner et al., 1993).

In another study, Gurvits et al. (1993) examined the neurological status of 27 medication free out-patient Vietnam veterans diagnosed with PTSD, using the DSM-III-R criteria, compared with 15 non-PTSD combat control subjects; all without alcohol or drug dependence or abuse. A neuropsychiatrist performed a general neurological examination and a special examination for neurological soft signs (NSS), an electroencephalogram (EEG), and a semi-structured neurological history. PTSD subjects showed significantly more NSS than non-PTSD subjects. NSS are minor neurological signs indicating non-specific cerebral dysfunction. No neurological hard signs were found. There were no significant EEG or neuropsychological differences, but there were significant correlations between several neuropsychological test scores and total neurological soft signs.

In 1995, Yehuda et al. examined memory functions for stimuli unrelated to trauma in a group of male veterans with PTSD (n=20) compared with 12 healthy controls. Intellectual

functioning was assessed using WAIS. Both groups were additionally evaluated for verbal memory using the CVLT-C. Controlling for IQ, the PTSD group displayed normal abilities on the measures of initial attention, immediate memory, cumulative learning, and active interference from previous learning. The PTSD group showed a circumscribed cognitive deficit, however, manifested by the presence of substantial retroactive interference, which was demonstrated by a significant decrement in retention following exposure to an intervening word list. Sutker and colleagues (1995) examined deficits in attention, learning and memory, and executive domains and two trauma components in the forms of biological trauma (prolonged malnutrition) and psychological trauma (leading to PTSD) in a group of 108 former prisoners of war. The researchers used the Digit Span and Visual Memory Span subtests of the WMS-R (Wechsler, 1987) and the Trail Making Test, Parts A and B (Army Individual Test Battery; U.S. Department of War, Adjutant General's Office, 1944) (Sutker et al., 1995). Results indicated all POW's experienced cognitive dysfunction that extended many years after the initial trauma. The group of POW's who were classified as being primarily biologically traumatized or malnourished displayed impaired learning and memory performance while the group classified as psychologically traumatized, and having been diagnosed with PTSD, displayed more impairments in attention and mental tracking functions as well as executive dysfunction (Sutker et al., 1995). This was a relatively large sample size, but the ways in which trauma was operationalized were not well supported, making the results somewhat difficult to disseminate. There was also no control group for comparison.

Vasterling and colleagues have conducted a number of studies on this subject, one of which compared 18 PTSD-diagnosed and 23 psychopathology-free veterans of the Persian

Gulf War zone, compared to 41 volunteers recruited from the enrollment lists of local military units (Vasterling et al., 1997). PTSD diagnoses were made using the SCID (Spitzer et al., 1990) and participants were administered the WAIS-R. The authors' results indicated when compared with psychopathology-free veterans, veterans diagnosed with PTSD performed significantly more poorly on WAIS-R Verbal subtests, including tasks assessing fund of general information, vocabulary knowledge, social reasoning and judgment, and verbal abstraction. The two groups did not differ on WAIS-R Performance subtests, which are thought to measure visuospatial and visuomotor skills, or on the Digit Span subtest of the Verbal scale, which is thought to measure attention span and mental control (Lezak, 1983). Although FSIQ differed between the two groups, this could be attributed to disparate Verbal performances. These findings suggest that verbal intelligence may be more significantly impacted in people with PTSD (Vasterling et al., 1997). Furthermore, Vasterling et al. (1998) published a study on veterans diagnosed with PTSD (n=19) that indicated relative performance deficiencies on tasks of sustained attention, mental manipulation, initial acquisition of information, and retroactive interference, compared to veterans without PTSD (n=24). The participants were assessed on the Stroop Test (Stroop, 1935), the Continuous Performance Test (CPT; Conners, 1992), the Wisconsin Card Sorting Test (WCST; Berg, 1948), the WAIS-R Digit Span and Arithmetic subtests, the AVLT (Rey, 1964), and the Continuous Visual Memory Test (CVMT; Trahan & Larrabee, 1988). The poor performance of the PTSD participants was further characterized by errors of commission and intrusion. The tendency toward response disinhibition and intrusion on cognitive tasks was correlated positively with re-experiencing symptoms and negatively with avoidance-numbing

symptoms. These cognitive deficit patterns are consistent with models of PTSD that emphasize the role of hyperarousal and implicate dysfunction of frontal-subcortical systems.

In contrast, when Macmillan et al. (1998) investigated the relationship between intelligence and PTSD by studying the association among pre-combat intelligence, current intelligence, and self-reported PTSD symptoms, they found lower pre-trauma intelligence increased the risk for developing PTSD, not that PTSD lowers performance on intelligence tests. This study was conducted on 90 Vietnam veterans. In 2002, Vasterling and colleagues examined attention, learning, memory, and estimated intellectual potential in 26 Vietnam veterans diagnosed with PTSD and in 21 Vietnam veterans without mental disorders, utilizing the same measures as in their 1998 study. These results indicated participants with PTSD had more cognitive deficits on tasks of sustained attention, working memory, initial learning, and estimated premorbid intelligence but not on measures of focus of attention, shift of attention, or memory savings. Cognitive task performances adjusted for estimated native intelligence remained negatively correlated with PTSD severity. The authors suggested that while intellectual resources may serve as a protective factor for PTSD development, PTSD is still associated with cognitive impairment independent of intellectual functioning (Vasterling et al., 2002).

Only one of these studies claimed to have found no evidence of psychological impairment in a group of Vietnam combat veterans with PTSD (Dalton, Peterson, Blom, & Besyner, 1986). This same group of men was found to display the lowest problem-solving performances on measures of attention thought to be sensitive to anxiety (Dalton et al., 1986). Furthermore, this study's finding of no psychological impairment is questionable given that the diagnosis of PTSD essentially dictates such impairments in order to meet

diagnostic criteria. All of the studies reviewed thus far in this section were conducted in male war veterans; it makes findings difficult to generalize to other populations.

Children: Neurocognitive Findings.

Like adults, exposure to prolonged trauma potentially alters the neurocognitive capabilities of children. Although compared to adults, fewer studies have examined cognitive functioning in children who have been maltreated and/or developed PTSD. Within these scarce studies there are a number of methodological issues regarding the current research on neurocognitive outcomes in children who have been maltreated. Some studies looked at children who have been maltreated within the context of other populations, such as foster care, having bipolar disorder, or failure-to-thrive (Oates, Peacock, and Forrest, 1984; Pears & Fisher, 2005; Savity et al., 2007); or offer no control group for comparison. This makes findings related specifically to the consequences of maltreatment difficult to disseminate. Small sample sizes make prospective studies difficult, and there are currently no longitudinal studies on this topic.

Barahal, Waterman, and Martin (1981) studied abused children who were not characterized as suffering from economic disadvantage or neurological damage. Seventeen children who were abused were compared with a group of 16 children matched on the basis of several demographic variables (i.e., age, gender, race, socioeconomic status, and family composition). Both groups scored within the normal range on the Slosson Intelligence Test for Children, although overall scores for the children who were abused were significantly lower than the controls. Given the matching of subjects on demographic variables, these findings suggested that the deficits observed in the abused children were not solely due to economic disadvantage or neurological injury.

Perry, Doran, and Wells (1983) matched 21 children who were physically abused with 21 non-abused children on the basis of social class and family structure. A greater proportion of abused than non-abused children exhibited delayed (1-2 standard deviations below average) or low normal intellectual and communication skills based on parent report (Developmental Profile) and testing on the Peabody Picture Vocabulary Test (PPVT, Dunn, 1965). Despite controlling for parents' educational level, children who were physically abused showed lower levels of intellectual functioning.

Hoffman-Plotkin and Twentymann (1984) conducted a study on preschool children who had a previous history of physical abuse (n=14), serious neglect (n=14), or no prior history of child maltreatment (n=14) to examine their cognitive and behavioral functioning. Results indicated that the children who were abused and neglected had lower scores on all the measures of cognitive functioning, as measured on the Stanford-Binet Intelligence Scale (Form L-M), the Peabody Picture Vocabulary Test, and the Merrill- Palmer Scale of Mental Tests, when compared to the matched comparison children.

Perez and Widom (1994) conducted the only prospective study examining the long-term intellectual and academic outcomes associated with early childhood maltreatment using a sample of previously individuals who were abused and neglected (n = 413) and a matched control group (n = 286). IQ (Quick Test) and reading ability (WRAT-R) were assessed at approximately age 28 years. The results from this analysis indicated childhood victims of abuse and neglect showed lower levels of intellectual ability and academic attainment (especially reading ability) in young adulthood compared to matched controls. These findings support Wodarski, Kurtz, Gaudin, and Howing's (1990) findings that concluded childhood maltreatment has a persistent effect on school performance. This study extended

such findings to include intellectual functioning and the continuance of symptoms into adulthood.

Sadeh, Hayden, McGuire, Saachs, and Civita (2004) conducted a systematic review of medical records of 100 (83 boys and 17 girls) consecutive admissions to a children's psychiatric inpatient unit to assess specific somatic, cognitive, and emotional characteristics of patients who were sexually or physically abused from other patients admitted to the unit. All participants were administered the WISC-R or WPPSI-R, the Children's Depression Inventory (CDI), and were evaluated for DSM-III-R diagnoses. Children who were sexually abused were found more likely to meet PTSD criteria than children who were physically abused. This study found no differences in Full Scale or Verbal IQ, but significant differences on the Performance IQ for sexually abused children from the non-abused and physically abused groups. It should be kept in mind that this comparison was made within a psychiatric population, and other factors could have affected the findings.

Porter et al. (2005) evaluated a group of 24 children who were sexually abused (girls=19, boys=5) compared to the same number of children who had not been maltreated on a cognitive assessment battery. The battery included the WISC-III (Wechsler, 1991), The Test of Memory and Learning (TOMAL, Reynolds & Bigler, 1994), and the Stanford Achievement Test (SAT, Harcourt, 2002). Clinical assessments for psychopathology were also conducted. The children who were sexually abused were significantly different from the matched comparison group on every clinical rating measure. The majority of which had PTSD (78%), supporting the research indicating that many children who have been sexually abused are at risk for developing PTSD (e.g., Kiser, Heston, Millsap, & Pruitt, 1991). As a

group, however, this sample of children who were sexually abused performed within the average range for memory and intellectual ability (Porter et al., 2005).

Saigh, Yasik, Oberfield, Halamandaris, and Bremner (2006) compared the WISC-III scores of traumatized youth with PTSD (n=25) to the scores of trauma-exposed (n=50) and non-exposed comparison (n=36) groups without PTSD. This study determined that the PTSD group had significantly lower scores on discrete measures of verbal intelligence relative to the comparison groups. The group with PTSD also demonstrated significantly lower Full Scale IQ when compared to the other groups, while the group with trauma exposure in the absence of PTSD and the non-exposed comparison group were not significantly different from each other. The lower Full Scale IQ in the PTSD group was largely attributable to the significantly low Verbal Comprehension Index. Interestingly, the only other study that employed a complete intellectual battery (WAIS-R) and controlled for comorbid disorders reported similar results in an adult sample (Vasterling et al., 1997). Together, these studies begin to provide support that PTSD may be associated with deficits on specific indices of verbal intelligence (Vasterling et al., 1997; Saigh et al., 2006).

Nolin and Ethier (2007) evaluated 79 children, aged 6-12 years, who were exposed to one of two types of maltreatment: neglect with physical abuse, n=56; neglect without physical abuse, n=28. These groups were compared to a control group of 53 children matched for age, gender, and annual family income across measures of cognitive functioning. Their neuropsychological assessment focused on motor performance, attention, memory and learning, visual-motor integration, language, frontal/executive functions, and intelligence. Measures included the Purdue Pegboard (Purdue Research Foundation, 1948), selected subtests of the French-Canadian form of the Developmental Neuropsychological Assessment

(NEPSY; Korkman, Kirk & Fellman, 1998), the CVLT-C (Delis et al., 1994), Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI; Beery, 1997), and four subtests of the Canadian WISC-III. Children who were neglected with physical abuse showed cognitive deficits in auditory attention and response set, and visual-motor integration and problem solving, abstraction, and planning. Children who were neglected without physical abuse differed from the control group in that they obtained lower scores in auditory attention and response set, and visual-motor integration. However, the neglected but not abused children demonstrated a greater capacity for problem solving, abstraction, and planning than both other groups.

In 2009, De Bellis compared groups of children who were neglected with PTSD (n = 22) children who were neglected without PTSD (n = 39) and demographically similar healthy non-maltreated controls (n = 45) across the neurocognitive domains of fine-motor skills, language, visual-spatial, memory/learning, and attention/executive functions, as well as on IQ, reading, and mathematics. Findings suggested significantly lower IQ, reading, mathematics, and selected differences in complex visual attention, visual memory, language, verbal memory and learning, planning, problem solving, and speeded naming in Neglect Groups. More PTSD symptoms (i.e., the worse the severity of PTSD) were associated with poorer performances on measures of IQ, academic achievement, and neurocognitive domains. Neglected children demonstrated significantly lower neurocognitive outcomes and academic achievement than controls.

Summary: Neurocognitive Findings.

Aside from the emotional, behavioral, and psychological consequences that result from trauma and maltreatment, chronic exposure to stress also initiates a biological stress

reaction that was developed to allow humans to perform adaptively in maladaptive or threatening situations. As reviewed, when exacerbated, this stress response works against itself and may fundamentally alter the structure and function of a person's neurobiological systems. In terms of neurocognition, memory deficits and dysfunction are most consistently linked to trauma exposure. Furthermore, the same regions of the brain and neurotransmitter pathways associated with the stress response, are also utilized for memory retrieval and storage. This provides physiological support for why memory and trauma are so closely linked. Based on the reviewed research, memory has been selected as the domain of interest in maltreated children due to the fact that it fundamentally underlies most other cognitive and behavioral capacities and because the psychopathology and neurobiological changes related to trauma exposure relate strongly to it. The following sections will provide support for further investigation of the specific domain of verbal memory; in particular, how it is uniquely impacted by trauma exposure and why it is crucial for adaptive functioning.

Neurocognitive Findings from Maltreatment: Verbal Memory

Overall memory functioning is of interest when assessing and working with trauma victims since much of the diagnosis and treatment focuses on the memories, or lack thereof, for the traumatic events; and because, by definition, PTSD symptoms are primarily manifested in the form of recall, overgeneralization, and hypersensitivity to remembered events. Within this domain, verbal memory becomes of particular interest due to the fact that it is both vital to everyday life, learning, and long-term functional outcomes; as well as being uniquely and specifically impacted by PTSD symptoms and the prolonged biological stress response elicited through trauma or maltreatment.

Research and theory both support that verbal memory is vital to everyday life and may play a significant role in long-term functional outcomes. Additionally, verbal memory is essential for learning and academic achievement, and yet has not been sufficiently studied in maltreated children. Thus, there is a strong case for examining it more closely. The following sections will describe the current research on verbal memory functioning in adult survivors of adult trauma, adult survivors of childhood trauma, and cognitive functioning in traumatized children.

Adults: Verbal Memory.

Within the domain of memory, some preliminary research suggests verbal memory may be specifically vulnerable to trauma. For example, American prisoners of war from the Korean War demonstrated deficits in verbal declarative memory function while their overall IQ remained intact (Sutker et al., 1995). Since these studies occurred before the development of the diagnostic category of PTSD, the question remained whether verbal memory deficits were associated with stress-related psychiatric disorders. In terms of non-combat induced trauma, Gil, Calev, Kuglemass, & Lerer (1990) assessed the cognitive functioning in 12 PTSD psychiatric patients, 12 psychiatric patients matched for severity of psychopathology, and 12 normal controls. The assessment battery included the Block Design, Picture Completion, Coding, Comprehension, Similarities, Information, and Digit Span subtests of the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955), and Army IQ Test, the mental control subtest from the WMS (Wechsler and Stone, 1945), the Bender-Gestalt Test, the Benton Visual Reproduction Test (Form C), a word fluency test, the Paired-Associated Learning subtest of the WMS, the Rey-Osterreith Complex Figure Reproduction Test, the Famous Events Questionnaire (Calev et al., 1985; Squire et al., 1979), the Continuous

Performance Task (CPT), and a subjective measure of the participants feelings about their concentration and attention ability. The results indicated that intelligence, organicity, verbal fluency, memory, and attention were significantly poorer in both groups of patients than controls; the performance of the patients with PTSD and that of the psychiatric controls was similar.

Brandes et al. (2002) evaluated the relationship between PTSD symptoms and cognitive functioning within 10 days of traumatic events. In this study, 48 survivors (28 women and 20 men) were assessed for symptoms of PTSD, anxiety, depression and dissociation; and for immediate and delayed verbal and figural memory, attention, learning, and IQ (Brandes et al., 2002). There was no control group in this study for comparison. Subjects were assessed on a battery that included the Information, Picture Completion, Block Design, Digit Span, Similarities and Digit Symbol sub-tests of the Wechsler Adult Intelligence Scale Revised (WAIS-R; Wechsler, 1981); the Mental Control, Logical Memory, Memory Span, Visual Reproduction and Associate Learning, sub-tests of the WMS (Wechsler and Stone, 1974); and Auditory Verbal Learning Test (AVLT; Vakil and Blachstein, 1993). Participants with high levels of PTSD symptoms showed impaired attention and immediate recall for figural information and lower IQ, although no impairment of verbal recall and learning was demonstrated.

More recently, and subsequent to the establishment of PTSD diagnostic criteria, research has provided primarily supportive findings in terms of verbal memory deficits in adults with PTSD. Several investigations have evidenced such deficits in adults with PTSD relative to trauma-exposed individuals without PTSD (Gilbertson et al., 1997, 2001; Bremner et al., 2004) and non-trauma-exposed control subjects (Bremner et al., 1993, 1995, 2004;

Sachinvala, vonScotti, McGuire, Fairbanks, Bakst, McGuire, & Brown, 2000). At this time, only a few investigations have not found verbal memory deficits among adults with PTSD (Bremner et al., 2003; Gurvits et al., 1993, 1996; Pederson et al., 2004; Stein et al., 2002; Zimering, Cadell, Fairbank, & Keane, 1993).

Bremner et al. (2004) conducted a literature review to examine the existing research on PTSD and deficits in verbal declarative memory functioning in adult populations who had been victims of rape, Vietnam combat exposure, or child maltreatment. They found within the modest group of studies, a variety of assessment measures were used, including the WMS, the visual and verbal components of the Selective Reminding Test, AVLT, the CVLT-C, and the RBMT. Bremner et al. (2004) found specific deficits in verbal declarative memory function, with a relative sparing of visual memory and IQ (Gil et al., 1990; Bremner et al., 1993, 1995; Uddo et al., 1993; Yehuda et al., 1995; Barrett, Green, Morris, Giles, & Croft, 1996; Golier et al., 1997; Jenkins et al., 1998; Vasterling et al., 1998, 2002; Moradi et al., 1999; Sachinvala et al., 2000; Gilbertson, Gurvits, Lasko, Orr, & Pitman, 2001; Roca & Freeman, 2001). Of these studies the populations of interest included patients with PTSD related to Vietnam combat (Bremen et al., 1993; Uddo et al., 1993; Yehuda et al., 1995; Barrett et al., 1996; Golier et al., 1997; Vasterling et al., 1998, 2002; Sachinvala et al., 2000; Roca and Freeman, 2001; Gilbertson et al., 2001), rape (Jenkins et al., 1998), adults with early childhood abuse (Bremner et al., 1995) and traumatized children (Moradi et al., 1999).

In 2008, Johnsen and Asbjornsen conducted a meta-analysis of the existing research on verbal memory impairment and PTSD. In order to meet inclusion criteria for the analysis, studies had to be in English, they had to follow specific diagnostic criteria for establishing PTSD (i.e., SCID, ETI, SADS-L, CAPS, PDS, DIS-III-A, M.I.N.I., SI-PTSD), they had to

compare adult patients with chronic PTSD to a control group of either healthy participants and/or exposed comparison participants without PTSD on a verbal memory measure, and they had to include sufficient data for the calculation of an effect size. The authors stated that the meta-analysis identified 32 studies published between 1993 and 2007 and 28 of these were included (Johnsen & Asbjornsen, 2008). It is unstated specifically why the 4 additional studies identified were not included in the analysis. The 28 studies comprised a total of 1,489 subjects, involving 667 individuals with PTSD and 822 controls. Sample sizes varied from 14 to 160 participants, with a mean of 53. Of the studies included, 17 were based on war veteran samples, 6 studies were on individuals exposed to sexual abuse, 2 studies were based on mixed traumas, 1 study on disaster exposure, 1 study on holocaust survivors, and 1 on civilians with war exposure. All of the studies were based on adult participants and included 12 studies based on samples of men, 4 studies based on samples of women, and 12 studies based on samples of mixed gender. The authors included free list recall and free recall neuropsychological paradigms (Johnsen & Asbjornsen, 2008). Several free recall memory tests were used in the studies, the CVLT-C (Delis et al., 1987), WMS Logical Verbal Memory, and AVLT (Lezak, 1983; Rey, 1941) were the most frequently used. The different versions of the WMS (WMS and WMS-R) were analyzed together (Wechsler, 1981, 1987). In this meta-analysis, 6 out of 28 were studies of retrospective childhood maltreatment and only in the form of sexual abuse; and 12 out of 28 studies used the CVLT-C (see Johnsen & Asbjornsen, 2008). Of those, only three examined histories of childhood maltreatment using the CVLT-C (Jenkins et al., 1998; Stein et al., 1999; Stein et al., 2002).

The PTSD groups displayed significant verbal memory impairment with each of the tested memory instruments (Johnsen & Asbjornsen, 2008). The WMS and AVLT showed the

largest effect sizes, and CVLT-C showed moderate effect size. The WMS and AVLT instruments were the most effective in showing between group differences. The greatest impairment was found for the PTSD groups compared to the healthy controls for both war combat trauma and sexual/physical abuse. Verbal memory appeared to be significantly impaired in the context of PTSD.

Overall, this meta-analysis indicated that verbal memory impairment and PTSD are strongly associated (Johnsen & Asbjornsen, 2008). The results from this analysis additionally found evidence that verbal memory impairment in patients with PTSD is greater than for patients with depression alone. It is important to note that few of the aforementioned adult studies accounted for the potentially confounding effects of comorbid psychiatric conditions (Bremner, Steinberg, Southwick, Johnson, & Charney, 1993; Gurvits et al., 1993, Zimering et al., 1993; Vasterling et al., 1998). Additionally, a few studies not included in the meta-analysis have also found deficits in verbal declarative memory in cases of veterans with PTSD (e.g., Golier and Yehuda, 1998; Buckley, Blanchard, & Neill, 2000; Brewin, 2001; Elzinga and Bremner, 2002).

The majority of research that has attempted to isolate the unique deleterious effects of childhood maltreatment on verbal memory from that of combat exposure in the adult population was reviewed in the meta-analysis and literature review. These studies that dealt specifically with the trauma exposure of interest to this study (child maltreatment), warrant a comprehensive review. Bremner et al. (1995) examined memory in adult survivors of childhood abuse (n=21). All subjects were assessed with the WMS Logical (verbal memory) and Figural (visual memory) components, the Verbal and Visual Selective Reminding Tests (SRT), and the WAIS-R, and compared to non-maltreated controls. The abused participants

demonstrated significantly lower scores on the WMS Logical component for immediate and delayed recall, no difference in visual memory, as measured by the WMS or the SRT, or IQ as measured by the WAIS-R. Deficits in verbal memory, as measured by the WMS, were associated with the severity of abuse, as measured by a composite score on the Early Trauma Inventory (ETI) (Bremner, Randall, Capelli et al., 1995). Additionally, Jenkins et al. (1998) examined female rape victims with (n=15) and without (n=16) PTSD compared to age- and education-matched non-traumatized subjects (n=16) on measures of learning and memory. The CVLT-C was used to quantify immediate free recall over five trials (amount learned), slope of the learning curve (learning efficiency), short-delay (3-minute) and long- delay (20-minute) recall (ability to retrieve newly learned information with or without category prompts), number of words discriminated from distractors (recognition memory), and semantic (category- or meaning-related) and serial (order of presentation) clustering measures of encoding strategy. The rape victims with PTSD performed significantly worse than the other groups on delayed free recall. The deficits were ameliorated by cueing and recognition testing (Jenkins et al., 1998). Bremner et al. (2004) also conducted an independent study comparing verbal declarative memory, using the WMS-R, between women with early childhood sexual abuse and PTSD, women with early abuse without PTSD, and non-abused women without PTSD. They found early abuse with PTSD to be associated with long-term deficits in verbal declarative memory compared to the other groups, and that these effects where not related to nonspecific effects of childhood abuse.

Contrastingly, in a study conducted by Stein, Hanna, Vaerum, and Koverola (1999) of women with a history of early childhood sexual abuse (with and without PTSD, n=22), no differences were found between abused and non-abused women with regard to specific

verbal memory deficits on measures of the CVLT-C and the Benton Visual Retention Task as compared to 20 demographically and educationally similar non-victimized women. This study excluded patients who had experienced head injury requiring rehabilitation or hospitalization for longer than an overnight stay, had a history of seizures or neurological disorders, had taken psychoactive medications within the past month, and women currently abusing alcohol or other substances. The women were also evaluated on a number of measures, including a version of the Structured Clinical Interview for the DSM-IV (First, Spritzer, Williams, & Gibbon, 1995), the Clinician Administered PTSD Scale (to assess severity of symptoms; Blake et al., 1995), the Beck Depression Inventory (BDI; Beck, Steer, & Garbin, 1998), and the Dissociative Experiences Scale (DES; Bernstein & Putnam, 1986). This study did not control for IQ however. The CVLT-C was used to quantify immediate free recall of a 16-item word list over five trials (immediate recall), as well as across short- and long-delays, as well as free and cued recall following the presentation of a new 16-item list. From these subtests the researchers investigated measures of global learning (immediate and total free recall), decay and interference (short-delay free and cued recall; percent change from trial 5 to short-delay free recall), retention (percent change between long-delay and short-delay free recall), response inhibitions (perseverations), and response to discrimination (intrusions; recognition score). Additionally, trials A and B of the Benton Visual Retention Task-Form F (BVRT-F; Benton, 1974) provided an index of immediate visual memory.

Geuze, Vermetten, Kloet, Hijman, and Westenberg (2009) conducted a study that used the CVLT-C, in a battery of memory assessments, and found patients with PTSD (n=25) did not perform significantly worse on any of the variables from the CVLT-C. In this study the participants were Dutch veterans of UN Peacekeeping missions, 25 who were

exposed to trauma and did not develop PTSD and 25 who did develop PTSD. No control group was included. All participants were assessed on four subtests of the Dutch version of the WISC (Wechsler, 1991), the Dutch version of the CVLT-C, the Dutch version of the AVLT, and the Dutch version of the WMS-R Logical Memory I and II and the WMS-R Visual Reproduction I and II. All participants were free of psychotropic medications or substance abuse. Of particular interest for this study, the following measures from the CVLT-C were used: the sum of correctly recalled words from list A trials 1–5, immediate recall of list A, immediate cued recall of list A, delayed recall of list A, delayed cued recall of list A, and number of hits (i.e., correctly recognized words from list A). The CVLT-C and the AVLT were not administered on the same day, and there was always one week between the two tests. Additional variables of interest from the WMS-R included logical memory immediate recall (correctly recalled elements from stories A and B), logical memory delayed recall, figural memory immediate reproduction, figural memory delayed recall, and figural memory recognition. Finally, three measures of subjective memory and attention performance were collected including: Clinical Administered PTSD Scale (CAPS): Criterion C3 that measures the inability to recall an important aspect of the traumatic event, and Criterion D3 that rates attention difficulties; as well as item 5 from the Hamilton Anxiety Scale that rates subjectively experienced difficulties in attention and memory.

In terms of major comorbid disorders, within the PTSD group, participants met lifetime (past) DSM-IV diagnostic criteria for the following disorders: major depressive disorder (n=12), bipolar disorder (n=3), alcohol abuse (n=3), substance abuse (n=2), and panic disorder with agoraphobia (n=1) (Geuze et al., 1999). Seven subjects with PTSD met current diagnostic criteria for major depression. One subject with PTSD met current diagnostic

criteria for panic disorder with agoraphobia. Four non-PTSD subjects met lifetime (past) DSM-IV diagnostic criteria for major depressive disorder, and one subject met lifetime diagnostic criteria for panic disorder with agoraphobia. Cognitively, patients with PTSD had similar IQ scores compared to controls. Overall, patients with PTSD performed significantly poorer than non-PTSD participants on all measures, including: poorer performance on total correct (trials 1–5) on the AVLT, delayed recall score, and the total number of correctly recognized items; significantly reduced performance on the WMS-R figural memory delayed recall score, the WMS-R figural memory recognition score, the WMS-R logical memory immediate recall score, and the WMS-R delayed recall score.

Veterans with PTSD also scored significantly higher on subjective measures related to attention and memory difficulties such as the CAPS C3 and D3 criteria and Hamilton anxiety item 5 (Geuze et al., 1999). Patients with PTSD were found to have significantly greater CAPS, Hamilton A, and Hamilton D scores. Patients with PTSD demonstrated reduced performance on measures of immediate and delayed recall of verbal, visual explicit memory material, and on measures of learning, immediate and delayed recall of both structured (i.e., WMS logical memory) and non-structured (i.e., AVLT and CVLT-C) verbal material compared to controls, however these findings were not significant. Geuze et al. (1999) suggested the CVLT-C may not be a sensitive enough measure for differentiating between PTSD and non-PTSD groups of adults, and cited other studies that have also found the CVLT-C did not identify differences between PTSD patients and control groups (Stein, Kennedy, & Twamley, 2002; Neylan et al., 2004). Overall, memory performance deficits in this veteran population were not related to intelligence, length of trauma exposure, or time since trauma exposure. Furthermore, the deficits in figural and logical memory, immediate

and delayed verbal memory, and learning accurately predicted current social and occupational functioning in veterans with PTSD.

Children: Verbal Memory.

Limited research has examined the role and importance of verbal memory in children who have been maltreated despite the preliminary support for such an investigation based on the adult research and the neurobiological underpinnings associated with stress and verbal memory. Moradi et al. (1999) administered the Rivermead Behavioural Memory Test (RBMT) to children and adolescents with PTSD (n=18) and a non-traumatized control group (n=22). PTSD was assessed using criteria outlined in the DSM-III-R (American Psychiatric Association, 1987) and ICD-10 (World Health Organization, 1992). All PTSD participants had been involved in a road traffic or personal violence incidents (without loss of consciousness), but not necessarily maltreatment, within the 2 years prior to the study. Control participants were matched on age, sex, and verbal IQ with the PTSD group. The control participants had no known history of emotional disorder or trauma according to parents and teachers. The Revised Impact of Event Scales (IES; Horowitz, Wilner, & Alvarez, 1979), a self-report scale, was used to assess intrusion of traumatic thoughts and memories, and the degree to which situations that evoke intrusions are avoided by the individual. The Revised Children's Manifest Anxiety Scale (RCMAS; Reynolds & Richmond, 1978) and Depression Self Rating Scale (DSRS; Birleson, 1981) were used to assess mood and anxiety. The British Picture Vocabulary Scale (BPVS short form; Dunn, Whetton, & Pintail, 1982) and Wechsler Objective Reading Dimensions (WORD, Basic Reading; Rust, Golombok, & Trickey, 1993) were used to evaluate participants reading and achievement levels. Reading scores and depression levels were used as covariates in the

study. The RBMT was used to assess verbal memory, and was originally developed to assess everyday memory problems in adults with non-progressive brain injury, although can be used with children as young as 5 years old (Wilson, Ivani-Chalian, Besag, & Bryant, 1993). Reliability and validity of the RBMT has been found to be high (Wilson et al., 1989). It contains 12 different subtests that cover verbal, visual, and visuospatial memory in immediate, delayed, and prospective conditions; purportedly emphasizing skills needed in real-life situations.

The results indicated approximately 78% of children with PTSD evidenced memory problems (impaired-22%, poor-56%), while only about 14% of the control subjects presented with poor memory, and none demonstrated impaired memory. Children with PTSD demonstrated significantly lower scores on the Immediate Story, Delayed Story, and overall memory performance profiles. Specifically, the PTSD group performed significantly more poorly on the prospective and orientation (Appointment, Belonging, and Message Delivery) items on the RBMT. Prospective memory processing refers to the stages of forming an intention, retaining the content of the intention, and accomplishment of the action (Barba, 1993). Despite being matched for verbal IQ, there was a highly significant difference between the two groups in reading ability as measured by WORD scores, with the normal control subjects scoring higher than the patients with PTSD on this scale. Hypothetically, the presence of the intrusion, avoidance, and hyperarousal symptoms of PTSD may interfere with everyday memory performance, as well as the development of reading skills.

Beers and De Bellis (2002) conducted an extensive neuropsychological evaluation of children who developed PTSD subsequent to a variety of traumatic experiences: sexual abuse (n=7), physical abuse (n=2), and witnessing domestic violence (n=5). Their sample included

14 “medication-naive” children with PTSD secondary to maltreatment who were psychiatric outpatients and 15 healthy comparison children who had not been maltreated and were similar to the patients with PTSD in terms of age, race, socioeconomic status (as measured by the Hollingshead Four-Factor Index) and IQ (as assessed by the WISC-III). Administration of a modified version of the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997) and a clinical detailed trauma interview (De Bellis, 1997) were used to diagnose patients with PTSD based on the DSM-IV’s criteria. Major co-morbid disorders identified within the PTSD population included (MDD; n=5), dysthymic disorder (n=2), separation anxiety disorder (n=2), Oppositional Defiant Disorder (ODD; n=6), and Attention Deficit Hyperactive Disorder (ADHD, inattentive subtype) (n=1). The control subjects had no lifetime history of Axis I disorders. Inclusion criteria for PTSD participants consisted of child maltreatment experiences that were reported to child protective services before the study, the availability and cooperation of a non-abusive caregiver, and a currently stable home environment. Exclusion criteria for all subjects included birth complications, substantial medical illnesses, head injuries requiring sutures, emergency room treatment or loss of consciousness, gross obesity, growth failure, full-scale IQ scores less than 80, history of treatment with psychotropic medications, anorexia nervosa, pervasive developmental disorder, schizophrenia, adolescent-onset alcohol or substance abuse or dependence, prenatal exposure to alcohol and/or other substance use greater than twice a month during the 3 months before discovery of pregnancy, and mother’s use of controlled substances during the known period of pregnancy.

Six cognitive domains were examined in this study, and participants with PTSD performed significantly more poorly than controls on four of them. In the domain of attention, subjects with PTSD performed more poorly on two measures of freedom from distractibility, Stroop Color and Word Test Color/Word and interference. The PTSD group made significantly more omission errors on a measure of sustained visual attention (Digit Vigilance Test). On measures of problem solving and abstract reasoning/executive function, subjects with PTSD completed fewer categories on the WCST. On two variables of semantic organization, the Controlled Oral Word Association Test Animal Naming and Total Words, children with PTSD generated fewer category members and named fewer words beginning with target letters. Children with PTSD scored significantly lower than comparison subjects on the WISC-III Similarities subtest. With regard to learning and memory, children with PTSD performed more poorly on one test, the CVLT-C's long delay free recall. Finally, on measures of visual spatial function, children with PTSD completed a poorer copy of the Rey-Osterrieth Complex Figure and made more errors on the Judgment of Line Orientation Test. No significant differences between groups were found on any tests of language or psychomotor speed. Upon examination of experiment-wise error, children with PTSD were not evidenced to have performed differently from comparison children on any measures of language, memory and learning, visual-spatial abilities, or psychomotor skills. The authors noted that the small number of subjects may have obscured significant findings. Furthermore the study lacked a comparison group of children who had been maltreated but did not have PTSD. Despite this, overall findings from this study did suggest deficits in long-term memory for verbal information may be evidenced in children with maltreatment-related PTSD symptoms, and should be further researched.

Yasik et al. (2007) compared three groups of children and adolescents: traumatized with PTSD (n=29), traumatized without PTSD (n=62), and non-traumatized control subjects (n=40). Because comorbid disorders associated with PTSD (e.g., ADHD, TBI, depression) may also influence memory (Saigh, Yasik, Oberfield, & Inamdar, 1999), and cofound the interpretation of PTSD and memory functioning (Barrett et al., 1996; Sachinvala et al., 2000; Neylan et al., 2004), youth with major comorbid disorders were excluded from their study. Furthermore, none of the non-traumatized participants received a Diagnostic Interview for Children and Adolescents (revised) (DICA-R, Reich et al. 1995) diagnosis of major depressive disorder (MDD), conduct disorder (CD), ADHD, substance dependence, or psychotic symptoms. Participants were assessed for PTSD using the Children's PTSD Inventory, IQ was assessed on the WISC-III (IQ scores less than 70 were excluded), SES was measured using the Hollingshead social class inventory (class ranges from I-V, I being lowest status), and overall stress symptoms were assessed using the Severity of Psychosocial Stress Scale: Children and Adolescents (SPSS-CA) (American Psychiatric Association, 1997). The Wide Range Assessment of Memory and Learning (WRAML) (Sheslow & Adams, 1990) was used to assess verbal memory and learning across participant groups. The results indicated significant group differences on the sentence memory subtest; the PTSD positive group scored significantly lower than the PTSD negative group and non-traumatized control group. Significant group differences were also noted on the visual learning and sound symbol subtests; the PTSD group scored significantly lower than the non-traumatized control subjects on both of these learning subtests. With regard to delayed recall performance on both the visual learning and sound symbols subtests, youth with PTSD evidenced significantly lower delayed recall on the visual learning subtest relative to the non-

traumatized control subjects and no difference were noted on sound symbol delayed recall. Given the exclusion of major comorbid disorders, this study determined that verbal memory impairments were specifically associated with PTSD and not with trauma exposure in the absence of PTSD. Furthermore, general memory and learning deficits were only observed among youth with PTSD when compared with the non-traumatized group. Trauma exposure in the absence of PTSD was not associated with memory and learning deficits, as the non-traumatized PTSD participants did not significantly differ from the control group.

Covariates Affecting Verbal Memory

While the primary variables that will be examined in this study include components of verbal memory and maltreatment subtypes, there are a number of other factors that stand to potentially impact verbal memory in the maltreated population. Many of the reviewed studies in this chapter have tried to control for variables such a race, age, economic status, cognitive deficits, and psychopathology; and some have noted differences based on these variables (e.g., gender in Trickett & McBride-Chang's 1994 review; Teicher et al., 2003). A number of such factors were theoretically considered in an account by Ayoub et al. (2006). For example, their paper proposed that children who have been maltreated may have deficits in some cognitive domains as well as more advanced skills related to their traumatic experiences, even when psychopathology is present (e.g., dealing with negative information and negative contexts). Although this paper was theoretical, it highlights the potential impact of factors such as age, psychopathology, and cognition (Ayoub et al., 2006). The following sections will review additional factors that should be considered in an analysis of the effect of maltreatment on verbal memory.

Sociodemographic Variables.

Child maltreatment is frequently associated with disturbed family and social relations (Hoffman-Plotkin & Twentyman, 1984; Cicchetti & Toth, 1993). The specific effects of sociodemographic variables on children's memory are difficult to parse out. The number of socio-emotional sequelae of child maltreatment, including the development of insecure, often disorganized attachment relationships, and deviations in symbolic and representational abilities (Cicchetti & Toth, 2005), may also affect processing of memories in abused and neglected children, and memory functions more generally. Failures in care-giving may lead children who have been maltreated to either defensively distort memories, or to distort memories to dissociate their memories of abusive or neglectful experiences (Cicchetti & Valentino, 2006). Child maltreatment is also related to a number of parental factors including poor knowledge of child development, substance abuse, domestic violence, and mental illness (AACAP, 2010). Although maltreatment occurs in families of all socioeconomic levels, abuse and especially neglect are more common in poor families (Slack, Hall, McDaniel, Yoo, & Bolger, 2004). Children who have been maltreated are more likely to come from families of lower socioeconomic status, however, and more ethnic minority groups also fall into this demographic, therefore these variables must be given consideration when accounting for differences found between children who have been maltreated. For example, Barnett, Vondra, and Shonk (1996) found that threats to academic functioning reside as much in the ecology of poverty as with maltreatment. Over and above the effects of poverty, however, maltreatment has been found to disrupt the psychological processes accounting for children's scholastic performance (Perez & Widom, 1994). The age at which the maltreatment occurs may impact perceptions of competence and the relationship

between perceived competence, motivation, and school functioning. In the same study, younger children who had been maltreated (6 and 7 year olds) reported more inflated self-perceptions than children who had not been maltreated, while older children who had been maltreated (8 through 11 year olds) reported lower perceived social acceptance than children who had not maltreated (Barnett et al., 1996). The determinants of academic engagement are different in maltreated and children who have not been maltreated and vary across age and development. Interestingly, children who have been maltreated who felt badly about themselves did better in school than the ones who felt good about themselves, while the inverse was true in children who have not been maltreated.

Barahal et al. (1981) studied abused children who were not economically disadvantaged and had sustained no neurological damage compared to a control group. The overall scores for the children who were abused were significantly lower than the controls, suggesting the deficits observed in children who were abused were not solely due to economic disadvantage or neurological injury. Perry et al. (1983) matched 21 children who were physically abused with 21 non-abused children on a number of demographic variables and similarly found, despite controlling for parents' educational level, children who were physically abused showed lower levels of intellectual functioning. Research also suggests that children with low socioeconomic status are more likely to display higher levels of cortisol than children with high socioeconomic status (e.g., Lupien, King, Meaney, & McEwen, 2000). This study also found that children's cortisol levels were significantly correlated with the mothers' level of depressive symptomology, suggesting a neurobiological determinant between socioeconomic status and health. Therefore when studying these populations, consideration should be given to controlling for sociodemographic factors.

Cognitive Factors.

While the development of memory has been examined on an independent trajectory, its theories would be found lacking were they to ignore the effect of attention processes. Many models of memory establish the role of attention during stages of selection, encoding, storage, and retrieval. Baddeley's (2000) model conceptualizes attention as being a component of the central executive system that plays a major role in working memory. Attention is required for monitoring the flow of information, switching between tasks, and selecting relevant stimuli while inhibiting irrelevant stimuli (e.g., Alloway, Gathercole, Willis, & Adams, 2004). Attention is also required for the process of selecting between competing stimuli and responses during the retrieval process (Roelofs, 2003). Aspects of short-term memory, such as maintaining focus on a specific stimuli and active rehearsal, also require attention (Cowan, Nugent, Elliott, Ponomarev, & Saults, 1999; Anderson, 2005). Attention has been found to play a role in episodic encoding, and a combination of attention and memory influences processing speed (Naveh-Benjamin, Guez, & Marom, 2003).

Attention develops and matures with age, and memory capacity is thought to also increase as children age. The theory of 'memory capacity' has been supported in research that has found older children were able to recall more verbal items than younger children when prevented from using mnemonic techniques while hearing lists of digits (Cowan, 2000), and processing load affects working memory more so than task duration (Gavens & Barrouillet, 2004). Both examples of this research suggest that there is a memory capacity that increases with age and limits performance. With regard to attention, developmental changes have been noted in vigilance, selective and focused attention (up to age 10), and on tests of executive functioning (up to age 11) (Klenberg, Korkman, & Lahti-Nuuttila, 2001;

Betts, McKay, Maruff, & Anderson, 2006). Vakil et al. (2009) found pronounced developmental changes in attention across a group of 8-11 year-olds, and stabilization of performance across 12-17 year olds (Vakil, Blachstein, Sheinman, & Greenstein, 2009). Developmental changes in attention have been reported even up to the age of 16 years (Manly, Kim, Rogosch, & Cicchetti, 2001). There are likely aspects of attention and memory that are dependent on, or at least related to, one another during development.

The course of development in attention and memory is typically studied independently. One study by Gomez-Perez and Ostrosky-Solis (2006) examined the development of both attention and memory measures across a wide age range (6–85 years). An interesting finding from this study was attention appeared to develop at a significantly quicker rate than memory. Vakil and colleagues observed similar parallel developmental courses in two separate studies, one on verbal memory (Vakil et al., 1998) and one on attention (Vakil et al., 2009).

The only subsequent study that has examined the relationship between verbal memory and attention was by Greenstein, Blachstein, and Vakil. (2010). Greenstein et al (2010) who sought to explore the relationships between the development of verbal memory, as measured by the Rey AVLT, and several attention measures. Results further supported the known influence of age and the interrelationship between memory and attention, but also indicated that verbal memory and attention are associated with each other primarily in younger children and significantly less so in older children. Of clinical concern, this study provides support that attention difficulties in younger children may be expressed as memory difficulties, and vice versa, and performance in memory and attentiveness might be predictive of one another in early, but not later, years. Furthermore, specific attention and

verbal memory difficulties may be related to one another (Greenstein et al., 2010), and controlling for attention may affect findings cross group differences. Additionally, controlling for attention may permit the isolation of specific memory functions without the interference of attention.

Many of the studies reviewed have examined cognitive factors, such as intelligence, in trauma victims and people with PTSD. The data for this study include an intelligence measure; however it will not be used as a covariate due to a number of methodological issues as summarized in a paper by Dennis et al. (2011). As the article points out, controlling for factors such as IQ and SES in a population where differences only occur by chance, allows the researcher to adjust for the sample differences and provide an unbiased estimate of population difference in means on the dependent variable. In a maltreated population, however, where the covariate (e.g., SES, IQ) becomes intrinsic to the condition, adjusting for differences in the covariate can lead to overcorrected or anomalous findings (Dennis et al., 2011). By attempting to control for intelligence as measured by the WISC-III, the effects of maltreatment will more than likely be rendered spurious.

Psychopathology (PTSD).

As reviewed, children who are maltreated differ in emotional and behavioral regulation from children who are not maltreated. The research in this section will evidence that a large proportion of children who have been maltreated additionally struggle with behavioral and emotional dysfunctions that can develop into frank psychopathology. For example, children who have been maltreated are at a heightened risk for trauma related psychopathology, including PTSD, major depressive disorders, mood disorders, anxiety disorders, ADHD, substance abuse disorders, and schizophrenia (Zlotnick et al., 1995;

Mullen et al., 1996; McCauley, et al., 1997; Young et al., 1997; Heim & Nemeroff, 2001). In addition to the alterations in attention and cognition caused by child maltreatment, trauma related psychopathology stands to further contribute to a child's ability to make and recall memories. Psychopathology is therefore important to consider due to its potential influence on verbal memory. In particular, PTSD and dissociation are known to contribute to deficits in memory performance in the adult population (Cicchetti & Toth, 2005; Howe, Toth, et al., 2006). It is important to distinguish between groups of children who were maltreated with and without psychopathology in an effort to parse out the unique contribution of maltreatment on memory. In some cases of psychopathology, such as dissociation, the symptoms may mask the deleterious effects of child maltreatment on at least some components of memory.

This study focuses on PTSD due to its proliferation in children who have been maltreated and due to its influence on and association with memory processes. PTSD is a severe anxiety disorder that may develop when an individual is exposed to any event that results in psychological trauma (American Psychiatric Association, 1994). Within the population of traumatized children, PTSD is one of the most common diagnoses (Browne & Finkelhor, 1986). In the United States, Child Protective Services receive approximately 3 million reports a year, which includes more than 5.5 million children (National Center for PTSD, 2008). Research today continues to indicate that children are susceptible to developing PTSD via age-specific features of the disorder.

The history of the development of PTSD as a diagnosis is important to consider when it is attributed to children because it was originally normed on adult males. It was officially recognized in the DSM-III (American Psychiatric Association, 1980) primarily due to the

need for American psychiatry to manage the needs of Vietnam veterans (Brett, 1996). In 1987, psychiatrists officially noted that the diagnostic criteria might not adequately account for children's reactions to trauma. Despite this, within the population of traumatized children, PTSD is one of the most common diagnoses (Browne & Finkelhor, 1986), however, it is unknown how many children who have been maltreated exhibit PTSD symptoms without meeting full diagnostic criteria. For example, compared with adults, children may express more generalized fears and anxiety, avoidance of situations, sleep disturbances, and a preoccupation with words or symbols in general that may be misinterpreted in the context of experiencing trauma (Terr, 1991). They may also demonstrate post-traumatic play (recreating and reproducing the trauma with toys during play) and demonstrate regression or loss of an acquired developmental skill (such as toilet training) (Terr, 1991). Such symptoms are not included as specific diagnostic criteria, although they are concerning and associated with maladaptive responses to chronic stress exposure.

Only a few studies have examined rates of exposure and PTSD in children and adolescents in the general population. A meta-analysis was conducted by the American Academy of Child & Adolescent Psychiatry (AACAP, 2010) to examine the current assessment and treatment procedures for PTSD in children. Results from this analysis indicated 15%-43% of girls and 14%-43% of boys have experienced at least one traumatic effect in their lifetime, and of those children, 3%-15% of girls and 1%-6% of boys meet criteria for PTSD (AACAP, 2010). These rates are higher when collected from at-risk samples, ranging widely from 3%-100%. For example, as many as 100% of children who witness a parental homicide or sexual assault, 90% of sexually abused children, 77% exposed to a school shooting, and 35% of urban youth exposed to community violence develop PTSD

(AACAP, 2010). The severity of PTSD, as experienced by children, has been shown to increase in accordance with the nature of the traumatic event, the parental reaction to the traumatic event, and the temporal proximity to the traumatic event (Pynoos & Nader, 2009; AACAP, 2010). Research also suggests that interpersonal traumas, such as rape and assault, are more likely to result in PTSD then other types of traumas (AACAP, 2010). There is also a relationship between the total number of previous traumas an individual has experienced and PTSD (AACAP, 2010). Research indicates that girls are more likely to develop PTSD than boys. The impact of age at time of exposure is less clear. This result may be due to the fact that PTSD does not present the same in children and adolescents as it does in adults based on current evaluation procedures. Children and adolescents who have experienced trauma are at a higher risk for having problems with school performance (AACAP, 2010). Some children may demonstrate a natural remission in their symptoms of PTSD. For many, however, the symptoms will continue to progress and negatively impact their lives if not treated.

A clinical history of trauma is not always available for children who have been maltreated and a number of PTSD symptoms may easily be misinterpreted as behavior problems, cognitive deficits, or ADHD. Researchers in the field have noted the potential for misdiagnosis and hypothesize that the effects of maltreatment not only impact emotional functioning but cognitive and neuropsychological functioning as well (e.g., De Bellis, 2005; Disseth, 2005; Ford, 2005). Many children who have been abused display symptoms such as intrusion (decreased concentration), hyperarousal and avoidance (decreased motivation to learn). These symptoms have the potential to affect a child's ability to form memories, be successful in school, and generally adapt in a number of developmentally appropriate ways.

PTSD symptoms are diagnostically clustered into three categories that must all be represented in order for a person to meet full diagnostic criteria (i.e., cluster B, intrusive symptoms; cluster C, avoidant symptoms; and cluster D, increased arousal symptoms).

PTSD was originally intended for adult veterans; therefore some children may not meet the full criteria for a diagnosis while still demonstrating a number of concerning PTSD symptoms. There is a growing awareness that "sub-threshold" PTSD (i.e., symptoms below the threshold for the DSM-IV diagnosis) exists and these individuals, who fail to meet all the diagnostic criteria for PTSD, still suffer significant psychosocial impairment (International Consensus Group on Depression and Anxiety, 2003). One of the few empirical studies to compare sub-threshold PTSD to full PTSD found adults in both categories approached similar degrees of work and social dysfunction when compared to symptom free individuals (Stein et al., 1997). With regard to children who have been maltreated, they are less likely to demonstrate cluster C symptoms (avoidant and dissociative symptoms), and thus meet the full PTSD diagnostic criteria (De Bellis, 2001). Furthermore, because children may not meet full criteria for PTSD, consideration should be given to specific symptoms they develop and are attributable to the trauma (Carrion, Weems, Richert, Hoffman, & Reiss, 2010). The number and type of symptoms children who have been maltreated develop may impact their global functioning. In addition to comparing controls with a maltreated group on a measure of verbal memory, the current study examined 1) whether variation in CVLT-C factor scores could be explained by the total number of PTSD symptoms experienced by children who have been maltreated, and 2) whether within the same group of children who had been maltreated, variation in CVLT-C factor scores could be explained by either having a

diagnosis of PTSD, having PTSD symptoms but no diagnosis, or having no PTSD symptoms.

Empirical findings indicate that maltreated individuals, who present with PTSD and other comorbid psychiatric conditions, evidenced significantly greater cognitive impairments than individuals without comorbidity (Barnett et al., 1996). Furthermore, a number of memory disturbances are associated with PTSD in adults, including gaps in memory for everyday events (dissociative amnesia; Bremner, Steinberg, et al., 1993), deficits in autobiographical memory (McNally, Lasko, Macklin, & Pitman, 1994), and an attentional bias for trauma-related material (e.g., Foa, McNally, Kaspi, Riemann, & Zeitlin, 1990; McNeil, Feske, Murdock, Kodak, & McCarthy, 1991; Cassiday, McNally, & Zeitlin, 1992; Bryant & Harvey, 1995; Tucker, Miranda, Lewen, & Nordgren, 1999; Moradi, Taghavi, Neshat-Doost, Yule, & Dalgleish, 2000). Additionally, the DSM-IV indicates that individuals with major depressive disorder, which is common in individuals who have been maltreated, "may appear easily distracted or complain of memory difficulties" (American Psychiatric Association 1994, p 322). Repression and other defensive emotional-regulation processes may work to suppress or avoid disturbing memories. Furthermore, becoming reliant on a defensive strategy may influence memories for non-traumatic events and contribute to the pathological condition of dissociation.

Dissociation is therefore another potential moderator to consider when assessing memories of people who have been traumatized. Dissociation is clinically understood to be a partial or complete disruption of the normal integration of a person's conscious or psychological functioning, in response to some type of trauma, as a way of cognitively distancing one's self from experiences that are too difficult or threatening to process at that

time (Dell & O'Neil, 2009). While dissociation has been a contested diagnosis in the fields of psychology and psychiatry, it is has been diagnostically defined as "the disruption of the usually integrated functions of memory, identity, or perception of the environment" (American Psychiatric Association, 1995, p. 477). Dissociative disruptions are unanticipated and can affect many aspect of a person's functioning. The majority of investigations on memory and maltreatment are done retrospectively and with adults who are asked to recall abuse from their childhood (Howe, Cicchetti, and Toth, 2006). Such investigations have found that adults who reported histories of maltreatment had a higher frequency of false recognition memory errors (inaccurately recognizing words that had not been presented as having been) than did non-maltreated comparison individuals (review see, Howe, Toth, et al., 2006). Clinicians have conceived dissociation as a defensive response but also an adaptive strategy. When it dissociation becomes habitual it may prevent the adequate processing and integration of information (e.g., Koopman, Classen, & Spiegel, 1994).

Compared to adults, there is less information available regarding the memory and learning skills of children and adolescents with PTSD. Based on the adult literature, however, dissociative and maladaptive thoughts and behaviors demonstrated in children who have been maltreated should also be considered potential moderators of neurocognitive ability (Cicchetti & Toth, 2005).

Summary: Covariates Affecting Verbal Memory.

To date only three studies have explored and explicitly discussed verbal memory deficits associated with PTSD in children (Moradi et al., 1999; Beers and De Bellis, 2002; Yasik et al., 2007), despite verbal memory being a neurocognitive area of interest based on the adult trauma literature. While a number of other factors associated with maltreatment

stand to additionally influence verbal memory and adaptive functioning in general, the current study examined the unique contribution of maltreatment on the various components of verbal memory. Covariates such as the number of PTSD symptoms, diagnosis of PTSD, and attention add depth to the understanding of how verbal memory is impacted by the experience of maltreatment. This research sought to contribute to the research aimed at identifying and treating symptoms associated with maltreatment, improving the quality of interventions for working with children who have been maltreated, and furthering the understanding of the cognitive domain of verbal memory as it related to maltreatment in childhood.

Summary and Rationale.

Child maltreatment is an important public health problem that is associated with a range of negative physical and mental health outcomes (MacMillan et al., 1997; McCauley et al., 1997). The chronic nature of maltreatment and its associated stress response leads to aversive neurochemical changes that impact cognitive and neurological functioning in a developing child, and perhaps to a number of pathological conditions such as PTSD. Adult trauma victims with PTSD have demonstrated significant verbal memory impairments related to the stress responses elicited from PTSD. Research indicates that the effects of maltreatment on children are similar to the dysfunction and maladaptive responses demonstrated in adults with PTSD, however, there is little research on PTSD symptoms in children who have been maltreated and their impact on verbal memory. It is therefore critical for clinicians and researchers to consider and study the impact of (non-retrospective) child maltreatment on verbal memory. This study examined maltreatment's overall effect on verbal memory as compared with children who have not been maltreated after controlling for

psychopathology, sociodemographic factors, and selected cognitive abilities (i.e., attention). These factors and their associated measures are outlined in Table 3.1. Subgroups based on maltreatment type as well as PTSD diagnostic groups were examined. While few studies have examined verbal memory in this population, fewer have utilized the CVLT-C, and fewer still have examined the specific components offered by the CVLT-C to distinguish specific verbal memory patterns, deficits, and strategies (e.g., Jenkins et al., 1998; Stein et al., 1999; Beers and DeBellis, 2002; Geuze et al., 2009). This study examined the various components of verbal memory the CVLT-C measures to investigate how and to what extent, if at all, verbal memory is disrupted in children who have been maltreated.

CHAPTER III

METHODS

Participants

The participants for this study come from an NIMH funded study at Duke University titled "Life Events & Childhood Brain Development" (funded under the title "PTSD & Childhood Sexual Abuse: Psychobiology," Principal Investigator: Michael DeBellis). It is a 5-year cross-sectional investigation to examine the psychobiology of childhood posttraumatic stress disorder (PTSD), secondary to child maltreatment. This dissertation examined a portion of the participants from this study through a secondary data analysis. The methods and analyses provided in this dissertation were found to be exempt from IRB approval (see Appendix A). A full description of the full NIMH study is provided in Appendix B.

For the original study, maltreatment status was determined by official state criteria for abuse. Children in this group were recruited from state agencies and mental health clinics that specialize in the assessment and treatment of maltreated children (e.g., Center for Child and Family Health-North Carolina). This dissertation examined children and adolescents who satisfied legal criteria by the Department of Social Services for maltreatment and who were evaluated by the Duke University Heathly Childhood Brain Development/ Developmental Traumatology Research Program staff for PTSD symptoms (N= 91). Participants were included in this study if they had a history of Maltreatment with PTSD or without PTSD, or had no history of maltreatment (N= 96). The sample used for this

dissertation ranged in age from 6.17 to 17.83 and fell within the middle SES using the Hollingshead Two Factor Index of Social Status (see Table 3.1). Intellectual functioning fell within the average range across the entire sample. To reduce bias, the study was advertised to child protective services across the State of North Carolina on a statewide level, and participants who lived more than 75 miles from the research program were given overnight accommodations. Controls were recruited from the same surrounding communities through IRB approved advertisement at schools and pediatric clinics. Table 3.1 provides a summary of the demographic characteristics for the sample used in this study; this table is provided as a reference for significant group differences in Chapter 4 as well.

Table 3.1
Group Differences on Demographics, Attention, and Behavioral Measures

Variable	Control Group mean (*sd*)	Maltreated Group mean (*sd*)	Test Statistic
N	96	91	
Child's Age in Years	12.40 (*2.96*)	11.32 (*3.04*)	F(1,185) = 6.01*
Child's current SES	43.62 (*10.74*)	36.52 (*13.92*)	F(1,185) = 15.35**
%White/Black/Other	53.1/35.4/11.5%	42.9/45.1/12.1%	$\chi^2 = 2.12$
% Male	41.7%	47.3%	$\chi^2 = .59$
Child IQ	108.12 (*14.05*)	95.25(*13.53*)	F(1,185) = 40.64**
CPT Variability Score	49.37(*10.31*)	56.58(*10.71*)	F(1,185) = 21.57**

**p < .05, **p < .01 significance*

Exclusion criteria for both groups included: (1) Full Scale Intelligence Quotient (FSIQ) < 70; (2) disability that made a comprehensive interview of the child difficult; (3) significant medical illness, head injury, or neurological disorder; (4) autism or pervasive developmental disorder; (5) Birth weight under 5 lbs or severe prenatal compromise with NICU stay; (6) current or lifetime alcohol or substance use disorder (defined as DSM-IV abuse or dependence). The local university hospital IRB committee approved the study.

Legal guardians gave informed consent and children assented prior to participation. This dissertation was found exempt from requiring IRB approval, see Appendix A. For full exclusion and inclusion criteria for all subjects and controls, see Appendix B.

The data were compiled into a single working dataset using SAS 9.2 (TS Level 2MO). The resulting SAS dataset was then converted to SPSS format using Circle Systems' Stat/Transfer program. Data analysis was performed using IBM SPSS Statistics release 19.0.0, SAS Version 9.3, and Mplus Version 7. Reports of model fit follow guidelines outlined by MacCallum and Austin (2000) and Hu and Bentler (1999), while effect sizes for path coefficients are reported as partial correlations.

Measures

Trauma-Related Variables.

Kiddie Schedule for Affective Disorders and Schizophrenia- Present and Lifetime Version (K-SADS-PL) (Kaufman et al., 1997). This semi-structured interview was administered with caregivers and subjects. Archival records were also used as sources of information. The KSADS-PL was modified to include information about (1) life event questions, including traumatic events from the Child and Adolescent Psychiatric Assessment (Angold et al., 1995); (2) disorders not present in the KSADS-PL; (3) a structured scale was added to quantify symptom frequency with a minimum score of 0 = no history of a symptom and maximum score of 10 = symptoms present several times a day; and (4) algorithms were created to determine Axis I psychiatric disorders based on DSM-IV criteria. Disorders were assigned a severity score of mild, moderate or severe. The number of PTSD symptoms was obtained from this assessment. Interviewers were individually trained to obtain 80% agreement for PTSD and over 90% agreement for the presence of any lifetime major Axis I

disorder with a board certified child and adolescent psychiatrist and experienced child trauma interviewer (MDDB). Discrepancies were resolved by reviewing archival information (e.g., child protection reports, medical records) or by re-interviewing the child or caregiver. If diagnostic disagreements were not resolved with this method, consensus diagnoses were reached among a child psychiatrist (MDDB) and child psychologist (SRH). Table 3.2 provides a summary of the clinical characteristics of the maltreated children in this sample.

Six categories of maltreatment were provided in the data set. The *failure to supervise* variable was composed of positive responses to seven questions regarding neglect resulting in (a) serious accidents, (b) not knowing child's whereabouts, (c) being left home alone, (d) unexplained school absences, (e) witnessing caregiver using drugs or being drunk, and (g) exposure to inappropriate adult sexual activity. *Failure to provide* was composed of three questions regarding basic physical or medical care. *Physical abuse* was composed of five questions regarding discipline by a caregiver resulting in bruises or serious injury sustained on one or more occasions, being pushed into objects, shaken, burned or being threatened with a deadly weapon. *Witnessing interpersonal violence* was composed of ten questions regarding witnessing or being told about domestic violence, threats involving violence to important attachment figures, threatening or violent crime where significant injury or death occurred or could have occurred, being the victim of serious threats or violent crime not perpetrated by a caregiver, or witnessing family members' explosive behaviors resulting in serious property damage or attempts to hurt themselves. *Emotional abuse* was defined by three questions regarding a caregiver making hurtful comments or swearing at the child or witnessing or hearing about other family members' physical abuse. *Sexual Abuse* was defined by questions regarding isolated incidents of genital fondling, oral sex, or vaginal or

anal intercourse by a person in a caregiver capacity (i.e., incest) (see table 3.2 for means and standard deviations within the maltreated group with regard to clinical characteristics). Of the 91 children in the Maltreated Group, only 13 children demonstrated no PTSD symptoms and 58.3% met DSM-IV criteria for a diagnosis of PTSD. These six original maltreatment variables will be examined to determine the amount of strong positive correlation between them to determine whether the maltreatment variables might be consolidate into fewer factors. Reducing the number of factors may simplify the model and reduce the possibility of multicollinearity.

Table 3.2
Means and Standard Deviations of the Clinical Characteristics for the Maltreated Group

Variable	Mean	*sd*
Total Number of PTSD symptoms	8.56	4.84
Failure to Supervise Neglect Index	2.42	1.84
Failure to Provide Neglect Index	0.67	0.99
Witnessing Interpersonal Violence Neglect Index	3.41	2.18
Physical Abuse Neglect Index	1.31	1.27
Emotional Abuse Neglect Index	1.32	1.00
Sexual Abuse Neglect Index	0.45	0.50

Neuropsychological Variables.

Attention-related functions were assessed using the *Conners' Continuous Performance Test-II* (Conners & MHS, 2000). The CPT-II measures the participant's attention regulation and inhibitory control. The T-scores are included for the errors of commission and variability variables, with each of these scores being reversed such that higher scores reflected better functioning.

Wechsler Intelligence Scale for Children-III (WISC-III) (Wechsler, 1989) and *Wechsler Adult Intelligence Scale- IV (WAIS IV)* (Wechsler, 2008). Participants received the age-appropriate version of the Wechsler scale. Participants between the ages of 6.0 and 16

years 11 months of age, were administered the WISC-III and older children received the WAIS-IV. A two-subtest short-form, comprised of Vocabulary and Block Design, generated an IQ score for both measures.

Verbal Memory Measure.

Verbal memory was measured using the children's version of the California Verbal Learning Test (CVLT-C). The CVLT-C was given in its entirety to all participants in the study, even those who were older than the 16.11 cutoff in order to make results comparable across participants. The CVLT-C is a widely used neuropsychological tool for evaluating verbal memory strategies (Delis, Kramer, Kaplan, & Ober, 1987). The extensive use of the CVLT-C is related in part to it being a portable and easy task to administer that produces a normally and broadly distributed range of results (Longenecker et al., 2010).

Administration entails that a list of 16 words of semantic categories (i.e., spices, tools, fruits, and clothes), each containing four words, is presented orally and then freely recalled; this occurs five consecutive times per administration. The performance metrics include the number of words during the first recall, words recalled during the fifth (final) trial, the improvement between the first and fifth trials, and overall recall across the five trials. The mnemonic strategies employed are categorized by semantic and serial clustering scores. Semantic clustering is operationalized as recall of categorically similar words one after another while serial clustering is defined as the sequential recall of words according to the presentation order. Generally, people who recall the most words employ a semantic clustering technique while those with poor recall tend to rely on serial techniques (Delis, Freeland, Kramer, & Kaplan, 1988). Paulsen et al. (1995) found that the recall strategy

employed by healthy individuals predicted the number of words successfully recalled in the final trial of the CVLT-C, more so than performance on the first trial.

As previously stated, the CVLT-C offers a large number of component scores, which are useful for assessment and evaluation of both quantitative (e.g., number of words recalled) and qualitative (e.g., strategies employed) aspects of verbal memory and recall in individual subjects. While scores on the CVLT-C are clustered in domains, interpretation of the scores remains largely left to theoretical and clinical interpretation, and little is known about the exact constructs underlying the CVLT-C. Delis et al. (1994, 2002) do include the results of a principal components analysis with a varimax rotation on the CVLT-C in the original manual. The authors performed the analysis on the raw scores of 19 variables that yielded a six-component solution (Delis et al., 1994; Delis et al., 2000). Donders (1999) conducted confirmatory factor analyses (CFA) on the CVLT-C and sighted a number of shortcomings to the procedures the authors utilized for creating the six factor scores.

Donders noted three primary drawbacks to the procedure utilized by the test's authors. The first problem was that a principal components analysis is less likely to reflect the underlying theoretical structure of a measure due to the fact that it calculates a linear combination for variables that does not account for the various sources of variance (Gorsuch, 1983; Martin, 1987). The second shortcoming is the authors' use of an orthogonal rotation, which does not account for the correlations between factors. When a single instrument seeks to measure several psychological constructs, there tends to be correlations between constructs as demonstrated by memory tests such as the Wide Range Assessment of Memory and Learning (WRAML-II; Burton et al., 1996). The third weakness noted by Donders is the fact that several of the variables included in the analysis were strongly dependent on the value of

other variables in the group, raising the issues of interdependence and collinearity. Thus, Donders sought to utilize a confirmatory factor analysis, to offer a more objective assessment of the factor structure of the CVLT-C.

Donders' examined six potential models for fit and parsimony and a five-factor model was deemed most parsimonious (Donders, 1999). Donders included the original 920 children from the CVLT-C standardization sample, who were determined to be a representative sample of the population of the United States in terms of race, parental education, and geographic location, with approximately equal distribution in terms of gender and each of 12 age levels. From the many scores that can be obtained from the CVLT-C, Donders included 13 in his investigation (Donders, 1999). A number of variables with available z-scores were excluded if there was interdependency with other variables that were considered stronger measures of the construct, based on previous theoretical support. Scaled z-scores were used in all statistical analyses and Pearson product-moment correlations were obtained for each pair of selected CVLT-C variables that provided the basis for maximum-likelihood structural equations for each hypothetical model using SAS covariance analysis of linear structural equation procedures (CALIS; SAS, 1993). Donders examined four measures of fit and parsimony. It was assumed that lower values of chi-square and Akaike's information criterion (AIC; Akaike, 1987) would reflect better model fit. It was determined a priori that only models with adjusted goodness-of-fit index (AGFI) values > .90, comparative fit index (CFI) values > .90, and parsimonious normed fit index (PNFI) values > .60 would be considered acceptable based on cited research. Six models were evaluated, and the five-factor model was found to provide the best fit in terms of predictive validity, based on the stated criteria. This model provided the best chi-square and AIC values, and all factor

loadings were statistically significant ($p < .001$). The five factors included Attention Span, Learning Efficiency, Free-Delayed Recall, Cued-Delayed Recall, and Inaccurate Recall. All variables had coefficients of .50 or greater, except Semantic Clustering and Middle Region Recall (See Table 3.3). All variables provided a positive correlation with their respective factor except for those making up Inaccurate Recall due to the fact that higher z-scores on those subtests reflect poorer performance.

Table 3.3
CVLT-C Variables and Associated Factors from Donders' CFA (1999)

Factor	CVLT-C Variable (degree of association with Factor)
Attention Span	List A, Trial 1 (.69); List B (.54); Middle Region Recall (.28)
Learning Efficiency	List A, Trial 5 (.93); Semantic Clustering (.27); Recall Consistency (.60)
Free-Delayed Recall	Short-delay free recall (.81); Long-delay free recall (.86)
Cued-Delayed Recall	Short-delay cued recall (.90); Long-delay cued recall (.92); Recognition hits (.55)
Inaccurate Recall	Total Intrusions (.54); Recognition false positives (.78)

Rationale for Methods

Donders (1999) suggests that his findings supporting a five-factor model for interpreting the CVLT-C provide an alternative, more parsimonious, and statistically more robust model of interpretation of the CVLT-C, compared to the principal components analysis in the test manual (Delis et al., 1994). Thus, for this study, the CVLT-C components will be broken down into five domains: Attention Span, Learning Efficiency, Free Delayed Recall, Cued Delayed Recall, and Inaccurate Recall. Inclusion of these components of verbal memory performance as predictors of the latent factors will allow for investigation of the effects of a number of relevant covariates and moderators (e.g., maltreatment subtypes,

number of PTSD symptoms, attention) on a particular recall or error profile. The questions and hypotheses for this study were developed to examine the variables that influence verbal memory in children who have been maltreated, and are based on the prior literature review. The review provides support for considering certain demographic factors, the type of maltreatment experienced, the number and of PTSD symptoms, whether diagnostic criteria was met for PTSD, and the contribution of attention as potential covariates in the analyses.

The following summary provides the support for hypotheses regarding the underlying relationships of the covariates examined in this study. These hypotheses are not necessarily directed specifically at the research questions for this study, but were made to offer some utility to the inclusion of the covariates and their predicted influence on variation in the latent factors.

In terms of the impact of certain demographic factors on verbal memory performance, research that has examined age, maltreatment, and PTSD symptoms has provided mixed findings. Some research has reported traumatic stress to be associated with negative consequences if it occurs during early childhood, others have found that younger children may not show the immediate consequences of maltreatment but develop symptoms over time (especially if the maltreatment continues), and still other studies have suggested that because adolescence is a time of rapid neuronal growth and pruning that maltreatment during this time can have worse consequences than earlier trauma. Younger children may be less likely to exhibit PTSD symptoms due their inability to, relative to adults, necessarily express their experience of trauma. Except in the case of child neglect, very young children may be less likely to have experienced long-term or chronic trauma simply by not having been alive as long as older children and adults. Furthermore, children younger than eight years old may

have a lower level of maturation of the verbal memory subsystem, and a developmental preference to use visual rather than verbal codes (Gathercole & Baddeley, 1993). Older children are more likely to utilize verbal over visual memory coding, but are also more likely to have been exposed to a lengthier period of maltreatment, and consequently developed more PTSD symptomology. While there are potentially complex interactions between age, maltreatment, and verbal memory, it was predicted that the number of symptoms and diagnosis of PTSD would provide the best predictor of verbal memory performance, above the effects of age and the type of maltreatment. With regard to gender, there is evidence that maltreated males with PTSD show more evidence of adverse brain development (De Bellis, & Keshavan, 2003), thus gender could be an important influence to consider in the results of this study. Therefore, it was hypothesized that males with PTSD will have poorer scores on the CVLT-C factors than males without PTSD and females. It was also hypothesized that number of PTSD symptoms will be a better predictor of poorer scores on the outcome measure than race. Studies that have examined the specific effects of maltreatment and poverty have suggested that maltreatment makes a unique contribution to relatively weaker performance on cognitive and academic assessments; therefore it was hypothesized that when controlling for SES, children who have been maltreated and developed PTSD symptoms will have significantly lower scores than those without PTSD symptoms. Overall, it was hypothesized that the existence of PTSD symptoms would provide a measure of the impact of the abuse and explain variance in performance on the CVLT-C above and beyond demographic factors.

A large part of the reviewed literature that has sought to examine the differences in cognitive functioning among people exposed to trauma in conjunction to PTSD

symptomology have broken down the samples into groups of three: those who were exposed to significant trauma and demonstrate no PTSD symptoms; those who developed some symptoms but not enough to meet the diagnostic threshold; and those who met criteria for the diagnosis. While these are somewhat arbitrary or subjective cut-off points, a reason for grouping in this way has to do with interpretive value, as well as diagnostic utility (supporting or not supporting such thresholds). One of the goals of this study was to examine the diagnostic utility of the PTSD diagnosis in children who have been maltreated, therefore, these groups were created in the data set. As previously reviewed, a significant body of prior research has examined PTSD symptomology by categorizing groups based on whether, after experiencing trauma, there were no PTSD symptoms, there were some but not enough to meet diagnostic criteria for PTSD, or diagnostic criteria for PTSD was met. This line of inquiry would contribute to the understanding of whether the PTSD diagnosis is relevant in terms of verbal memory functioning in children.

All types of abuse can lead to aversive outcomes. Co-morbid experiences of abuse are also considered more aversive than experiencing a single form of abuse. This study also sought to examine whether certain types of abuse might contribute to variation in verbal memory performance. With regard to the contribution of attention factors, it was hypothesized that PTSD symptoms would contribute to poorer attention as measured by the CPT. There was support from the literature that verbal memory and attention may be more associated with each other in younger children, and significantly less so than in older children.

The following table outlines how co-factors may potentially contribute to verbal memory performance, and how the co-factors will be measured in this study.

Table 3.4
Influence of Covariates on Verbal Memory and Associated Measures

Co-Variable	Potential Influence	Measures	Research Question
Maltreatment Status	Children who were exposed to maltreatment are more likely to perform worse across a number of psycho-educational domains	Screener and K-SADS	Questions 1 and 2
Maltreatment Subtype	Exposure to different types of maltreatment (i.e., sexual abuse vs. neglect) may impact a child's development	K-SADS	Questions 2, 3, and 4
Sex	Boys are more likely to demonstrate aversive effects of maltreatment	Self-report	Questions 2, 3, and 4
SES	Lower SES correlated with higher levels of neglect and maltreatment	Self-report	Questions 2, 3, and 4
Race	Minority groups more likely to be lower SES	Self-report	Questions 2, 3, and 4
Age	Critical periods of development and length of exposure	Self-report	Questions 2, 3, and 4
Attention	Attention and inhibitory control contribute to memory storage and retrieval	CPT	Questions 2, 3, and 4
# of PTSD symptoms	As # of PTSD symptoms increase, verbal memory performance will be negatively affected	K-SADS	Question 3
PTSD Diagnostic Status	Some participants met full criteria for PTSD, others displayed symptoms but did not meet threshold criteria, others displayed no PTSD symptoms; sought to investigate whether diagnostic status related to performance	K-SADS	Question 4

In light of a review of the existing research and the Donders' factor analysis of the CVLT-C, the following sections outline the plan for data analyses related to the research questions, hypotheses, and associated data analyses.

Data Analysis

Preliminary Data Preparation and Analysis.

Data were first screened for missing items, demographic information was summarized through descriptive statistics, and the two groups were examined for significant differences on the observable variables using an ANCOVA. Dummy variables were coded

for sex, race, and PTSD diagnostic ("dx") status. For sex, males were coded as 1 and females were 0. For race, whites served as the reference group: Race1= African Americans compared to whites, Race2 = Asians compared to whites, and Race3 = all other races compared to whites. There were no Asians who had been maltreated in this sample, therefore in the research questions examining the maltreated only group there are only two races coded (i.e, Race1 and Race3). For the diagnostic status, having no PTSD symptoms ("No Symptoms") was the reference group for both those children who had some PTSD symptoms but did not meet full diagnostic criteria for PTSD ("PTSD Symptoms, no Dx") and those children who met criteria for PTSD ("PTSD Dx"). As a form of data reduction, a CFA was run on the six types of maltreatment and two factors were generated and coded as "General Maltreatment" and "Sexual Abuse."

The 13 component scores that made up the five factors Donders proposed were standardized (z-scores), and reverse z-scores were generated for the Inaccurate Recall scores as to allow for easier interpretation of results. All scores can therefore be interpreted as lower scores indicating poorer performance, whereas previously higher scores on Inaccurate Recall were indicative of declining performance (i.e., *more* inaccurate recall). Factor scores for the latent variables were generated in the CFA that included the full sample of children (maltreated and control groups). These factor scores were used throughout the remaining research questions.

Hypotheses and Data Analysis for each Research Question

Research Question 1. Is verbal memory significantly different in children who have experienced maltreatment than matched controls as measured by the CVLT-C? This question will be addressed by controlling for selected demographic variables (i.e., age,

socioeconomic status, sex, and race) and other covariates (e.g., attention, intelligence) as needed.

Hypothesis Associated with Research Question 1. After controlling for other potential covariates, it was predicted that verbal memory performance in children who had been maltreated would be significantly lower than the children who had not been maltreated. The Total Recall Score was used as the basis for comparison between the groups, as it is the best overall measure verbal memory provided by the CVLT-C.

Data Analyses Associated with Research Question 1. After preliminary analyses and data screening, an ANCOVA was run on the two groups to compare the control group's performance with the maltreatment group's performance on the overall measure of verbal memory performance, as measured by the CVLT-C Total Score.

Research Question 2. Do children who have been maltreated perform differently on specific factors of the CVLT-C (i.e., Attention Span, Learning Efficiency, Free-Delayed Recall, Cued-Delayed Recall, and Inaccurate Recall) than the matched control group?

Hypothesis Associated with Research Question 2. After controlling for other potential covariates, it was predicted that children who had been maltreated would perform significantly lower across the Attention Span, Free-Delayed Recall and Cued-Delayed Recall, Learning Efficiency, and Inaccurate Recall factors of verbal memory performance compared to those children who have not been maltreated.

Data Analyses Associated with Research Question 2. Structural Equation Modeling (SEM) using MIMIC (Multiple Input and Multiple Cause) was used to answer this question. The Control group was compared with the Maltreatment group across the five factors from the CVLT-C component scores: Attention Span, Learning Efficiency, Cued-Delayed Recall,

Free-Delayed Recall, and Inaccurate Recall. SEM was utilized in order to explicitly separate the covariance of items based on common influence by the latent variables. Model fit was examined as well as the extent to which the two groups differed on the latent variables; as well as the degree to which the other fixed variables (e.g., demographics) influenced variation the latent variables (Attention Span, Learning Efficiency, Cued-Delayed Recall, Free-Delayed Recall, and Inaccurate Recall).

Research Question 3. Within the sample of children who had been maltreated, how do the number of PTSD symptoms a child exhibits contribute to verbal memory performance on the factors of the CVLT-C above and beyond the specific covariates of attention (Conners' CPT Variability), trauma type (i.e., Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Hypothesis Associated with Research Question 3. After controlling for potential covariates, it was predicted that the more PTSD symptoms a child who has been maltreated displayed, the lower their scores would be across the five latent factors of the CVLT-C.

Data Analyses Associated with Research Question 3. SEM was used to analyze this question. A full model including all predictors, covariates, and latent variables (Attention Span, Free-Delay Recall, Cued-Delay Recall, Learning Efficiency, and Inaccurate Recall) was examined in order to identify significant sources of variance on the latent factors and to assess overall model fit with regard to the five latent factors and their proposed predictors.

Research Question 4. Within the sample of children who had been maltreated, how do the three diagnostic categories of either having no PTSD symptoms, exhibiting PTSD symptoms but not meeting criteria for diagnosis, and meeting diagnostic criteria for a PTSD diagnosis contribute to variance in performance on the CVLT-C factors above and beyond

the covariates of attention (Conner's CPT Variability), trauma type (i.e., Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Hypothesis Associated with Research Question 4. After controlling for other potential covariates, it was predicted that children with PTSD symptoms would demonstrate lower scores on the five latent factors of the CVLT-C than children who had not developed PTSD symptoms. Furthermore, it was predicted that children who had PTSD symptoms but did not meet diagnostic criteria for PTSD would demonstrate higher scores on the latent factors compared to the children had been diagnosed with PTSD. As a follow-up to Research Question 3, this question sought to investigate whether diagnostic status was related to deficits in verbal memory performance, as it has been found to be in adult populations (e.g., Vasterling et al., 1997; Saigh et al., 2006).

Data Analyses Associated with Research Question 4. SEM and MIMIC modeling were used to analyze this question. A full model including all predictors, covariates, and latent variables (Attention Span, Free-Delay Recall, Cued-Delay Recall, Learning Efficiency, and Inaccurate Recall) was examined in order to identify significant sources of variance on the latent factors and to assess overall model fit with regard to the five latent factors and their proposed predictors. Dummy variables were created to separate the PTSD symptom categories into three groups: the presence of "no PTSD symptoms" was coded as a zero, "PTSD symptoms but no diagnosis" was coded as a one, and "symptoms with PTSD diagnosis" was coded as a two. The diagnostic categories were specifically examined to ascertain their unique contribution to variation in the latent variables.

CHAPTER IV

RESULTS

Preliminary Analyses

The data were screened and examined for any missing items. Very few data were missing, and because of this it was impossible to infer a pattern or relationship among the data that were missing. Therefore all missing data were treated as values that were "missing at random." Upon examination of histograms and the Shapiro-Wilk W Test, it was determined that the data were not normally distributed. Therefore a robust maximum likelihood estimator (MLR) was used to model the data while maintaining optimal type I error rates and to provide more accurate standard errors for data that are non-normal than full information maximum likelihood estimation (Yuan & Bentler, 2000).

The final groups consisted of 96 children who served as controls, and 91 children who had been maltreated. The number of observations varies slightly from model to model depending on the structure of each model and the data the program selects to estimate a solution. The ages of the participants ranged from 6.92-17.50 years-old for the control group and from 6.17-17.25 years-old for the Maltreatment group. Before investigating the specific research questions for this project, both samples were examined for group differences. As expected, the two groups were significantly different in terms of SES, full scale IQ, and attention (as measured by the CPT) (See Table 4.1). The two groups were not significantly different in terms of average age, gender, and race (see Table 4.1**).** Dummy

variables were constructed to compare sex, gender, race and PTSD diagnostic status groups. Additionally, prior to engaging in statistical analyses, all CVLT-C scores were standardized in order to make their examination more straightforward.

Table 4.1
Group Differences on Demographics, Attention, and Behavioral Measures

Variable	Control Group mean (*sd*)	Maltreated Group mean (*sd*)	Test Statistic
N	96	91	
Child's Age in Years	12.40 (*2.96*)	11.32 (*3.04*)	F(1,185) = 6.01*
Child's current SES	43.62 (*10.74*)	36.52 (*13.92*)	F(1,185) = 15.35**
%White/Black/Other	53.1/35.4/11.5%	42.9/45.1/12.1%	$\chi^2 = 2.12$
% Male	41.7%	47.3%	$\chi^2 = .59$
Child IQ	108.12 (*14.05*)	95.25(*13.53*)	F(1,185) = 40.64**
CPT Variability Score	49.37(*10.31*)	56.58(*10.71*)	F(1,185) = 21.57**

**p < .05, **p < .01 significance*

Structural Equation Modeling (SEM), specifically using MIMIC (Multiple Input and Multiple Cause) modeling, was used to examine model fit and theoretical relationships between predictor variables, latent variables, and indicators. SEM allows for the construction of latent variables that are not measured directly but can be estimated by measured variables that are thought to underlie or tap into the variability in the latent variable. MIMIC is a type of SEM; chosen because it provides a good way to determine which covariates have direct effects, allows for examination of differences in intercepts and factor means, and is more practical for smaller samples compared to multiple group analysis.

For this study, Donders' (1999) CFA provided the basis for the proposed factor structure: the indicators are the 13 CVLT-C scores and the latent variables are the five factor scores (i.e., Attention Span, Free-Delay Recall, Cued-Delay Recall, Learning Efficiency, and Inaccurate Recall). SEM separates the covariance of the CVLT-C scores due to the common

influence of the factor score, while additionally taking into consideration the sources of variance from other factors. This separation of variation allows for relationships between the underlying constructs of interest to be more accurately understood and modeled. One assumption of SEM is that data are normally distributed across each variable (Bowen & Guo, 2012).

In order to avoid a complex model in which both type of abuse and number of maltreatment reports were included as predictors, the possibility that certain types of abuse tend to co-occur due to an underlying abuse type factor was examined. That is, individuals who maltreat children in some ways are likely to abuse them in other ways as well, while refraining from certain other types of abuse. Two models for grouping abuse type were identified, a priori, in order to determine whether the categories of abuse might be simplified for this research study. The first model was based on past research that suggested grouping maltreatment by two categories of "general maltreatment" (i.e., children who experienced all forms of abuse except for sexual abuse) and "sexual abuse" (i.e., children who were exposed to sexual abuse, and other forms of abuse as well) was described in De Bellis, Hooper, Woolley, & Shenk, 2010 and the same method was used here. This prior work utilized a principal components analysis approach rather than a factor analysis, and therefore did not directly test this hypothesis. A model testing this hypothesis was fit to the data for this study, in addition to an alternative hypothesis where "direct forms of abuse" (e.g., sexual abuse, physical abuse, and emotional abuse) versus "abuse by proxy" (e.g., witnessing interpersonal violence, failure to supervise, failure to provide) were predicted to co-occur (e.g., Moylan et al., 2010; Herrenkohl et al., 2008).

Both models demonstrated adequate model fit. The model using "general maltreatment" versus "sexual abuse" provided the following fit indices: $\chi^2(9) = 13.01$, $p = .162$, *CFI* = 0.98, *SRMR* = .05, *RMSEA* C. I. = .000 - .105. The model using "direct forms of abuse" versus "abuse by proxy" provided the following fit indices: $\chi^2(8) = 12.82$, $p = .118$, *CFI* = 0.97, *SRMR* = .05, *RMSEA* C. I. = .000 - .115. Because these two models are not nested, chi square difference testing cannot be used to compare these hypotheses. Rather, AIC and BIC statistics were used to examine which model provided a better fit to the data estimates (Akaike, 1973; Sakamoto, Ishiguro, Kitagawa, 1986). Because both the AIC (2760.087 versus 2758.087) and the BIC (2820.541 versus 2815.359) were lower for the general versus sexual maltreatment hypothesis, this theory was used to group maltreated participants into abuse types. In the final model, children were scored as either having undergone general maltreatment (i.e., children who experienced all forms of abuse except for sexual abuse) and/or sexual abuse (i.e., children who were exposed to sexual abuse, and other forms of abuse as well) . For Research Questions 3 and 4, only the children who were maltreated were included in the analysis in order to examine within group differences.

In order to assess model fit, four fit indices were considered. The Chi-Square statistic indicates the magnitude of discrepancy between the sample and fitted covariance matrices. It assumes multivariate normality and deviations from normality may lead to model rejections even when the model is properly specified (McIntosh, 2006). In small samples, the Chi-Square lacks the ability to discriminate between good and poor fitting models due to relative power (Kenny & McCoach, 2003). A good model fit would provide a statistically non-significant result at a 0.05 threshold (Barrett, 2007). The Root Mean Square Estimate of Approximation (RMSEA) provides an assessment of how well the model would fit the

population's covariate matrix, assuming the parameter estimates are unknown but well chosen (Byrne, 1998). The RMSEA confidence interval should include 0.05 in order to be indicative of an acceptable model fit. Additionally, narrower confidence intervals are indicative of how precise the estimate is. A number of the models in this analysis produced either too wide or too narrow confidence intervals than what researchers might consider ideal (e.g., wider than .05-.07, so narrow as to not include .05), and these models should be interpreted with some caution in terms of generalizability. The Standardized Root Mean Square Residual (SRMR) is the square root of the difference between the residuals of the sample covariance matrix and the hypothesized covariance model. Hu and Bentler (1999) state that an SRMR below .05 is supportive of good model fit. The Comparative Fit Index (CFI) (Bentler, 1990) makes up the Incremental Index and performs well even if the sample size is small (Tabachnick & Fidell, 2007). A CFI value of 0.90 or higher is desirable (Hu & Bentler, 1999).

All covariance structure modeling was conducted using Mplus Version 7. In order for the models to be identified, the first factor loading was always set to one. Occasionally, Heywood cases occurred (when a model produces a negative residual variance); this was dealt with by setting the variance parameters to .01 in order to force the variance to be positive, but still very small (Dillon, Mulani, Kumar, 1987). In this study, Heywood cases likely arose from the relatively small sample size. These parameters are not testable because they have been assigned a value.

For Research Questions 3 and 4, a single model including all predictors, covariates, and latent factors was initially run in order to provide a full overview of potential sources of variation. When the five latent variables were included in a single model with all of the

predictors and covariates, however, the model displayed poor model fit and became exceptionally complex. Additionally the standard errors in models using small samples and maximum likelihood estimators tend to be biased upward, resulting in an increased number of type II errors (Hart & Clark, 1999). Bentler and Yuan (1999) also noted that a number of model fit indices do not perform adequately in this situation, leading to questions concerning the actual fit of the model. As a result of the poor model fit and biased standard errors, an exploratory analysis aimed at simplifying the model while still maintaining its authenticity was embarked upon. One potential way to improve the over-complexity was to identify covariates in the full model that were not making a significant contribution to the variance in the latent factors. The model was subsequently re-run after removing the covariates that were non-significant, except for the ones of substantive interest pertaining to the research questions (i.e. Total PTSD Symptom count and PTSD Diagnostic Status). While the fit indices were only somewhat improved, this was deemed the best way to obtain estimates of the regression paths in order to test the hypotheses for Research Questions 3 and 4.

Analysis and Results

Research Question 1. Is verbal memory significantly different in children who have experienced maltreatment than matched controls as measured by the CVLT-C? This question will be addressed by controlling for selected demographic variables (i.e., age, socioeconomic status, sex, and race) and other covariates (e.g., attention, intelligence) as needed.

Analysis and Results for Research Question 1. A one-way analysis of covariance was conducted to answer this research question (ANCOVA). The independent variable was group membership (i.e., Maltreated or Control), the dependent variable was the total score on

the CVLT-C, and the covariates were socioeconomic status and attention (the variables that were statistically significantly different between the groups). A preliminary analysis to test the assumptions of an ANCOVA indicated that the relationships between the covariates and the dependent variable did not differ significantly as a function of the independent variable: attention $F(1, 183) = .82$, $p > .05$ and socioeconomic status $F(1, 183) = 1.89$, $p > .05$. The ANCOVA was significant $F(1, 183) = 19.12$, $p < .001$ (see Table 4.2). Overall 12.31% of the total variance on the CVLT-C total score was accounted for by group membership ($R^2 = .12$).

Table 4.2
Analysis of Co-Variance for Total CVLT-C score by Group Membership

Source	*SS*	*Df*	*MS*	*F*	*P*
Group	1615.99	1	1615.99	19.12	<.0001
SES	109.39	1	109.39	1.29	.257
Attention	146.42	1	146.42	1.73	.191
Group*SES	159.55	1	159.55	1.89	.171
Group*Attention	69.29	1	69.29	.82	.366
Error	14958.66	177	84.51		
Total	17059.31	182			

The results indicated that the Control group (average score of 55.51) performed statistically significantly better on the Total score for the CVLT-C compared to the Maltreatment group (average score of 50.52). This was in accordance with the hypothesis associated with the first research question of this study.

Research Question 2. Do children who have been maltreated perform differently on specific factors of the CVLT-C (i.e., Attention Span, Learning Efficiency, Free-Delayed Recall, Cued-Delayed Recall, and Inaccurate Recall) than the matched control group?

Analysis and Results for Research Question 2. Donders' 1999 Confirmatory Factor Analysis derived five factors from the CVLT-C component scores: Attention Span, Learning

Efficiency, Cued-Delayed Recall, Free-Delayed Recall, and Inaccurate Recall. A CFA was run in order to determine whether Donders' factors could be supported by the data in this study and to compare the two groups on the five factors.

The CFA exhibited an adequate fit with regard to the aforementioned fit indices, except for the chi-square, which was significant: $\chi^2(63) = 112.65$, $p < .001$, *CFI* = 0.94, *SRMR* = 0.05 and *RMSEA* confidence interval (C. I.) = 0.045 - 0.084. The MIMIC model indicated significant group differences across the five factors (see results in Table 4.3). Children who had been exposed to maltreatment performed significantly below than those children who had not been maltreated.

When combined, all of the predictors in the model explained a significant portion of the variance in two latent variables: 11% of the variance in Cued-Delay Recall ($R^2 = .11$, $p < .05$) and 8.6% of variance in Free-Delay Recall ($R^2 = .09$, $p < .05$).

Table 4.3
Standardized Model: Group Membership on Latent Variables

	Estimate
Attention Span by	
Middle Region Recall	0.40***
List A, Trial 1	0.65***
List B	0.56***
Learning Efficiency by	
Recall Consistency	0.62***
List A, Trial 5	0.84***
Semantic Clustering	0.17^{+}
Cued-Delay Recall by	
Short-delay cued recall	0.95***
Long-delay cued recall	0.85***
Recognition hits	0.46***
Free-Delay Recall by	
Long-delay free recall	0.92***
Short-delay free recall	0.86***
Inaccurate Recall by	
Total Intrusions	0.52***
Recognition false positives	0.66***
Attention Span on Group	-0.34***

Learning Efficiency on Group	-0.30***
Cued-Delay Recall on Group	-0.33***
Free-Delay Recall on Group	-0.29***
Inaccurate Recall on Group	-0.31**
R Square	
Attention Span	0.12^{+}
Learning Efficiency	0.09^{+}
Cued-Delay Recall	0.11*
Free-Delay Recall	0.09*
Inaccurate Recall	0.10

Note. All significance tests are 2-tailed.
$^{+}$*<0.1, *p < .05, **p < .01, ***p < .001*

Research Question 3. Within the sample of children who had been maltreated, how do the number of PTSD symptoms a child exhibits contribute to verbal memory performance on the factors of the CVLT-C above and beyond the specific covariates of attention (Conners' CPT Variability), trauma type (i.e., Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Analysis and Results for Research Question 3. A Multiple Indicator Multiple Causes (MIMIC) model was used to analyze this question. Non-significant covariates, excluding Total PTSD Symptoms, were removed based on the full, but overly complex, model's results. For this question it was predicted that Total PTSD Symptoms would be a significant contributor to variation in scores on the latent variable: that the more symptoms a child manifested the lower their scores would be on the latent variables.

The model for Total PTSD Symptoms, with non-significant variables excluded, exhibited marginal model fit (i.e., the chi-square was significant at the .05 level and the SRMR was larger than desirable): $\chi^2(118) = 153.90$, $p = .015$, *CFI* = 0.92, *SRMR* = .08, *RMSEA* C. I. = .027- .082. The model should be interpreted with some caution due to the inconsistent fit across these indices. The hypothesis associated with this question, that the more PTSD symptoms a child displayed the worse their overall performance would be on the

latent factor scores, was not supported. The following describes each of the five latent factors' sources of variance explained by the model.

Sex, FSIQ, and PTSD symptom count were found to be statistically significant contributors to the latent factor of Attention Span (see Table 4.4). The contribution of an increasing number of PTSD symptoms had a positive rather than negative effect on Attention Span. When all other variables were held constant, being a male predicted a .41 standard deviation decrease in Attention Span compared to being a female, for every standard deviation increase in FSIQ a .38 standard deviation increase in Attention is predicted, and standard deviation increase in PTSD symptomology was predictive of a .32 standard deviation *increase* on Attention Span (Table 4.4). All of the predictors and covariates combined explained a statistically significant 36% portion of the variance in Attention Span.

Child's FSIQ was the only significant predictor of the Free-Delay Recall latent factor. For every standard deviation increase in FSIQ an increase of .17 standard deviations on the Free-Delay Recall factor score was predicted. These results do not support the hypothesis that the number of PTSD symptoms a child displays were a significant predictor of performance on the Free-Delay Recall factor score (Table 4.4). The R^2 was not statistically significant, indicating that all the predictors in the model combined are not significantly contributing to variation in scores on the Free-Delay Recall variable.

A child's age was the only significant predictor of the Cued-Delay Recall factor score (Table 4.4). For every standard deviation increase in a child's age, an increase of .13 standard deviations on the Cued-Delay Recall factor score was predicted when holding all other variables constant. These results do not support the hypothesis that Total PTSD symptoms were a significant predictor of performance on the Cued-Delay Recall factor score. The R^2

was not statistically significant, indicating that all the predictors in the model combined are not significantly contributing to variation in scores on the Cued-Delay Recall variable.

None of the predictors and variables included in the model were found to make a significant contribution to predicting performance on the Learning Efficiency factor score, including the hypothesized Total PTSD Symptom count (Table 4.4). The R^2 was not statistically significant, again suggesting that the sources of meaningful variation in Learning Efficiency were not accounted for by this model.

A child's FSIQ and type of abuse factor score were found to be significant predictors of the latent factor of Inaccurate Recall. Total PTSD Symptoms were not a significant predictor (Table 4.4). Holding all other variables constant, for every standard deviation increase in FSIQ, the model predicted a .35 standard deviation increase in performance on Inaccurate Recall, and children who fell into the Sexual Abuse category were predicted to perform .36 standard deviations above those who fell into the General Maltreatment category. The R^2 was not statistically significant, again suggesting that the sources of meaningful variation in Inaccurate Recall were not accounted for by this model.

Table 4.4
Standardized Model: Total PTSD Symptoms

	Parameter Estimate
Attention Span by	
List A, Trial 1	0.67***
List B	0.46***
Middle Region Recall	0.18
Free-Delay Recall by	
Long-delay free recall	0.89***
Short-delay free recall	0.89***
Cued-Delay Recall by	
Short-delay cued recall	0.94***
Long-delay cued recall	0.82***
Recognition hits	0.49***
Learning Efficiency by	
Recall Consistency	0.53***

List A, Trial 5	0.87***
Semantic Clustering	0.14
Inaccurate Recall by	
Total Intrusions	0.35*
Recognition false positives	0.73**
Attention Span on	
Sex	-0.41***
Age	0.11
SES	0.18^{+}
FSIQ	0.38*
PTSD Total Symptoms	0.32**
Cued Delay Recall on	
Age	0.13*
FSIQ	0.14
PTSD Total Symptoms	0.01
Free Delay Recall on	
Sex	-0.09
FSIQ	0.17*
PTSD Total Symptoms	-0.07
Learning Efficiency on	
PTSD Total Symptoms	-0.09
Inaccurate Recall on	
FSIQ	0.35**
Sexual Abuse	0.36*
PTSD Total Symptoms	0.10
R Square	
Attention Span	0.36*
Free Delay Recall	0.03
Cued Delay Recall	0.04
Learning Efficiency	0.01
Inaccurate Recall	0.20

Note. All significance tests are 2-tailed.
*+p≤0.1, *p ≤.05, **p ≤.01, ***p ≤ .001*

Research Question 4. Within the sample of children who had been maltreated, how do the three diagnostic categories of either having no PTSD symptoms, exhibiting PTSD symptoms but not meeting criteria for diagnosis, and meeting diagnostic criteria for a PTSD diagnosis contribute to variance in performance on the CVLT-C factors above and beyond the covariates of attention (Conner's CPT Variability), intelligence (FSIQ), trauma type (i.e.,

Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Analysis and Results for Research Question 4. A Multiple Indicator Multiple Causes (MIMIC) model was used to analyze this question. Non-significant covariates, excluding PTSD Diagnostic Status, were removed based on the results from the original full model. The results did not support the hypothesis that children with a PTSD diagnosis would score significantly lower scores on the five latent variables than the children with PTSD symptoms but no diagnosis and children with no PTSD symptoms.

The model for PTSD Diagnostic Status with non-significant variables excluded exhibited marginal model fit (i.e., the chi-square was significant at the .05 level and the SRMR was larger than desirable): $\chi^2(126) = 161.03$, $p = .02$, *CFI* = 0.92, *SRMR* = .07, *RMSEA* C. I. = .024 - .079. The model should be interpreted with some caution due to the inconsistent fit across these indices. The following describes each of the five latent factors' sources of variance explained by the model.

The Attention Span factor was the only factor where PTSD diagnostic status was found to make a significant contribution to variance; however, it was not in the way that was hypothesized. Children with PTSD symptoms but no diagnosis were found to perform .39 standard deviations better than children with no symptoms, and children with a PTSD diagnosis were not found to perform statistically significantly differently from children with no symptoms on the Attention Span factor (Table 4.5). Sex and IQ were found to make significant contributions to variance on this factor. Holding all other variables constant, being a male predicted a .44 standard deviation decrease in Attention Span compared to being a female and for every standard deviation increase in FSIQ a .37 standard deviation increase in

Attention Span was predicted. The R^2 was not statistically significant, suggesting that the sources of meaningful variation in Attention Span were not accounted for by this model.

For the Free-Delay Recall factor, a child's intelligence was found to be the most significant predictor in this model. For every standard deviation increase in FSIQ a .18 standard deviation increase in Free-Delay Recall was predicted. These results do not support the hypothesis that PTSD diagnostic status would be a significant predictor of performance on the Free-Delay Recall factor score. The R^2 was not statistically significant, suggesting that the sources of meaningful variation in Free-Delay Recall were not accounted for by this model.

Holding all other variables constant, age was the only predictor found to be significant of scores on the latent factor for Cued-Delay Recall; the hypothesized groupings by diagnostic status were not (Table 4.5). A single standard deviation increase in age was predictive of a .12 standard deviation increase in Cued-Delay Recall. The R^2 was not statistically significant, suggesting that the sources of meaningful variation in Cued-Delay Recall were not accounted for by this model.

None of the predictor variables, including the hypothesized groupings by diagnostic status were predictive of Learning Efficiency (see Table 4.5). The R^2 was not statistically significant, again suggesting that the sources of meaningful variation in Learning Efficiency were not accounted for by this model.

The Inaccurate Recall factor score was significantly impacted by the child's FSIQ, and Abuse Type categorization. When all over variables were held constant, for every standard deviation increase in FSIQ the model predicted a .36 standard deviation increase on performance on Inaccurate Recall, and children who fell into the Sexual Abuse category were

predicted to perform .39 standard deviations above those who fell into the General Maltreatment category. The hypothesis that PTSD diagnostic status would be a significant predictor of variation in Inaccurate Recall was once again not supported by this model. The R^2 was not statistically significant, again suggesting that the sources of meaningful variation in Inaccurate Recall were not accounted for by this model.

Table 4.5
Standardized Model: PTSD Diagnostic Status

	Parameter Estimate
Attention Span by	
List A, Trial 1	0.68***
List B	0.46***
Middle Region Recall	0.17
Free-Delay Recall by	
Long-delay free recall	0.89***
Short-delay free recall	0.90***
Cued-Delay Recall by	
Short-delay cued recall	0.94***
Long-delay cued recall	0.82***
Recognition hits	0.49***
Learning Efficiency by	
Recall Consistency	0.53***
List A, Trial 5	0.87***
Semantic Clustering	0.13
Inaccurate Recall by	
Total Intrusions	0.37*
Recognition false positives	0.69***
Attention Span on	
Sex	-0.44***
Age	0.09
SES	0.11
FSIQ	0.37*
PTSD Symptoms, No Dx	0.39*
PTSD Dx	0.34^{+}
Cued Delay Recall on	
Age	0.12*
FSIQ	0.15^{+}
PTSD Symptoms, No Dx	0.15
PTSD Dx	0.09
Free Delay Recall on	
Sex	-0.09

FSIQ	0.18*
PTSD Symptoms, No Dx	0.24^{+}
PTSD Dx	0.07
Learning Efficiency on	
PTSD Symptoms, No Dx	0.06
PTSD Dx	-0.12
Inaccurate Recall on	
FSIQ	0.36**
Sexual Abuse	0.39*
PTSD Symptoms, No Dx	0.17
PTSD Dx	0.15
R Square	
Attention Span	0.34^{+}
Free Delay Recall	0.07^{+}
Cued Delay Recall	0.05
Learning Efficiency	0.03
Inaccurate Recall	0.23

Note. All significance tests are 2-tailed.
$^{+}\leq 0.1$, $^{*}p \leq .05$, $^{**}p \leq .01$, $^{***}p$ .001

Summary of Results

Significant group differences were found between the Maltreated and Control groups of children in terms of both overall performance on the CVLT-C and across the five latent variables. The hypotheses regarding differences within the Maltreated group, in terms of the contribution of variance made by PTSD Total Symptom count and PTSD Diagnostic Status on the latent variables, were not supported. The model fit indices were often inconsistent, and therefore generalizability of these results should be done cautiously. The models produced for Research Questions 3 and 4 indicated that all of the accumulated predictors were not accounting for a significant portion of the variation in the latent variable. This suggests that sources of variation were not accounted for by these models, or that the latent variable was not adequately constructed. The following chapter will discuss results and implications of these findings.

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CHAPTER V

DISCUSSION

The primary goal of this investigation was to establish whether exposure to maltreatment in childhood has a significant and negative impact on verbal memory performance as measured by the CVLT-C. Based on previous research, it was hypothesized that the children in this sample who had been maltreated would differ significantly from a control group. This hypothesis was supported through this research. Because the CVLT-C provides 32 component scores, an investigation into whether they could be simplified into indices or factors seemed warranted. Donders' (1999) study provided a CFA that generated five latent factor scores that he labeled Attention, Cued-Delay Recall, Free-Delay Recall, Learning Efficiency, and Inaccurate Recall. Through a CFA, it was found that this model adequately fit the current sample as well. This is the first study to replicate his findings and investigate group differences among these factors. In addition to the Total score of the CVLT-C, there were significant group differences between the children who were maltreated and the controls across all five latent factors.

The remaining research questions centered around whether there were within group differences on the factor scores among the children who were maltreated with regard to PTSD symptomology. To date there have been no other studies on children who have been maltreated that have looked exclusively at within group differences in terms of the accumulation of PTSD symptoms and the role of diagnostic status on verbal memory

performance. These hypotheses were not supported by the findings from this study; neither Total PTSD Symptom count nor PTSD Diagnostic Status was found to be a statistically significant predictor of variance in the latent variables. While factors such as target population (one that is not normally distributed and not representative of the population the CVLT-C was initially normed on), sample size, model fit, and validity of latent variables may have contributed to the overall lack of statistically significant findings, some interesting findings emerged from this study. Not surprisingly, FSIQ was found to be a significant predictor of performance in all latent variables except for Learning Efficiency, which had no significant predictors and was the weakest factor in both this study and in Donders' (1999). Sex, age, abuse type, and PTSD Total Symptoms or PTSD Diagnostic Status made significant contributions to variation on specific latent factor scores. The Attention Span model provided the richest amount of information, followed by Inaccurate Recall.

The text below describes the results of this study's analysis and discusses the extent to which the results relate to each of the previously postulated hypotheses. A discussion of the results, the limitations of this study, and potential future research are also provided in the text below.

Interpretations for Research Questions 1-4

Research Question 1. Is verbal memory significantly different in children who have experienced maltreatment than matched controls as measured by the CVLT-C? This question will be addressed by controlling for selected demographic variables (i.e., age, socioeconomic status, sex, and race) and other covariates (e.g., attention, intelligence) as needed.

Hypothesis Associated with Research Question 1. After controlling for other potential covariates, it was predicted that verbal memory performance in children who had been maltreated would be significantly lower compared to those children who have not been maltreated. The Total Recall Score was compared between groups, as it is the best overall measure of short-term verbal memory provided by the CVLT-C.

This hypothesis was supported by the data in this study. Statistically significant group differences were found between those children who were maltreated compared to those who were not. This finding provides further support for research that examined various aspects of cognitive and academic functioning between children who have been maltreated and their non-maltreated peers (e.g., Barahal, Waterman, & Martin, 1981; Perry, Doran, & Wells, 1983; Hoffman-Plotkin & Twentymann, 1984; Perez & Widom, 1994; Porter et al., 2005; Saigh, Yasik, Oberfield, Halamandaris, & Bremner, 2006; Nolin & Ethier, 2007; De Bellis, 2009); as well as an addition to the sparse literature specifically examining group differences in verbal memory in children who have and have not been exposed to maltreatment (Moradi et al., 1999; Beers & De Bellis, 2002; Yasik et al., 2007).

Research Question 2. Do children who have been maltreated perform differently on specific factors of the CVLT-C (i.e., Attention Span, Learning Efficiency, Free-Delayed Recall, Cued-Delayed Recall, and Inaccurate Recall) than the matched control group?

Hypothesis Associated with Research Question 2. After controlling for other potential covariates, it was predicted that children who had been maltreated would perform significantly lower across the Attention Span, Free-Delayed Recall and Cued-Delayed Recall, Learning Efficiency, and Inaccurate Recall factors of verbal memory performance compared to those children who have not been maltreated.

This hypothesis was supported. In terms of model fit, Learning Efficiency was the only latent variable with an indicator (Semantic Clustering) that was statistically non-significant. Donders'1999 study also found that Semantic Clustering had the weakest degree of association to the latent variable. Follow-up exploratory research might re-examine the validity of Semantic Clustering as a predictor for Learning Efficiency.

In terms of group differences on each of the latent variables, all were statistically significant. All of the predictors in the model combined were able to predict a statistically significant portion of variation in the latent abilities of Cued-Delay Recall and Inaccurate Recall. The model was not able to account for a statistically significant portion of the variation in the remaining latent factors.

The results of this study indicated that children who have been maltreated not only perform statistically significantly below typical controls on overall verbal memory performance, but across various latent factors associated with verbal memory. This provides support that maltreatment contributes to pervasive deficits in verbal memory, which aligns with the adult research that has found verbal memory impairment to be the most consistent cognitive impairment related to PTSD and trauma (Buckley, Blanchard, & Neill, 2000; Vasterling and Brailey, 2005; Isaac, Cushway, & Jones, 2006). These findings are particularly harrowing given the necessity of verbal memory for academic, social, and occupational success.

Research Question 3. Within the sample of children who had been maltreated, how do the number of PTSD symptoms a child exhibits contribute to verbal memory performance on the factors of the CVLT-C above and beyond the specific covariates of attention

(Conners' CPT Variability), intelligence (FSIQ), trauma type (i.e., Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Hypothesis Associated with Research Question 3. After controlling for potential covariates, it was predicted that the more PTSD symptoms a child who has been maltreated displayed, the poorer their performance will be across the factors of the CVLT-C.

This hypothesis was not supported. The latent variable of Attention Span provided the most statistically significant findings compared to the four other latent factors. The data indicated that when holding all other variables constant the latent ability of Attention Span was best predicted by gender, PTSD symptoms, and intelligence of the child. Previous research has supported the finding that maltreatment and chronic stress can negatively impact attention development (e.g., De Bellis, 2001; Perry & Pollard, 1998), however that was not found to be the case in this study. With regard to the role of gender, there is research that has found boys are more likely than girls to be diagnosed with ADHD and to demonstrate attention deficits (especially of the hyperactive variety) (e.g., Biederman et al., 2002). If boys are more likely to have attention problems, this may explain why male gender was significant when it came to the Attention Span factor. The measure of attention used in this study (the CPT), however, was not found to be significant in terms of predicting variance in the latent ability of Attention Span. Caution should be taken in conflating *attention*, as a neurocognitive construct, and *Attention Span*, as a latent variable in this study, as there is some suggestion that these are not necessarily measuring the same thing. The role of IQ as a predictor of verbal memory performance is not surprising. Overall cognitive functioning is a precursor to other various capacities, including verbal memory (e.g., Caplan & Waters, 1999;

Tillman et al., 2009; Dennis et al., 2011), and was found to be a statistically significant contributor to variation in verbal memory performance in almost all models.

The accumulation of PTSD symptoms was the next strongest predictor of Attention Span, when holding all other variables constant. The finding was the reverse of what was hypothesized, however, and a standard deviation increase in PTSD symptoms was related to a .32 standard deviation increase in Attention Span. Attention Span, as conceptualized in this study, may be a latent ability that is more resilient to trauma or perhaps enhanced by some of the hypervigillant symptoms associated with trauma (e.g., Bremmer, 1999; De Bellis, 2003). All of the predictors significantly explained over a third of all variation in Attention Span.

The latent factors of Free-Delay Recall and Cued-Delay Recall were each found to have only one significant predictor of variance based on this model. FSIQ was a statistically significant contributor to variation in Free-Delay Recall while age was the only statistically significant predictor of Cued-Delay Recall. In the maltreatment literature, age has been examined with regard to developmentally sensitive periods and chronic exposure to maltreatment throughout life (e.g., Crozier & Barth, 2005). In this study, an increase in age was associated with an increase in performance on the Cued-Delay Recall factor score. This finding is more in line with neurotypical developmental research that supports cognitive maturation promotes cognitive performance (e.g., Teicher et al., 2006). Future research might examine whether specific domains of verbal memory (i.e., Cued-Delay Recall) are especially associated with age. No predictors were found to be statistically significant with regard to predicting change in scores measuring the latent factor of Learning Efficiency. All predictors combined were found to make an insignificant contribution to variation in Free-

Delay Recall, Cued-Delay Recall, and Learning Efficiency scores. Due to the lack of significance in these models, interpretation is limited.

The Inaccurate Recall model indicated that FSIQ and maltreatment subtype were the only significant predictors of performance. FSIQ predicted an increase in the score on Inaccurate Recall, which is again likely related to the significant relationship between overall intelligence and verbal memory (e.g., Perez & Widom, 1994; Kaplow & Widom, 2007; Yanos, Czaja, & Widom, 2010). Children who fell into the maltreatment category of Sexual Abuse were predicted to perform better than a child who fell into the General Maltreatment category. This finding is interesting when one considers that an improved performance on this variable suggests *better* accuracy in recall (e.g., less intrusions, less false positives). In terms of forensics and controversy surrounding a child's ability to reliably speak as a first-person witness and recall trauma, further investigation into the finding that children in the Sexual Abuse category of this study were predicted to perform better than other children who had been maltreated as measured by the Inaccurate Recall score seems warranted and has important public health implications.

Research Question 4. Within the sample of children who had been maltreated, how do the three diagnostic categories of either having no PTSD symptoms, exhibiting PTSD symptoms but not meeting criteria for diagnosis, and meeting diagnostic criteria for a PTSD diagnosis contribute to variance in performance on the CVLT-C factors above and beyond the covariates of attention (Conner's CPT Variability), intelligence (FSIQ), trauma type (i.e., Sexual Abuse and General Maltreatment), and demographic factors (i.e., age, socioeconomic status, sex, race)?

Hypothesis Associated with Research Question 4. After controlling for potential covariates, it was predicted that children with PTSD symptoms would demonstrate lower scores on the five latent factors of the CVLT-C than children who had not developed PTSD symptoms. Furthermore, it was predicted that children who had PTSD symptoms but did not meet diagnostic criteria for PTSD would demonstrate higher scores on the latent factors compared to the children had been diagnosed with PTSD. As a follow-up to Research Question 3, this question sought to investigate whether diagnostic status was related to deficits in verbal memory performance, as it has been found to be in adult populations (e.g., International Consensus Group on Depression and Anxiety, 2003; Buckley, Blanchard, & Neill, 2000; Vasterling and Brailey, 2005; Isaac, Cushway, & Jones, 2006; Saigh et al., 2006).

This hypothesis was not supported. Attention Span was the latent ability that was best defined by this model compared to the other factors; however, all predictors combined did not explain a statistically significant portion of the variance in the factor. The model for PTSD Total Symptom Count, as a continuous variable, provided more sources for predictive information than the PTSD Diagnostic Status model that was dichotomized into three categorical groupings (i.e., no symptoms, symptoms but no diagnosis, and PTSD diagnosis). Removing predictive sources of variance by dividing a continuous variable into discrete groups may weaken the model's predictive capacity and rob it of power (MacCallum, Zhang, Preacher, & Rucker, 2002). Since dichotomizing a continuous variable (i.e., PTSD symptoms into diagnostic categories) removes potential sources of variation, it is not necessarily surprising that this research question would yield less sources of significant variance. PTSD diagnostic status was a significant predictor of Attention Span, but not in the

way that was hypothesized. The children who had PTSD symptoms but did not meet the diagnostic threshold were found to perform better than children who had no symptoms. Children with a PTSD diagnosis were not found to perform statistically differently than children who had no symptoms. This suggests that the accumulation of PTSD symptoms and understanding the manifestation of psychopathology associated with trauma may need to be conceptualized differently in children than it has been in adults (e.g., Stein et al., 1997; Carrion, Weems, Richert, Hoffman, & Reiss, 2010; International Consensus Group on Depression and Anxiety, 2003; Carrion, Weems, Richert, Hoffman, & Reiss, 2010). The latent ability of Attention Span was also found to vary based on the gender and intelligence of the child. Being female was predictive of a higher score on Attention Span than being a boy, and having higher intelligence was predictive of having a higher score on Attention Span. Again, caution should be taken in assuming that Attention Span and other psychological measures that purport to measure the neurodevelopmental construct of attention, are measuring the same thing.

Similar patterns for sources of variation were found on the Free-Delay Recall, Cued-Delay Recall, Learning Efficiency, and Inaccurate Recall factors for this Research Question as were found for the previous question. The Free-Delay Recall variable was best predicted by intelligence of the child, where having a higher FSIQ was predictive of having a higher score on this latent variable. The Cued-Delay recall model indicated that age was the only statistically significant predictor of variance. An increase in a child's age was associated with a higher score on Cued-Delay Recall. The latent ability of Cued-Delay Recall may be a cognitive area that is not as disrupted by exposure to maltreatment compared to other domains of verbal memory. Additional research in this area is necessary in order to draw

conclusions. For Learning Efficiency, no predictors were found to be statistically significant with regard to predicting change in scores measuring this latent variable. FSIQ and maltreatment subtype were the only significant predictors of performance on the Inaccurate Recall factor, in the same pattern of influence as the previous research question: increases in intelligence were associated with increases on the Inaccurate Recall factor and children who were classified as having Sexually Abused factor score were found to perform better than children classified as having a General Maltreatment factor score.

All predictors combined were found to make a non-significant contribution to variation in any of the five factors and the model's fit indices were inconsistent. This limits the interpretation of the results, and follow-up research is required to draw any conclusions from these findings. Some of the unexplained variance is normal and expected, but future research might investigate whether the sources of unexplained variance are systematic or caused by a condition that has not been identified in these models.

Research questions 3 and 4 yielded very similar results, suggesting there was not much to be gained by examining Total Symptom count versus Diagnostic Status. The only model that indicated that PTSD symptoms had any statistically significant relationship to the variance in verbal memory was on the Attention Span factor score. The PTSD Total Symptom Count actually predicted an increase in the latent ability of Attention Span, suggesting that an increase in symptoms contributed to an improvement in performance on Attention Span, rather than what was hypothesized. The model that included diagnostic status indicated that having some PTSD symptoms was better than having no symptoms or meeting diagnostic status for PTSD. This also went against what was hypothesized and is deserving of further investigation.

Limitations

As with all research, there are limitations to this study that must be addressed in order to clarify the generalizability of the results. First, because this study made use of a preexisting data set,inclusion and exclusion criteria were set as were available measures for use in this dissertation. Additional variables not included in the chosen model could potentially affect the validity of the conclusions drawn (e.g., age at time of maltreatment, length of time the maltreatment continued, additional protective or risk factors in the child's life, etc.). However, the maltreatment factors identified in our sample were chronic, pervasive, and multidimensional. It was not possible to assign these factors into discrete time categories for statistical investigation, as determining the age of maltreatment onsets and offsets could not be reduced to a simple construct. Data collection was cross-sectional, so causal mechanisms cannot be established.

Another limitation to this study is that the latent abilities that were examined were based on indicator scores from the CVLT-C, but have yet to be empirically supported as reliable constructs. The terms Attention Span, Cued-Delay Recall, Free-Delay Recall, Learning Efficiency, and Inaccurate Recall, were specified by Donders and may be misleading in terms of how other empirical research conceptualizes them. There needs to be more consensus surrounding the implications for the names of these variables; for example, whether Attention Span really is measuring something recognized as being related to what the social science world conceives as attention. This study found that the measure for attention did not account for significant variance in the Attention Span variable, which makes the title of "Attention Span" somewhat questionable. Definitions for these latent abilities

outside of the CVLT-C scores that indicate them are lacking and can make interpretation of findings challenging.

As with many studies, this one had limitations with regard to sample size. Specifically, the maltreatment group sample size was potentially too small for conducting structural equation modeling. Therefore the reduction in sample size for the third and fourth research questions likely contributed to the lack of precision in the parameters within the models, specifically the wide RMSEA confidence intervals found for a number of models. Further research is required to verify the results found in this study.

The initial full models generated to answer Research Questions 3 and 4 were found to have poor model fit and therefore unreliable parameters. As a result, an exploratory examination was embarked upon in order to simplify the models by removing the non-significant contributors to variance in verbal memory identified through the initial model. These simplified models provided improved, but still inconsistent, fit. Another limitation to this study, therefore, is the generalizability of the findings and caution should be taken when interpreting the results.

Finally, because the sample of maltreated children in this study is not representative of a normal population, results from this study should not be generalized to a non-maltreated population. Moreover, since the sampling was not random, care should be given even when generalizing to other maltreated populations.

Future Research

While the majority of the findings in this study were non-significant, they offer a springboard for follow-up inquiry. One significant finding from this study was that girls and boys may differ in their reactions to maltreatment, in that girls are predicted to perform better

on verbal memory tasks involving Attention Span. This finding supports previous research that has found that males are more impacted by maltreatment than females (e.g., McGloin & Widom, 2001; De Bellis, 2003). Follow-up research could further explore these findings to gain a better understanding about causality. An increase in age was found to be predictive of an increase in score on the latent ability of Free-Delay Recall. Chronicity of maltreatment was not explored in this study, but the developmental trajectory for children who have been maltreated remains to be a domain requiring further investigation. Intelligence continues to be the strongest predictor of verbal memory performance. Within the maltreated sample of children, having a higher IQ score was predictive of higher scores on the Attention Span, Free-Delay Recall, and Inaccurate Recall factors. Interventions aimed at preserving and enhancing domains associated with intelligence may provide the most global benefits to offset the consequences of maltreatment.

The findings of this study suggest that being exposed to maltreatment in of itself is likely more related to deficits in verbal memory than PTSD symptoms or a diagnosis of PTSD. Neither the accumulation of PTSD symptoms nor the diagnosis of PTSD was especially predictive of verbal memory performance. This finding adds to the limited research comparing sub-threshold PTSD to full PTSD. One of the few empirical studies on this topic found that adults in both categories approached similar degrees of work and social dysfunction when compared to symptom free individuals (Stein et al., 1997). Future research should continue to explore the cut–off points for diagnostic criteria for PTSD, so that diagnostic status offers utility to clinicians and researchers. The applicability of PTSD to children remains an intense area of scientific inquiry.

In order for a clinical diagnosis to be a useful indicator of impaired functioning, findings from this study suggest that PTSD, as it is currently defined, may not be the best indicator in children who have been maltreated. Future research that explores additional cognitive domains with regard to PTSD symptom accumulation and diagnostic status would be useful in supporting or refuting this hypothesis. This study's findings indicate that verbal memory is either a domain that is not significantly impacted by the accumulation of PTSD symptoms, above and beyond the trauma itself, or that PTSD, as it is currently diagnosed, is not capturing the extent to which the cognitive domains of children who have been maltreated have been affected. Future research may examine other ways of comparing groups for a richer understanding of the relationships between variables, such as contrast coding.

Over the course of this research, the Fifth Edition of the DSM (DSM-5) was released, and includes a new developmental subtype of PTSD called posttraumatic stress disorder in preschool children (American Psychiatric Association, 2013). Changes in the diagnostic criteria for PTSD were based on studies that showed that when a developmentally-sensitive set of criteria were used, approximately three to eight times more children qualified for the diagnosis compared to the DSM-IV (i.e., Scheeringa, Myers, Putnam,& Zeanah, 2012; Scheeringa, Zeanah, & Cohen, 2011). Although we captured all PTSD symptoms described in DSM-V, because the DSM-V was published after the completion of this work, we did not use DSM-V criteria for this dissertation. The DSM-V changes to the diagnosis of PTSD may have changed the way in which PTSD is conceptualized and diagnosed in this study and influenced our results for the research questions based only on diagnosis as a yes or no variable. It would not, however, have changed our results when examining PTSD symptoms

in our outcomes. Speculatively, one hypothesis regarding the finding that an increase in PTSD symptoms was found to be predictive of an increase in performance on Attention Span is that some of the hypervigilant symptoms related to PTSD may be either more pronounced or utilized as a coping strategy for relating to stress, and perhaps may enhance attentiveness in stressful situations. Research investigating relationships between age and both the quality and quantity of PTSD symptoms is warranted. This study suggests an accumulation of symptoms in the face of trauma may be adaptive or protective as opposed to developing no symptoms (under-reactive) or too many symptoms (this threshold has not been established but is hypothesized to exist). Investigation into these changes in functioning could provide support for cut-off points for threshold and sub-threshold levels of PTSD. Investigation into the occurrence of post-traumatic *growth*, positive psychological changes in response to the struggle with highly challenging life circumstances, may also be an area of investigation as it relates to treating and working with children who have been maltreated.

In light of new diagnostic criteria, specific clusters of symptoms and their influence on verbal memory are also deserving of potential inquiry. The results of this study suggest that children who have been sexually abused are predicted to perform better than children who have been exposed to other forms of maltreatment on a measure of inaccurate recall, as conceptualized in this study. This has interesting implications regarding whether and how the type of maltreatment a child is exposed to impacts the quality of retention of information. The type of abuse may also be related to the type of symptoms a child develops. Specifically, sexual abuse may be related to a hypervigilance that results in more accurate recall, and that general maltreatment, without the component of sexual abuse, may be associated with more inattentive symptoms. Forensic research might follow-up with these

findings with regard to investigations of eye-witness testimony, especially related to a child's capacity to accurately recall abuse.

Generalizability of these findings would require investigation into the chronicity of the maltreatment (which was not specifically accounted for in this study), as the effects of chronic stress may vary by age and become stronger based on the duration and timing of the exposure (e.g., Crozier & Barth, 2005). More direct investigations are needed to test precisely when and how childhood trauma affects different types of memory. Research also needs to continue to consider the possible theoretical mechanisms that influence a child's memory following maltreatment and the various defensive emotion-regulation processes aimed at suppressing or avoiding disturbing memories. Larger sample sizes, more precise measures, and more in-depth analysis of possible moderating factors known to influence verbal memory in the face of trauma must be considered before conclusions are drawn about its effect on verbal memory processes. Longitudinal research is also necessary in order to examine how exposure to maltreatment affects people over time.

Lastly, further research to investigate Donders' (1999) factor scores can provide support for them as constructs and aid in tailoring findings to specific interventions for schools and clinics working with children who have been maltreated. Additional factors and different measures that were not included in this study may also help in understanding the complex, chaotic, and disruptive nature of maltreatment on children's verbal memory.

Conclusion

The findings from this study support the conclusion that exposure to maltreatment during childhood has a significant deleterious effect on verbal memory compared to children who have not been exposed to maltreatment. Despite the fact that verbal memory has been

found to be the most consistent cognitive impairment related to PTSD in adults (Buckley, Blanchard, & Neill, 2000; Vasterling and Brailey, 2005; Isaac, Cushway, & Jones, 2006), this study is among only a few to specifically examine verbal memory in children who have been exposed to trauma (Moradi et al., 1999; Beers and De Bellis, 2002; Yasik et al., 2007). This study found significant differences between a group of maltreated children and a group of controls on the CVLT-C Total Score, as well as across five factor scores that were derived from a CFA based on Donders' (1999) CFA. The findings surrounding within group differences were less decisive. The extensive literature review provided in this study is predictive of the complexity of such an investigation. It is not surprising that when examining the disrupted and unpredictable world of a child who has been maltreated, there will be some complicated and nuanced relationships that may be difficult to model or capture statistically. This supports the need for more investigation of this national health issue. Partialling out these relationships has implications for both more individualized interventions, as well as developing a better understanding for how the brain responds to various types of stress and trauma, and where the thresholds lie in terms of the point at which stress reaches its adaptive decline and becomes distress. The changes made to the diagnosis of PTSD in the DSM-5 seem to be an attempt to address what research has supported for a number of years: that children's response to stress and trauma are different from adults, and this needs to be accounted for through the diagnostic criteria.

APPENDIX A
IRB EXEMPTION LETTER

From: IRB [irb_no_reply@mailserv.unc.edu]
Sent: Wednesday, October 03, 2012 7:28 PM
To: rskits@email.unc.edu
Cc: stephen.hooper@cidd.unc.edu
Subject: IRB Notice

To: Rachel Kitson
School of Education

From: Office of Human Research Ethics

Date: 10/03/2012

RE: Notice of IRB Exemption
Exemption Category: 4.Existing data, public or deidentified
Study #: 12-1400

Study Title: An examination of verbal memory performance data in children who have been maltreated

This submission has been reviewed by the Office of Human Research Ethics and was determined to be exempt from further review according to the regulatory category cited above under 45 CFR 46.101(b).

Study Description:

Purpose: I will be examining parts of an existing data set to study the consequences of child maltreatment on children's verbal memory.

Participants:Data records without identifiers from 101 control subjects and 108 maltreated subjects between the ages of 6 and 18 years old will be used. original study had received IRB approval from both UNC and Duke Universities [Pro00009018 (DUHS) and 10-1166 (UNC-CH)].

Procedures (methods): Measures of intelligence, attention, psychopathology, behavior, verbal memory, and demographic data will be examined statistically using SPSS software.

Investigator's Responsibilities:

If your study protocol changes in such a way that exempt status would no longer apply, you should contact the above IRB before making the changes. The IRB will maintain records for this study for 3 years, at which time you will be contacted about the status of the study.

Researchers are reminded that additional approvals may be needed from relevant "gatekeepers" to access subjects (e.g., principals, facility directors, healthcare system).

IRB Informational Message—please do not use email REPLY to this address

APPENDIX B

RESEARCH SUMMARY - August 12, 2010
Life Events & Childhood Brain Development (funded under the title "PTSD & Childhood Sexual Abuse: Psychobiology") NIMH PI: Michael D. De Bellis, M.D. MPH

PURPOSE OF THE STUDY

This NIMH funded study is a 5-year cross-sectional investigation with an at least one-year prospective follow-up to examine the psychobiology of childhood posttraumatic stress disorder (PTSD) secondary to child maltreatment. In cross-sectional studies, we reported that clinically referred maltreated children with PTSD had elevated biological stress system measures (24-hour urinary catecholamine and free cortisol levels) and evidence of adverse brain development (smaller intracranial and cerebral volumes, smaller midsaggital areas of the corpus callosum, and larger ventricles compared to non-abused controls) (De Bellis et al 1999a; De Bellis et al 1999b). PTSD trauma for the majority of these children was sexual abuse. Earlier age of onset of abuse, longer duration of abuse, and greater PTSD symptoms each were associated with more extreme difference from normal's on these measures. Animal studies suggest that elevated levels of catecholamines and cortisol during development may lead to adverse brain development. Our pilot study did not address to what extent our results were PTSD specific or the result of abuse.

Specific Aim #1: To compare measures of biological stress systems and brain maturation in maltreated children with PTSD to those without PTSD and controls at Time-01.

Specific aim #2: To determine the one-year effects of maltreatment with PTSD and maltreatment without PTSD on these same children's biological stress systems and neuropsychological function.

Specific Aim #3: To identify the separate psychobiological predictors of the persistence of PTSD and resiliency to PTSD at Time-02.

Specific Aim #4: This study Life Events & Childhood Brain Development (#3928) was designed and funded to complement the data collection for the PI's other RO1 studies. These three studies are IRB-approved studies: 1) Factors Influencing Childhood Brain Development (#4148), 2) Adolescent Alcohol Abuse, PTSD & Hippocampal Development (#4197) and 3) Frontal Brain Function in Adolescents and Young Adults (#7718). Since similar methods are used in all three studies, for specific aims #4, we will use the combined data for secondary investigation of the development of risk and resiliency for psychopathology (e.g., PTSD, adolescent substance use disorders) as it relates to the developmental study of biological stress systems, brain maturation and cognitive function in maltreated children (with and without PTSD) and healthy developing children, ages 3 to 19 years.

BACKGROUD AND SIGNIFICANCE

In clinically referred samples, the reported incidence rates of PTSD resulting from sexual abuse range from 42% to 90% (McLeer et al 1994). Famularo et al., reported a 39% incidence rate of PTSD in a non-clinically referred maltreated sample interviewed within 8 weeks of disclosure and initial court petition for removal from parental custody. Of those children who disclosed sexual abuse, 63% had a diagnosis of PTSD (Famularo et al 1994). They also showed that 32.7% re-examined from the original sample of PTSD subjects continued to meet PTSD criteria at 2-year follow-up (Famularo et al 1996). Thus,

maltreatment of children, especially sexual, physical, and emotional abuse, is associated with high incidence rates of and is a risk factor for acute and chronic PTSD as well as other negative developmental consequences (DeBellis 2001). As stated above, we reported that clinically referred maltreated children with PTSD had elevated biological stress system measures and evidence of adverse brain development (De Bellis et al 1999a; De Bellis et al 1999b). We plan to study the psychobiological effects of PTSD as distinct from those of maltreatment. We will test specific developmental hypothesis regarding age of onset and duration of abuse on biological and developmental outcomes that may help us design future treatments.

DESIGN AND PROCEDURES

This study includes 2 parts. **Part I** is a comprehensive clinical research assessment that will provide publishable data on parental and child cognitive and mental health functioning and will also determine eligibility for **Part II,** which is the completion of Time-01 psychobiological assessments (24-hour urine collections, morning and evening salivary cortisol levels, sleep/wake activity measures, and MRI procedures) and the after 1-year Time-02 follow-up. 280 subjects referred for maltreatment and 140 controls will undergo Part I Clinical assessment, 140 subjects with histories of maltreatment (70 with PTSD, 70 without PTSD) and 70 controls will undergo the Part II psychobiological assessments and the after 1-year Time-02 follow-up.

Thus, this protocol will consist of: **a)** initial telephone screening to determine eligibility for Part I clinical assessment, **b)** Part I completion of Time-01 clinical assessment screening to determine presence of PTSD, psychiatric and neuropsychological assessments and Part II scheduling and completion of biological collections and MRI scans, if subject does not meet exclusion criteria, c) completion of Time-02, after one-year follow-up of all subjects who undergo Part II.

Time-01 Part I Clinical assessment will consist of a one-day visit to the Healthy Childhood Brain Development Program. Clinical research interviews and questionnaires of the parent and child will be conducted to determine the child's mental health status, absence or presence of PTSD, family history of mental disorders, and cognitive function. Clinical research interviews and questionnaires of the parent will be conducted to determine the non-abusing parent's mental health status, absence or presence of PTSD, family history of mental disorders, and health and cognitive function. Blood and salivary levels and vagal tone for determination of biological stress measures and markers of biological mediators of stress and brain development (i.e., cortisol, catecholamines) will be taken on the interview morning of the child. A brief physical exam of the child in the parent's presence will determine cranial size, heart rate and sitting and standing blood pressure. Subjects may refuse these measures and still be eligible to complete the remaining protocol. Audiotaping of the interviews will be done to insure good reliability for the interviews. Dr. De Bellis and the clinical interviewer will review the tapes. If subjects choose not to have their interviews recorded, they may still participate in the study. It is estimated that the evaluations can be completed in 6 hours. We are planning on scheduling each child and legal guardian (caregiver) for one day consisting of 8 hours to allow for breaks. Lunches will be purchased by the study.

Part II: After Part I clinical assessments are completed, subjects who meet the eligibility inclusionary criteria and do not meet the exclusion criteria will be asked to undergo the following Part II procedures.

Since maltreated subjects usually do not disclose abuse after the first occurrence, especially when this abuse is incest (Putnam and Trickett 1993), *it is important to ascertain if neglect on the part of the non-abusing caregiver is related to the delay in disclosure*. *It is important to measure emotional neglect as this may have its own contributions to adverse brain development.* We also collect data on neglect as part of the interview process.

Biological Sample Collection: 24-hour urinary cortisol and catecholamine measures and morning and evening salivary cortisol measures will be collected as a reflection of biological stress system function. Subjects and their caregiver/s will be given detailed instructions. Subjects will follow a low monoamine diet and keep a daily log of diet and activities for two days prior to and on the days of collection. 24-hour urine collections will be performed over a non-school day in which the subjects are not engaged in stressful activities such as athletic competitions or studying for important exams. We also will ask our subjects to wear an actograph. This device measures levels of physical activity and sleep-wake cycle. We have found that subjects in this age group are compliant with the diet, daily log, complete collections, and actigraphy measures. Urine collections will be done at the subject's home and brought in by subjects or picked up by our staff. Subjects can chose to do all, some, or none of these procedures. All subjects will also be asked to undertake a salivary alcohol test and urine drug screen prior to clinical assessment, MRI scans, and neuropsychological testing to assess recent substance use. Female subjects who started their periods, must undergo a urine pregnancy test before the MRI scan. Any positive results will be shared with the subjects and their parent.

MR brain scans (anatomical MRI, functional MRI and MR Spectroscopy): MRI technology is a safe and novel approach to measure brain structure and chemistry in living children. This technology does not use ionizing radiation. To date, we have successfully scanned over 200 children and adolescents (age range: 3 to 19 years) at Duke for anatomical MRI measures without sedation using the desensitization procedure described below. Subjects listened to relaxing music during the CAMROD scan and may watch videos during the BIAC scans. Showing movies for the children, using a projector and video screen during the actual scan, has not only greatly enhanced our success, but it has made scanning an enjoyable experience for the children. Subjects aged 6 to 7 are only asked to do one scan at the CAMROD scanner for anatomy, MRS and DTI. Subjects 8 years and older are asked to do 2 scans, the scan at CAMROD and an fMRI scan at BIAC. The MRI CAMROD procedures take a total time of about 1.5 hours. The MRI BAIC procedures take a total time of about 2.5 hours. This includes an extra half hour to undergo the simulation scanner. We noted that less than 2% of children had difficulty completing a successful scan (due to movement artifact or claustrophobia). An experienced person will monitor the subject for anxiety by observation and by self report and physiological measurements of pulse, blood pressure and respiration. No sedation will be used during the actual scanning procedure. The caregiver is welcome to stay in the control room during the scan, where the child can be viewed via a video camera and talk through a two-way audio system. Prior to entering the MR scanner, subjects will be trained in our simulation scanner which reproduces the sights and sounds of the scanning environment. MRI measures will be performed at the

Department of Radiology, DUMC. Subjects may choose to do one, two or none of the MRI scans and still participate in other Part II procedures.
Completion of Time-02, after one-year follow-up will include repeat parent and child's diagnostic clinical interview for presence of PTSD and other mental disorders, an assessment of interventions, repeat Biological Sample Collection, repeat neuropsychological testing, and may include another series of MRI scans.

RISK/BENEFIT ASSESSMENT

Costs to participation are their time and effort. There are no expenses associated with this study. The risks of the interview part of this study are those associated with discussing personal issues with a trained interviewer. There may be embarrassment and discomfort in talking to the interviewer about some aspects of the sensitive material in the child's and parents' life. Experienced clinically trained interviewers will conduct the interviews. At any time the subject may discontinue the interviews or chose not to talk about a certain topic. Our clinicians will be supervised directly by Dr. De Bellis, a board certified child and adolescent psychiatrist, and are well trained in these areas and will attempt to minimize the psychological distress of the interview situation. In our previous studies of maltreated children with PTSD subjects handle the interviews well and without untoward effects. However, certain procedures will be followed in order to decrease the psychological risks of this investigation. All abused subjects will be re- assessed for clinically important symptoms such as suicidal and/or homicidal ideation or increases in psychiatric symptoms prior to leaving their clinical research appointment. All abused subjects will be telephoned the next day by the interviewer in order to ascertain their psychological stability after the interview. The risk of the MRI scan is considered minimal. The MRI procedure is painless but it does require the subject to lie still with the head and part of the body confined in a tunnel-like device. If a subject feels upset by this procedure or if his/her pulse or blood pressure changes a lot, he/she may refuse the MRI scan. If Dr. De Bellis and his colleagues feel that undergoing the MRI scan will upset a subject, they may also stop the subject from participating in this procedure. Legal guardian(s) are invited to remain in the scanner room during the practice MRI scan and the real MRI scanning procedure. There are no personal benefits to the participants other the possibility of incidental findings of clinical significance from the MRIs, appropriate referrals for mental health care for the subject or subject's legal guardians, and participant payments. Other potential benefits include the ability to help in a study that will greatly increase knowledge about child abuse and childhood brain development.

SUBJECT IDENTIFICATION AND RECRUITMENT

Subject identification and recruitment sites: In Part I of this study, we will recruit and assess 280 subjects referred for child maltreatment (sexual abuse, physical abuse, neglect, and emotional abuse) and 140 controls, between 6 years 0 months and 16 years 0 months. The racial distribution of the Raleigh/Durham metropolitan region is approximately 45% Caucasian, 45% African-American, and 10% other underrepresented minorities. We will not exclude other underrepresented minorities from participating in this study. The control group will be recruited from the community through IRB approved advertisements. Groups will be matched on age, sex, SES, and family structure (one vs. two-parent family). *Please note recruitment procedures regarding abused children are attached in an addendum below.*

Determination of maltreatment status: Children referred from State agencies and mental health clinics that specialize in the assessment and treatment of maltreated children (e.g., Center for Child and Family Health-North Carolina) will be recruited. Official state criteria for abuse will be used to identify children for subject recruitment. Abuse information will be derived from parents, children and/or adolescents, clinicians, medical records, and caseworkers and records. It is likely that past or ongoing abuse will be revealed in these investigations. Appropriate clinical interventions will be made (see below).

Maltreated children and adolescents inclusion and exclusion criteria:

Inclusion. 1) 70 subjects who meet and 70 subjects who do not meet DSM-IV criteria for PTSD at Time-01, 2) a Child Protective Services incident of child maltreatment (sexual abuse, physical abuse, neglect, and/or emotional abuse) disclosed within 2 years prior to entry, and 3) one non-abusing biological caregiver or legal guardian who can cooperate with this protocol.

Exclusion. 1) Meeting DSM-IV criteria for a psychotic disorder or a pervasive developmental disorder, 2) current or ongoing maltreatment, 3) additional exclusionary criteria see below.

Healthy control group inclusion and exclusion criteria:

Inclusion. 1) No past or current history of trauma or maltreatment and 2) one biological caregiver or legal guardian willing to cooperate with the protocol. Consent will be obtained from caregivers (or legal guardians) for conducting a check of local child abuse registry records for each subject in the study.

All Subject Exclusion: 1) The presence of a significant medical or neurological illness or head injury, severe pregnancy or birth complications, prenatal exposure to alcohol and/or drugs in a chronically abusing mother, and contraindications for MRI which include metal in the body (including braces, BB gun bullets) and severe claustrophobia, 2) <u>subjects using psychotropic medications in controls or medications for chronic medical illnesses in both controls and subjects,</u> 3) full scale intelligence below 70 as estimated by the short form of the Wechsler Intelligence Scale for Children 3rd edition (WISC-III)(Wechsler 1991), 4)) history of or current DSM-IV diagnosis of alcohol and/or substance abuse or dependence, 5) pregnancy, and 6) a child subject with current functional enuresis of greater than 2x per month will also be excluded from the 24 urine collection only in order to ensure an adequate sample size for 24-hour urine collections.

COMPENSATION

Children and their legal guardians will not be charged for participation in this study. Because these measures require the commitment of both the child and the legal guardian, the payments will be designated as follows: Children and their legal guardians will not be charged for participation in this study. Because these measures require the commitment of both the child and the legal guardian, the payments will be designated as follows: $100 total for the clinical assessment and child morning blood draw, neuropsychological tests, self-reports, and brief physical exam ($50 for the child, $50 for the parent) and $25 for only completing half a day of the research day tests ($10 for the child, $15 for the parent). However, if subjects are unable to complete their testing in one day, they will be paid an additional $25 for each half day of their time. Subjects will be paid $10 per day for maintaining the low monoamine diet (three days =$30)($5/day x three days for the child, total =$15)($5/day x three days for the parent, total =$15) and $30 ($15 for the child, $15 for

the parent) for each 24 hour urine and for each morning and evening saliva collection (total =$30 for the child, $30 for the parent), $75 total for one hour MRI scan ($50 for the child, $25 for the parent) and up to $125 for the 2 hour MRI scan. because the child may be paid an additional amount, up to $25, depending on how well he or she performs on the task given during the MRI. Female subjects, who started their periods, must undergo a urine pregnancy test before the MRI scan, and it must be negative. If a pregnancy test is positive,, parent and adolescent will be notified. These payments are in addition to travel reimbursement. Payments will be the same at Time-02 for all repeated measures.

Potential conflicts between a potentially neglecting or abusing parent and a child subject will be initially handled as follows. After initial clinical screening, the PI and study staff will ascertain if the child is currently living in a safe home environment. If the PI and study staff have reason to believe that the child is currently not safe in his/her home environment, appropriate clinical intervention as discussed in the addendum will be undertaken. Subjects will be paid for their efforts. We split the parent and child participate payments relative to the amount of time and effort each undertakes. If our clinical assessment reveals that the caregiver has an active and serious substance use disorder, is currently living with the child, and cannot commit to substance abuse treatment, we may pay the subjects in store coupons (for something the child or family wants or needs) instead of a check to avoid giving the parent cash which can be used for drug use. We do this because we do not want to put our child subject in danger of coercion to do the study to support a parent's drug use. The PI and project staff will discuss this with the parent caregiver on a case-by-case basis, and, with parental permission, the child protective service worker, before the payment of checks versus vouchers is considered.

EMERGENCY PROCEDURES

Children or parents are occasionally identified who appear to be at serious risk of suicidal or homicidal actions, or who are subject to current physical, sexual, or emotional abuse or neglect. When an interviewer believes that such a possibility exists, s/he at once consults with either Dr. De Bellis. If professional opinion is that the child or parent subject would benefit from psychiatric care, they will be offered this care through an appropriate referral. If professional opinion is that the child or parent subject is a danger to themselves or others or would benefit from inpatient psychiatric admission, arrangements will be made for admission to a hospital. If in professional opinion it is judged that the child subject is continuing to live in an unsafe or aversive environment, a Suspected Child Abuse and Neglect Report will be filed and arrangements will be made to maintain the subjects' safety. Written reports will be made every time an emergency plan is implemented. This research is covered by a Certificate of Confidentiality issued by the Department of Health and Human Services (DHHS). This Certificate will protect the investigators from being forced to release any research data in which subjects are identified, even under court order or subpoena, without the subject's or guardian's written consent. This protection, however, does not prohibit the investigators from voluntarily reporting information about suspected or known sexual or physical abuse of a child or a subject's threatened violence to self or others.

DATA ANALYSIS AND MONITORING

Group comparisons will be conducted using ANOVAs (ANCOVAs), MANOVAs (MANCOVAs), and, where multiple assessments are obtained, repeated-measure ANOVAs

to detect group differences over time. Multiple and logistic regression analyses will be used to document predictors of important outcomes.

This study (Life Events & Childhood Brain Development (#3928)) was designed and funded to complement the data collection for the PI's other RO1 studies. These three studies are IRB-approved studies: 1) Factors Influencing Childhood Brain Development (#4148), 2) Adolescent Alcohol Abuse, PTSD & Hippocampal Development (#4197) and 3) Frontal Brain Function in Adolescents and Young Adults (#7718). Since similar methods are used in all three studies, the combined data allows the secondary investigation of the development of risk and resiliency for psychopathology (e.g.,PTSD, adolescent substance use disorders) as it relates to the developmental study of biological stress systems, brain maturation and cognitive function in maltreated children (with and without PTSD) and healthy developing children, ages 3 to 19 years. These secondary analyses were planned in the original funding. Therefore this study will remain open until all secondary analysis is completed. Therefore this study will remain open until all secondary analysis is completed. After October 2005, subjects from all studies will give consent and authorization for inclusion of their data in the combined analyses. Subjects enrolled before November, 2005, will be reconsented.

A Data and Safety Monitoring Plan (DSMP) will ensure that the subject's participation in the research study and respective data will be confidential. Any adverse event or effect will be reported by staff to the PI as soon as possible. These issues will be discussed at the weekly project meetings which are attended by the PI, co-investigators, and research staff. At the beginning of that meeting, there is a discussion of any problems of any sort (including minor difficulties or questionable events) that have occurred. If a review of those details reveal any adverse events, then the PI will take responsibility to report adverse events. If any breaks in confidentiality or any changes in risk classification occur, Dr. De Bellis and the co-investigators will work promptly to correct them, and assure that we immediately notify the IRB, as per IRB current guidelines.

DATA STORAGE AND CONFIDENTIALITY

Data will be collected in the form of written interview schedules, pencil and paper self-reports and questionnaires, audiotape-recordings of interviews and home visits, neuropsychological testing results, and MRI scans and biological materials. Ensuring the integrity and confidentiality of the data is an essential part of safeguarding the rights of subjects. The Healthy Childhood Brain Development/ Developmental Traumatology Program has instituted a series of checks at several levels of data handling to maintain its quality and confidentiality. 1) We will ensure that any information (behavioral observation, clinical data, as well as biological measures) are identified only by subject numbers. All information that identifies subjects beyond their patient numbers are kept in locked file cabinets in a locked data storage room that is locked at night (e.g., subjects' medical or archival records obtained for research purposes). 2) Interviewers, who are clinically trained, will be given extra training in the importance of confidentiality in regards to collecting research data. Like all study personnel, they will promise in writing to maintain confidentiality. 3) After data are entered, all identifying information that may be in physical form (e.g., interviews, questionnaires, biological materials) that may lead to subject identification will be destroyed or blacked out. From this point it will not be possible to trace back an individual except by linking with a separate computer file that links the identification number with the individual's identity. This file is password protected, and kept in a special

computer volume to which only the senior data manager, our network administrator and the PI have access rights. 3) Protocols, written materials, audiotapes, MRI scans, neuropsychological scores, and written results of cognitive and biological tests will not identify subjects except by subject number, without the written consent of the person concerned. All records including audiotapes related to a subject's involvement in this research study will be stored in a locked file cabinet. Subject identity on these records will be indicated by a unique code number, and the information linking this code number with identity will be kept locked separately from the research records. All audiotapes will be labeled by a number, and no personal information such as last name, address or full names of friends or relatives will be asked or recorded during these recorded interviews. The tapes will be kept locked separately from the research records. The study results will be retained in our child subject's research record for six years, until subject's reach the age of 21, or until the end of the study, whichever is longer. At the end of this retention period, either the research information not already in the subject's medical record will be destroyed or information identifying the subject will be removed from such study results at DUHS. Any research information in a medical record will be kept indefinitely.

The sponsor of this research study requires that data collected as part of this research that does not identify subjects be archived in a national database. Data from this study will be archived in accord with the requirements set forth by the Data Resource Program of the National Institute of Justice and the National Data Archive on Child Abuse and Neglect. The Data Resource Program of the National Institute of Justice is a research, development, and evaluation agency of the US Department of Justice. Its mission is to advance scientific research, development, and evaluation to enhance the administration of justice and public safety. Data Resources Program was established to ensure the preservation and availability of research and evaluation data collected through National Institute of Justice funded research. Data sets collected through National Institute of Justice funded research are archived and made available to others in order to support new research to replicate original findings or test new hypotheses. National Institute of Justice Data Collections and Activities are housed at the National Archive of Criminal Justice Data and maintained by an Inter-university Consortium for Political and Social Research at the University of Michigan. More information about the National Institute of Justice can be found at http://www.ojp.usdoj.gov/nij/. The National Data Archive on Child Abuse and Neglect (NDACAN) is a data resource that promotes scholarly exchange among researchers in the child maltreatment field. NDACAN is located at the Family Life Development Center, College of Human Ecology, Cornell University, Ithaca, New York. More information about NDACAN can be found at http://www.ndacan.cornell.edu/. If subjects choose not to have their data archived, they may still participate in the study. Subjects may also be asked to sign another consent form so that the data collected as part of this study can be used in a Duke Database for future research of Healthy Childhood Brain Development.

Data Sharing with New York University

Our group is considering sharing our fMRI data collected at BIAC in a de-identified, anonymized form with a group at NYU, headed by Francisco Xavier Castellanos, MD. The group we would like to share our data with is not funded for a research study and is doing analyses for a grant proposal and possibly a paper on resting state brain function with us. NYU will not make any attempt to deduce the identity of the subjects from whom this data

was collected. The fMRI data has already been collected and we are not planning to collect more fMRI data at this time. The data will be deidentified (all 18 HIPAA identifiers removed) and anonymized (no code to link with identifiers)
when the data is transferred to NYU. This concerns only the fMRI study and data already collected at the Duke Brain imaging analyses Center (BIAC).

Addendum:

Recruitment of community (control) subjects. Community (control) subjects are recruited by responding positively by telephone to IRB approved advertisements. In order to determine whether or not a potential subject is eligible for this study, a Child Medical Screening form, which involves asking the potential subject's parent or legal guardian Protected Health Information (PHI) needs to be completed to determine eligibility. Eligibility for the study is ultimately determined by the PI from this information. Verbal consent and authorization (C/A) will be obtained before questions concerning PHI are asked. As per the Duke University Health System (DUHS) Institutional Review Board (IRB) Policy on Use of Questionnaires by Telephone or Mail (Version 06/07/04) section 1b this verbal consent explains: 1) Purpose of the telephone call; 2) A Brief description of the research; 3) Who will use the screening information and for how long; and 4) How privacy and confidentiality will be assured.

Special Procedures in the Recruitment of Maltreated Children.

Recruitment. Recruiting maltreated subjects is a sensitive issue, particularly in regards to maintaining confidently. We will be recruiting maltreated child subjects directly from child protective services (in the State of North Carolina) and local forensic and treatment specialty clinics such as The Center for Child and Family Health-North Carolina. Maltreatment must be legally indicated by child protective services (i.e., must meet the legal definition of maltreatment) and disclosed within the past 2 years prior to entry (Time-01). The majority of the maltreated subjects will be recruited through The Center for Child and Family Health-North Carolina. Ken Dodge, Ph.D. of Duke University and Anne Sayers MSW of Prevent Child Abuse North Carolina will also assist in helping us make contacts with child protective service agencies in North Carolina. Dr. De Bellis and his Healthy Childhood Brain Development research program are part of the Center for Child and Family Health-North Carolina. Thus, Dr. De Bellis and the Center for Child and Family Health-North Carolina staff will recruit subjects directly from the Center for Child and Family Health-North Carolina staff and through child protective service agencies by visiting agencies and describing to case-workers the research study. We will also invite the caseworkers to visit the Healthy Childhood Brain Development Program and have educational meetings on child maltreatment, mental health and brain and cognitive development to be given by Dr. De Bellis and his staff. We will describe our research program to caseworkers then. To assist in recruitment, we offer free comprehensive psychiatric evaluations and recommendations for child and caregiver to eligible families for this study. We also pay the subjects for participation and pay travel expensive to the research program.

To preserve confidentially, parents of eligible subjects at The Center for Child and Family Health-North Carolina will be given the Healthy Childhood Brain Development

Research Program telephone number *by their intake worker or therapist*. To preserve confidentially, parents of eligible subjects at child protective service agencies will be given our Research Program telephone number by their caseworker or clinic staff, so that the subjects can freely contact us. We will also have legal guardians of subjects sign an IRB approved Consent to Contact Form provided to Child Protective Service caseworkers or community therapists who specialized in treating maltreated children that can be faxed by the caseworker to a fax machine located in a private area of the Research Program so that we can contact the legal guardians of subjects directly if they agree to this.

When a telephone call is received or when we contact a subject after we received a signed Consent to Contact Form, research staff will ask about the potential subject interest (i.e.,source of referral) in the study. A brief explanation about the study will be given. Then a verbal informed consent will be given in order for the research staff to collect information to determine if the inclusion /exclusion criteria are met. This information is detailed in our telephone medical screening form. To determine whether or not a potential subject is eligible for this study, a Child Medical Screening form, which involves asking the potential subjects parent or legal guardian Protected Health Information (PHI) needs to be completed to determine eligibility. Eligibility for the study is ultimately determined by the PI from this information. Verbal consent and authorization (C/A) will be obtained before questions concerning PHI are asked. As per the Duke University Health System (DUHS) Institutional Review Board (IRB) Policy on Use of Questionnaires by Telephone or Mail (Version 06/07/04) section 1b this verbal consent explains: 1) Purpose of the telephone call; 2) A Brief description of the research; 3) Who will use the screening information and for how long; and 4) How privacy and confidentiality will be assured. To protect privacy and confidentiality less sensitive information that would exclude a child will be asked first (such as does your child wear braces) before any other and more sensitive information is asked. If the subject is not eligible for the study or if the parent/child decide they do not want to do the study, this information will be immediately destroyed. If the subject is eligible for the study, the medical screening form will become part of the subject's research medical record. If the potential subject is then determined to meet the eligibility criteria for the study, a screening clinical interview (Part I) is set up, and the PI and/or a co-investigator will explain the study in detail and the complete written informed consent for Part I will be signed at this meeting before any clinical assessment data is collected (as described below).

These procedures have lead to the successful recruitment of subjects in the past. Since we provide an evaluation appointment and written recommendations within a reasonable amount of time, our services have been seen as helpful to Child Protective Services staff and our subjects. We will make clinical evaluations available to the caseworkers and schools provided a release of information is signed by the subject's legal guardian.

We believe that recruitment for this study is feasible. The Center for Child and Family Health-North Carolina evaluates appropriately **20-50 maltreated subjects per week (56 per month)**. The referrals come from the Department of Social Services, Law Enforcement and Pediatric Clinics from wide urban and rural areas including Durham, Chatham, Orange, Wake, Vance, Henderson, Johnson and Moore Counties. The percentage in the 6 to 16 year old age is 70% of the overall referrals. Therefore, there are 7 eligible subjects seen per week at The Center for Child and Family Health-North Carolina. If 50% agree to be screen (3-4 subjects per week) and 50% of these subjects meet all inclusion/exclusion criteria for Part II of the study, we will be able to recruit appropriately 1-

2 subjects a week from Part I screening. We need to recruit 28 subjects a year (or 2-3 maltreated subjects per month) for Part II of this study. Therefore, we believe we can recruit a representative sample of maltreated subjects in this age range for this study. These methods, particularly our ability to assist the caseworkers in finding appropriate treatment in the community for these individuals, have led to successful recruitment of maltreated subjects in our ongoing research in the City of Pittsburgh, PA. The numbers of referred children to Child Protective Services are more than adequate to meet our recruitment needs of maltreated children eligible for this protocol. Controls will be recruited by IRB approved advertisements from the same community neighborhoods as our subjects. Our consultants, Frank Putnam, MD., and Ken Dodge, Ph.D. have much experience in this area and will assist in this process.

Special Procedures when obtaining consent by mail. Given our study population it is sometimes necessary to obtain consent from a parent or legal guardian by mail. These circumstances are as follows: 1) when adolescents are in the custody of the Department of Social Services (DSS) and for informed consent, we need the signature of the DSS legal guardian, who may not have time to come to our offices to sign the consent forms. This is especially the case for adolescents from wider geographic region. 2) The parent lives out of state or not within a comfortable driving distance and may not be able to come to our offices to sign the consent forms. This is especially true for 18 to 19 year old subjects who may be in college. In this case, early mental health history can be obtained by telephone from the parent after inform consent is given by mail.

In order to obtain Consent and Authorization (C/A) by Mail, we will follow DUMC IRB guideline attachment 4: Procedure for Obtaining Consent and Authorization (C/A) by Mail. We first obtain verbal consent as outlined and previously approved in this IRB protocol under **Recruitment of subjects: Verbal Consent Procedures.** This procedure is used to contact potential subjects to explain the study and the C/A process. When contact is made by telephone, an IRB-approved script is used to explain the study and to inform potential subjects about the study Verbal consent and authorization (C/A) will be obtained before questions concerning PHI are asked. As per the Duke University Health System (DUHS) Institutional Review Board (IRB) Policy on Use of Questionnaires by Telephone or Mail (Version 06/07/04) section 1b this verbal consent explains: 1) Purpose of the telephone call; 2) A brief description of the research; 3) Who will use the screening information and for how long; and 4) How privacy and confidentiality will be assured. This process was previously approved by the IRB.

After this **Recruitment of subjects: Verbal Consent Procedures** process is undertaken and a subject is determined to be eligible for the study, it will be determined if it is necessary to obtain consent from a parent or legal guardian by mail. Then the following procedures will be undertaken as per the Consent and Authorization (C/A) by Mail, and we will follow DUMC IRB guideline attachment 4: Procedure for Obtaining Consent and Authorization (C/A) by Mail.

1) If it is necessary to obtain consent from a parent or legal guardian by mail the Part I and Part II consents will be mailed to the legal guardian along with a cover letter, after which the parent or legal guardian will be called in about two weeks to answer their questions. The

IRB-approved cover letter will be used to explain the study and give instructions. The cover letter will say:

a. Read the form carefully.
b. Before signing the form, wait until after the researcher calls you to answer questions.
c. Only sign the form if you are willing to participate in the study.
d. Please have another adult sign the form as a witness.
e. And to please send the signed form back to the researcher by mail or fax.

2.The investigators will wait until the signed C/A form has been received before scheduling the subject into the study and before using PHI research purposes.
3.The investigators will mail to the subject's parent or legal guardian a copy of the C/A form that has all the required signatures, i.e., those of the subject, the witness, and the person obtaining C/A to the parent or legal guardian .

Informed consent. At the initial clinical assessment screening appointment, both non-abusing parent (also referred to as the caregiver in this proposal) and child will receive a full explanation of all aspects of the protocol and procedures, including risks and side effects associated with MRI/MRS scan procedures. The parent and the child will understand that acceptance or refusal will not influence any aspects of the clinical care they receive, and further, that they are free to withdraw from the study at any point. The families are encouraged to carefully examine the information, and as stated above are given multiple opportunities over days prior to the study to ask questions to clarify issues. Informed written consent to participate will be obtained from parents and assent will be obtained from the child. Both children and parents will receive written and verbal explanations of the entire research protocol. Also, at this time, written consent for releases of information to obtained information from child protective services, juvenile court, the child's school, and archival (medical) records will be obtained from the child's legal guardian.

Consistent with Federal Guidelines, participants will be informed of the federally mandated reporting laws for child abuse and neglect, verbally and in the written consent form. Specifically, the consent form will read "This protection, however, does not prohibit the investigator from voluntarily reporting information about suspected or known sexual or physical abuse of a child or a subject's threatened violence to self or others. If the researchers learn that you or someone with whom you are involved is in serious danger or harm, they may inform the appropriate agencies". Therefore, a serious, though rare, risk to families is disruption of the home based upon the severity of the abuse or neglect disclosed. A Federal Certificate of Confidentiality has been obtained for this study.

Child abuse reporting. As discussed, all reports made to Child Protective Services will be in accord with the definition, rules and guidelines of federally mandated reporting laws for child abuse and neglect. To be eligible for participation in this study, *we will require that the perpetrator is no longer living with or involved with the maltreated subject in a non-supervised setting.* If a Suspected Child Abuse and Neglect Report is filed, this is not considered an emergency response to an imminent child abuse situation. If in professional opinion it is judged that the subject is continuing to live in an unsafe or abusive environment,

a child abuse report will be filed and arrangements will be made to maintain the subject's safety.

Confidentiality. In conducting research with maltreated children, it is important to protect the privacy of the individuals and families involved. All data that would lead to subject identification will be labeled using a research code number only so that no names will be used in any of the data. Confidentiality of all subject information will be preserved by housing all records and interview tapes in locked files in locked offices. Data will be maintained on a computer accessible only to research project staff. To protect against violation of confidentiality, research training sessions will emphasize the preservation of confidentiality and all research staff will sign a confidentiality agreement. Further, all computerized data will be maintained in a limited access, password-protected hard drive or on floppy disks or CD's locked in files in the research office.

In addition, except under circumstances covered under the mandated child abuse reporting laws, and/or situations in which the child and/or a caregiver is judged clinically to be a danger to themselves or others, no information about the child or family will be shared with any individual or agency without prior written consent.

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APPENDIX C

Components of the CVLT-C

Adapted from the California Verbal Learning Test, Children's Version Manual

Delis, Kramer, Kaplan, & Ober (1994)

Immediate-recall trials:

List A Trial 1- Thought to reflect problems in auditory attention span with intact learning ability.

List A Trials 1-5 total- Provides a global measures of immediate free-recall performance, specific interpretation of low scores on these measures requires an evaluation of the child's learning strategies, recall errors, and performance on the delayed recall and recognition trials.

List B-Immediate recall- The child is asked to repeat this list after List A has been recollected five times. Poor scores on both the list B and list A Trial 1, with normal scores on list A Trial 5 and the List A Trials 1-5 total, provide evidence for an attenion deficit in the face of intact learning.

List B vs. List A Trial 1- Performance on List B can be adversely affected by the 5 previous List A trials. A low scaled-score on this contrast measure, that compares immediate free-recall of List B with immediate free-recall of List A Trial 1, is thought to reflect an unusually high degree of proactive inferences.

Learning strategies Across Trials 1-5:

Semantic Clustering Score- is indicative of the degree to which a child uses the active learning strategy of reorganizing the target words into categorical groups. It is a highly effective learning strategy that can aid in allowing words to be categorized into higher order semantic units for more efficient encoding and retrieval. On the other hand, low Semantic

Clustering scores correlate with poor performance on the CVLT-C recall measures and suggests a less effective or haphazard learning strategy.

Serial Clustering Score- assesses the degree to which the examinee recalls target words in the same order in which they are presented. The use of this strategy is thought to reflect a "Stimulus-bound" response style, where the child adheres rigidly to the temporal order of the list when recalling the list, thus high scores on this cluster are correlated with poor performance on the CVLT-C recall measures, although in some cases children with superior memory may use serial clustering to make the challenge more difficult.

Middle Region Recall- children typically recall a higher percentage of words from the primacy (beginning) and recency (end) regions of a list than from the middle region. Poor recall of primacy region and middle region words in conjunction with considerably better recall of recency-region words is thought to indicate a passive learning style of echoing the last words presented. Average to above average scores on the primacy-region and middle-region measures correlate with normal savings or retention rates over the short-delay and long-delay intervals.

Learning Slope- This index reflects the average number of new words per trial that a child is able to recall across Trials 1-5. A learning slope of one suggests that a child is able to learn an average of 1 new word per trial. A slope value near zero may mean the child quickly reaches a learning plateau, a slope value of greater than 1 reflects sizeable increase in new words recalled from trial to trial.

Percentage of Recall Consistency- Proportion of target words recalled on one to the first four trials that are also recalled on the very next trial. Low recall consistency suggests

haphazard or disorganized styles of learning and may indicate the child has difficulty formulating or maintaining a new learning plan.

Short-Delay Free-Recall Trial- This index provides a global measure of a child's delayed recall. Specific interpretation of low scores requires an evaluation of the child's short-delay savings score, recall errors, and recognition performance. Because memory researchers differ in their operational definitions of the constructs short and long term memory, interpretations can be task specific.

Short-Delay Free-Recall Savings Score- a low savings score may be related to the combination of an unusually rapid forgetting rate during the delay interval and retroactive interference, average to above average score suggests normal storage of information over time and normal vulnerability to retroactive interference

Short-Delay Cued-Recall Trial- a poor free-recall performance combined with a considerably better cued-recall performance may suggest problems in retrieval contribute significantly to the child's memory deficits. A worse cued-recall performance than free-recall performance may suggest the presence of a developmental verbal disability. The cued-recall trial requires the retrieval of words according to their semantic categories; a language based strategy that might overly tax the child's already deficient verbal abilities.

Intrusion Errors- the number of responses not on the target list- should be considered. Some children with impaired memory will confabulate, naming many items that are members of the categories provided by the examiner. If a child exhibits markedly elevated intrusion rates on cued recall tasks they may be reporting some of the target words by accident, a product of confabulation rather than accurate memory.

Long-Delay Free-Recall Trial- this provides a global measure of a child's level of recall after a 20-minute interval that is free of interfering material. Interpretation requires an evaluation of the child's short-delay free-recall score, short-delay savings score, long-delay savings score, recall-error measures, and recognition performance.

Long-Delay Cued-Recall Trial- this contrast measure reflects the proportion of words a child recalled on the short-delay free-recall trial that are also recalled on the long-delay free-recall trial. A low score might reflect an unusually rapid forgetting rate during the delay interval. It might also suggest that a childs short-delay savings performance is below normal while their long-delay savings performance is normal. A pattern such as this may suggest above average vulnerability to retroactive interference arising from the presentation of list B during the short-delay interval, and normal storage of information over time as long as the delay interval is free of interfering material. An above average long-delay savings score is thought to indicate a child profited from the category cues provided by the examiner during the intervening short-delay cued-recall trial- learned to use semantic clustering to a greater degree as a result of being asked by the examiner to recall words according to their semantic categories. This can be confirmed when the child's semantic cluster score is higher on the long delay free recall trial than on the short delay free recall trial.

Recall Error Measures:

Perseveration Errors- repetitions of previous responses during the same trial. An elevated rate (scaled score of 1 or higher) is thought to reflect a source of memory impairment.

Intrusion Errors- responses that are not on the target list. Elevated scores (scaled score of 1 or higher) can reflect different kinds of memory problems or other cognitive difficulties and exist on a continuum of minor to serious (type and number).

Synonym Intrusions- substituting a synonym for a target word (coat for jacket), more minor, occur in children of below average intelligence but with no memory impairment.

Cross-Trial Intrusions- more serious when a word from a former list is inserted into a later list. A high number of these may suggest a memory impairment of not being able to remember the source of a word retrieved. Can be proactive or retroactive in nature.

Semantically Related Intrusions- extra list responses that are semantically related to categories on the target list (apple, shirt) are considered to indicate a possibly serious memory problem, possibly indicating confabulatory tendencies. A high level of these often correlates with low levels of recall and recognition memory.

Semantically Unrelated Intrusions- most serious type where words are totally unrelated. A large number of these suggests impaired memory in conjunction with significant deficits in other cognitive functioning such as language or attention.

When intrusions are given primarily to cued-recall rather than free-recall trills the external prompting of the examiner may be responsible for the triggering the tendency to confabulate.

Recognition Measures:

Correct Recognition Hits- the number of List A words a child endorses as correct on the recognition trial, but should not be interpreted in isolation since a high rate would result if someone said yes to every item.

Recognition False Positives- takes into account both hits and false positives and provides the best measure of overall recognition performance. An average to above average score is obtained when a child endorses target words (hits) and rejects distractor items. Low discriminability likely occurs as a result of either: a high hit rate with a high false-positive rate, child has failed to distinguish target words from distractor words accurately, thought to

reflect serious encoding or storage deficit combined with confabulatory tendencies. Or from a low hit rate combined with a low false positive rate, reflecting a serious encoding/storage deficit without confabulatory tendencies, or may be suggestive of an antagonistic toward testing and adopted a rigid no response bias.

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