Published in final edited form as:
Child Maltreat. 2013 August ; 18(3): 171–183. doi:10.1177/1077559513497420.

Neuropsychological Findings in Pediatric Maltreatment: Relationship of PTSD, Dissociative Symptoms, and Abuse/ Neglect Indices to Neurocognitive Outcomes

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Abstract

Maltreated (n=38), maltreated+posttraumatic stress disorder (PTSD)(N=60), and control youth (N=104) underwent comprehensive neuropsychological testing. The two maltreated groups performed significantly lower on IQ, Academic Achievement, and nearly all of the neurocognitive Domains than controls. Maltreated+PTSD performed significantly worse than maltreated youth without PTSD on a task in the Visuospatial Domain that assessed higher-order visuoconstructive abilities. No group differences were evident on the Fine-Motor Domain. PTSD diagnosis duration negatively correlated with the Visuospatial, and dissociation negatively correlated with the Attention Domain. Cumulative lifetime maltreatment types experienced negatively correlated with Academic Achievement. Sexual abuse negatively correlated with Language and Memory functions after controlling for other maltreatment types. These data support the adverse effects of maltreatment on neuropsychological functions in youth, and suggest that all child protective services identified youth should be comprehensively examined for the integrity of their neuropsychological functioning and academic skills, regardless of the presence or absence of mental health symptoms.

Introduction

Although maltreated children represent a small percentage of the pediatric population, the effects of maltreatment on an individual and society are disproportionately high (Wang & Holton, 2007). Developmental traumatology is the systemic investigation of the psychobiological impact of chronic interpersonal violence on the developing child (De Bellis, 2001). This field provides a theoretical framework for increasing our understanding of psychopathology, brain differences, and neuropsychological deficits associated with child maltreatment. In developmental traumatology research, youth identified as maltreated by child protective services (CPS) are an unfortunate naturalistic model of the psychobiological effects of chronic and severe stress in childhood.

The developmental traumatology model is based on a psychobiological model of posttraumatic stress disorder (PTSD) often called the “fight-or-flight or freeze reaction” (for

Conflict of interest: None declared.

review see (De Bellis & Thomas, 2003). PTSD occurs in response to child maltreatment, a DSM-IV-TR type A or life threatening trauma. PTSD prevalence rates in maltreated children are high; 40–60% of sexually abused children have PTSD following abuse disclosure (Famularo, Fenton, & Kinscherff, 1993; McLeer et al., 1998). Physical abuse is associated with PTSD, with rates as high as 50% (Dubner & Motta, 1999; Green, 1985). Domestic violence is commonly witnessed by neglected children (Burns et al., 2004) with resultant high PTSD rates of about 36% (De Bellis, Hooper, Spratt, & Woolley, 2009). The psychobiological model of PTSD suggests that fear and traumatic reminders associated with child maltreatment experiences are processed through the brain’s thalamus, activating the amygdala, a center of the brain’s fear circuit. The amygdala then transmits fear signals to neurons in the prefrontal cortex, hypothalamus, and indirectly to the hippocampus, a brain structured involved in memory, which indirectly causes elevated cortisol response. There is also increased activity in the locus coeruleus in the brainstem, which then increases sympathetic nervous system activity, stress related neurotransmitters (catecholamines), heart rate, blood pressure, metabolic rate, and alertness. These changes prepare the body to protect itself from ancient enemies (e.g., lions), but are not necessarily healthy when they persist in unequal and stressful human social relationships, such as between a maltreating parent and child. These stress chemicals impair the brain’s prefrontal cortex and executive functions (Arnsten, 1998). The prefrontal cortex in turn can inhibit amygdala activation, a mechanism that may be responsible for remission of PTSD symptoms (LeDoux, 1998). Thus, the developmental traumatology model, based on a static psychobiological model of PTSD, would predict that maltreated youth would show specific deficits in prefrontal executive functions and memory. However, a dynamic developmental traumatology model also predicts that the developing stress system affects multiple brain functions that may have initially been related to acute PTSD symptoms, but which then trigger independent adverse developmental effects. Thus, an early trauma shared mechanism may cause global and multiple neuropsychological deficits in domains that are not related to current PTSD symptoms or psychopathology.

The few available studies in CPS identified youth support both the static and dynamic developmental traumatology model. PTSD secondary to maltreatment is associated with elevated 24 hour urinary (De Bellis, Baum, et al., 1999) and salivary (Carrion et al., 2002) cortisol and urinary catecholamine (i.e., dopamine and norepinephrine) (De Bellis, Baum, et al., 1999) concentrations compared to non-maltreated children. PTSD symptoms have significant overlap with depression. Maltreated children with internalizing problems show cortisol dysregulation (Alink, Cicchetti, Kim, & Rogosch, 2012; Bruce, Fisher, Pears, & Levine, 2009; Gunnar, Morison, Chisholm, & Schuder, 2001; Hart, Gunnar, & Cicchetti, 1996; Kaufman, 1991; Kaufman, Birmaher, Perel, et al., 1997) and elevated catecholamines (Queiroz et al., 1991). During development, elevated catecholamine and cortisol levels can lead to adverse brain maturation through a variety of mechanisms (De Bellis, 2001). Early life stress impairs the function of the brain-derived neurotrophic factor gene, whose actions are important for normal brain development and neuropsychological function (for review see (Roth & Sweatt, 2011). In fact, the few studies that examined brain maturation in maltreated children with PTSD or sub-threshold PTSD symptoms show smaller cerebral (Carrion et al., 2001; De Bellis, Keshavan, et al., 1999; De Bellis et al., 2002) and cerebellar (De Bellis & Kuchibhatla, 2006) brain volumes compared to non-maltreated children.

However, the relationship between PTSD that is secondary to maltreatment in CPS identified youth to brain structure and neuropsychological function is vastly understudied. Data from maltreated youth may differ from those of studies in adults who have child maltreatment histories. Pediatric studies show that younger age of onset and longer duration of trauma are associated with smaller brain volumes and elevated biological stress chemicals (De Bellis, Baum, et al., 1999; De Bellis, Keshavan, et al., 1999) indicating cumulative neuro-effects of trauma. Although studies in adult PTSD suggest that the hippocampus, a stress-sensitive glucocorticoid receptor-rich limbic structure which is important for memory, is smaller in adult PTSD (Kitayama, Vaccarino, Kutner, Weiss, & Bremner, 2005), no hippocampal differences are seen in cross sectional studies of pediatric PTSD (Carrion, et al., 2001; De Bellis, Keshavan, et al., 1999; De Bellis, et al., 2002). However, one prospective study showed that both PTSD symptoms and cortisol levels predicted hippocampal reductions over time (Carrion, Weems, & Reiss, 2007). The few studies of adults with PTSD secondary to maltreatment as children show decreased cerebral frontal and grey matter volumes (Fennema-Notestine, Stein, Kennedy, Archibald, & Jernigan, 2003), a global effect, as well as decreased cerebral white matter and hippocampal volumes (Villarreal et al., 2002), a specific brain structural effect.

Most neuroimaging studies in adults support the static psychobiological model of PTSD. These studies show that adults with PTSD secondary to child maltreatment demonstrated hypoactivation of the prefrontal cortical regions and associated regulatory executive and attentional functions, and hyperactivation of the affective emotional circuits (that include amygdala and hippocampus) in response to aversive stimuli (Bremner et al., 1999; Bremner et al., 2005; Shin et al., 1999). Limited neuroimaging studies on maltreated youth also suggest dysregulation in executive attentional and inhibitory circuits and hyperactivation of the affective emotional circuits involving the hippocampus and amygdala (Carrion, Garrett, Menon, Weems, & Reiss, 2008; De Bellis & Hooper, 2012; Maheu et al., 2010; Mueller et al., 2010; Tottenham et al., 2011). Thus, maltreatment as seen through a static developmental traumatology PTSD mechanism can theoretically lead to specific impairments in prefrontal executive functions and memory in accord with this psychobiological model of PTSD. However, the developing stress system affects multiple brain functions so maltreatment experiences may have effects on multiple neuropsychological domains that are not related to PTSD symptoms and remain understudied.

Neuropsychological assessments, based on human research on children and adults with brain lesions compared to those without lesions, has traditionally provided a reliable and valid method for assessing specific cognitive functions that are associated with specific brain regions (Spreen, Risser, & Edgell, 1995; Spreen & Strauss, 1998). However, to date most neuropsychological assessments in CPS identified maltreated children have focused on global measures such as IQ or one or two specific domains such as executive function, which reflects prefrontal cortex, and memory which reflects hippocampal integrity. For example, in cross-sectional studies, maltreatment is associated with lower IQ, language, and academic achievement compared to non-maltreated children (Aber, Allen, Carlson, & Cicchetti, 1989; Carrey, Butter, Persinger, & Bialik, 1995; R.E. Culp et al., 1991; Eckenrode, Laird, & Doris, 1993; McFadyen & Kitson, 1996; Trickett & McBride-Chang, 1995) while childhood trauma is associated with specific deficits in executive dysfunction (DePrince, Weinzierl, & Combs, 2009; Fishbein et al., 2009). The few longitudinal studies also demonstrate that children at risk for maltreatment have lower IQ, language, and academic achievement (Zolotor et al., 1999) and that in substantiated cases of maltreatment, lower IQ and reading ability are seen in adolescence and adulthood (Lansford et al., 2002; Mills et al., 2011; Noll et al., 2010a; Perez & Widom, 1994; Strathearn, Gray, O'Callaghan, & Wood, 2001; Trickett, McBride-Chang, & Putnam, 1994).

There have been relatively few studies that have comprehensively examined all neuropsychological domains in CPS identified maltreated children who were carefully assessed for medical exclusions and for a diagnosis of PTSD. In a pilot study, maltreated youth with abuse-related PTSD performed more poorly on measures of attention and abstract reasoning/executive function than non-maltreated sociodemographically matched children (Beers & De Bellis, 2002). In a study comparing neglected children with and without PTSD secondary to witnessing interpersonal violence, those with PTSD performed worse on the NEPSY Memory for Faces-Delayed than neglected children without PTSD and non-maltreated children (De Bellis, et al., 2009). In a community sample of children who witnessed intimate partner violence, those children with PTSD performed worse on the California Verbal Learning Test–Children's Version compared to children without PTSD; while both groups were below average on measures of executive functioning, attention, and IQ (Samuelson, Krueger, Burnett, & Wilson, 2010). These findings suggest that maltreated children with PTSD may have more neuropsychological deficits across different cognitive abilities when compared to maltreated children without PTSD, and but also supports a dynamic developmental traumatology model; that is, an early trauma may cause global neuropsychological deficits that are not related to current PTSD symptoms.

In this study, we comprehensively examined domains of neuropsychological functioning across three groups of medically healthy children and adolescents: maltreated+PTSD, maltreated, and a healthy non-maltreated control group. In accordance with both a static and dynamic Developmental Traumatology Model (De Bellis, 2001), we hypothesized that both groups of maltreated children would perform significantly lower than the non-maltreated group on all neuropsychological domains, but that the maltreated+PTSD group would perform significantly worse than the maltreated and control groups on measures of executive function and memory. We also examined the relationship between neuropsychological domains, PTSD and dissociative symptoms, PTSD duration, psychopathology, and lifetime summary of maltreatment types experienced to test the Developmental Traumatology Model, which predicts that maltreatment gives rise to cognitive deficits through PTSD symptoms and trauma severity. We hypothesized that in maltreated youth, both PTSD and dissociative symptoms and greater severity of maltreatment would predict poorer outcomes across all neuropsychological domains. This study also included a planned exploration to investigate if specific types of abuse and neglect would be associated with specific neuropsychological domains while controlling for maltreatment severity.

Methods

Participants

Participants are described in Table 1. The maltreated groups were defined by a positive forensic investigation with CPS that indicated physical, sexual, emotional abuse or neglect as defined by state criteria and disclosed within the 6 months prior to study entry. Maltreated participants were recruited through statewide advertisements and recruitment presentations targeted at CPS agencies. To reduce bias, the study was advertised to CPS in North Carolina on a statewide level and participants who lived more than 75 miles from the Research Program were given overnight accommodations. To be eligible for this study, we required that maltreated participants not be living with a perpetrator unless this was done in accord with active CPS supervision.

The non-maltreated group was recruited from schools and other community settings from the surrounding catchment area and had a negative screen on both telephone interview for eligibility and research interview for any history of participant or participant sibling having CPS involvement. The three groups were similar in age, gender distribution, handedness, racial/ethnic distribution, height, and weight. Despite attempts to control for socioeconomic status (SES) between groups, lower SES children recruited as members of the comparison group were more likely to meet exclusionary criteria. Lower SES is an inherent confound and risk factor in maltreatment and child studies (Gilman, Kawachi, Fitzmaurice, & Buka, 2003; Lansford, et al., 2002).

Exclusion criteria were: 1) IQ< 70; 2) a disability that made a comprehensive interview of the youth difficult; 3) significant medical illness, head injury, or neurological disorder; 4) schizophrenia, anorexia nervosa, psychosis history, autism or pervasive developmental disorder; 5) birth weight < 5 lbs., or severe prenatal (e.g., significant fetal alcohol and/or drug exposure) or perinatal compromise with NICU stay; 6) current or lifetime alcohol or substance use disorder (defined as DSM-IV abuse or dependence); 7) Axis I disorder or report of maltreatment that warranted CPS investigation or maltreatment reported during the interview that would meet the state criteria for investigation in non-maltreated controls.

All participants underwent 6 to 8 hours of clinical research assessments. Assessments were usually done by research associates under the supervision of a child neuropsychologist. All maltreated participants received a free and comprehensive psychiatric and psychological evaluation which they could make available to their primary treatment provider or school personnel. The local university hospital IRB committee approved the study. Legal guardians gave informed consent and children assented prior to participation.

Measures

Clinical Measures—Kiddie Schedule for Affective Disorders and Schizophrenia- Present and Lifetime Version (K-SADS-PL)(Kaufman, Birmaher, Brent, et al., 1997) semi-structured interview was administered to caregivers and youth to assess for major DSM-IV-TR diagnoses including PTSD in the maltreated youth for group identification and to confirm lack of maltreatment and psychiatric diagnosis in controls. The KSADS-PL was modified to include: 1) life event questions, including traumatic events from the Child and Adolescent Psychiatric Assessment (Angold & Costello, 1995); 2) disorders not present in the KSADS-PL; 3) a structured scale 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 to determine Axis I psychiatric disorders based on DSM-IV criteria. 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. Because multiple sources of information are needed to gather accurate maltreatment history and related symptoms (Kaufman, Jones, Stieglitz, Vitulano, & Mannarino, 1994), we additionally used archival records (e.g., birth records, pediatric records, school attendance records, forensics records, and CPS records) as sources of mental health symptoms, trauma history, birth history, and pediatric health for inclusion/exclusion criteria and as responses in the trauma section of the KSADS in addition to interview data. These archival records were collected on all participants and in some cases lead to exclusion of subjects (e.g., controls for maltreatment history or maltreated subjects for positive birth urine toxicology).

Child maltreatment was defined as witnessing domestic violence (which was state defined as neglect by omission or commission and/or emotional abuse), physical abuse, sexual abuse, emotional abuse, and/or neglect. All participants were asked detailed questions about early adverse life events, including maltreatment events. Discrepancies were resolved by reviewing archival information or by re-interviewing the child or caregiver. If diagnostic disagreements were not resolved with this method, consensus diagnoses were reached among a clinically experienced child psychiatrist and child psychologist. Since studies show that most CPS involved maltreated children suffered from several types of abuse and neglect (Kaufman, et al., 1994; Levy, Markovic, Chaudry, Ahart, & Torres, 1995; McGee, Wolfe, Yuen, Wilson, & Carnochan, 1995; Widom, 1989), we created six maltreatment indices to comprehensively examine both maltreatment type and severity. The *failure to supervise* variable was composed of adding positive responses to any of seven questions regarding this variable: a) neglect resulting in serious accidents; b) caregiver not knowing child's whereabouts; c) being left home alone without an adult or babysitter prior to age 8 years; d) unexplained school absences; witnessing caregiver e) using drugs or f) drunk; and, g) exposure to inappropriate adult sexual activity. *Failure to provide* was defined using three questions regarding basic physical or medical care (i.e., being hungry and having no food, going to school with dirty clothes, and failing to provide medical care when ill). *Physical abuse* was defined using five questions regarding discipline by a caregiver resulting in bruises or a serious injury sustained on one or more occasions, or resulting in severe pain, scars; or being pushed into objects, shaken, burned or being threatened with a deadly weapon. *Witnessing interpersonal violence* was defined using ten questions regarding: a) witnessing a threatening or violent crime where significant injury occurred or could have occurred; b) witnessing a traumatic violent death; c) being the victim of a serious threatening or violent crime not perpetrated by a caregiver; d) being present during threats to important attachment figures; witnessing explosive arguments involving threatened or actual harm to e) caregivers or f) other family members; g) hearing about a potentially life threatening fight involving threats or harm to attachment figures that occurred at home; h) witnessing adults in an uncontrolled explosive rage; or, i) witnessing or, j) hearing about other family members' attempts to hurt themselves. *Emotional abuse* was defined by three questions regarding an episode of 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 a question regarding multiple isolated incidents of genital fondling, oral sex, or vaginal or anal intercourse by a person in a caregiver capacity (i.e., incest). None of the sexually abused subjects in this study reported only one isolated incident of sexual abuse, and these cases involved removal of the perpetrator from the home.

The *Child Behavior Checklist* (Achenbach, 2003) T-scores were used as a valid measure of internalizing and externalizing behavior problems reported by the child's caregiver.

The *Child Dissociative Checklist (*Putnam & Peterson, 1994) score was used as a valid measure of dissociative experiences that were reported by the child's major caregiver.

Children Global Assessment Scale score (Shaffer et al., 1983) was provided by the interviewer after assessment of all clinical data collection to provide a continuous variable measure of child global function.

Neuropsychological Measures—These measures were given in the morning while caregivers underwent the KSADS-PL interview. Youth completed their KSADS-PL interview after the cognitive tasks so they would not be asked about potentially upsetting life event questions prior to the testing. The neuropsychological battery of tasks was age-appropriate, psychometrically sound, comprehensive, and appropriate for a maltreatment sample (Gabowitz, Zucker, & Cook, 2008). The neuropsychological domains were IQ, fine-motor, attention, language, visuospatial, memory and learning, executive function, and academic achievement. Note the outcome variables from each of the measures were age-based standard scores.

All participants were administered the abbreviated version (Vocabulary and Block Design) of the age-appropriate Wechsler Intelligence Scale for IQ (e.g., Wechsler Intelligence Scale for Children-III, (Wechsler, 1991). Because controlling for IQ is a debatable question in neuropsychological research as it has produced overcorrected, anomalous, and counterintuitive findings about cognitive functions (Dennis et al., 2009) and was demonstrated to be lower in maltreated participants followed prospectively (Perez & Widom, 1994), IQ was employed as an outcome measure in this study.

Caregivers underwent a two-subtest (Vocabulary and Matrix Reasoning) IQ test using the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) to control for environmental stimuli in the current home and familial factors. Note most IQ data were obtained from a biological parent or grandparent in this study, even if their child was not living with them, as it was possible to gather biological parent IQ from investigative record review and/or adoption records if biological parent were not available.

The fine-motor domain consisted of the *Finger Tapping Test* (Shimoyama, Ninchoji, & Uemura, 1990) and *Grooved Pegboard Test (*Heaton, Grant, & Matthews, 1992). Both of these measures provide estimates of fine motor speed and control, bilaterally, with the Finger Tapping Test assessing simple fine-motor speed and the Grooved Pegboard assessing more complex fine-motor speed and control.

The attention domain consisted of the *Conners' Continuous Performance Test-II (CPT-II) (*Conners, 2000). The CPT-II is a computerized continuous performance measure that requires the participant to inhibit their response each time they see a targeted letter. The CPT-II provides estimates of sustained attention, inhibitory control, and performance variability.

The language domain consisted of the *Peabody Picture Vocabulary Test-III* (Dunn & Dunn, 1997) and the *Concepts and Directors Subtest* from the *Clinical Evaluation of Language Fundamentals (*Semel, Wiig, & Secord, 2003). These tasks provide for an estimate of receptive vocabulary and increasingly complex receptive language, respectively.

The visual-spatial domain consisted of two tasks, *Rey-Osterrieth Complex Figure Test-Copy* Condition (Duley et al., 1993) and the *Judgment of Line Orientation Test(*Benton, Varney, & Hamsher, 1978). These measures provided estimates of higher-order visuoconstructive abilities and two-dimensional visual-spatial functions, respectively.

The memory and learning domain consisted of three tasks: the *Test of Learning and Memory (TOMAL)Paired Recall Subtest (*Reynolds & Bigler, 1996*), Symbol-Digit Paired Associate Learning Test (*Ryan & Butters, 1980), and the *California Verbal Learning Test (CVLT) (*Delis, Kramer, Kaplan, & Ober, 1994). These memory measures were selected to provide assessment of both visual and verbal memory, and learning using paired associate and multiple repetition paradigms.

The executive domain consisted of a selected number of tasks to reflect the complexity of this domain. Specifically, we selected tasks to gain estimates of inhibitory control with the *CPT-II errors of commission* and the *Stroop Color and Word Test interference score (*Stroop, 1935), working memory *with the Woodcock Johnson Test of Cognitive Abilities-III Numbers Reversed Subtest (*Woodcock, McGrew, & Mather, 2001b), and cognitive flexibility with the perseverative response measure of the computerized *Wisconsin Card Sorting Test (*Fortuny & Heaton, 1996).

The Academic Achievement domain consisted of the *Woodcock-Johnson-III (WJ-III)* Tests of Academic Achievement Reading and Mathematics subtests (Woodcock, McGrew, & Mather, 2001a).

Data Analyses

Preliminary data analyses examined differences among the three groups on demographic variables using either Chi Square or analysis of variance (ANOVA). To address the research questions regarding hypothesized neuropsychological differences between groups, we first engaged in data reduction strategies and constructed neuropsychological domains.

Specifically, these domains were created by calculating a mean of the standard scores for each test that made up each neuropsychological domain. To address the first research question pertaining to group differences on the IQ, academic achievement, and neuropsychological variables, we conducted an analysis of covariance (ANCOVA) for IQ, and a series of multivariate analyses of covariance (MANCOVAs) for each of the domains For any significant ANCOVA or MANCOVA, univariate procedures were conducted to examine which tasks produced the group differences. Follow-up pairwise comparison using Tukey-Kramer HSD was then used to determine which groups were different from one another. Partial Eta Square (η^2) was reported to reflect effect sizes for significant group differences (Small = .01–.05; Medium = .06–.13; Large > .14)(Cohen, 1988).

To address the second research question, Pearson correlations were used to examine the relationships between clinical measures and each neuropsychological domain. For these correlations, we hypothesized significant relationships between targeted maltreatment variables and the neurocognitive functions in accordance with the developmental traumatology model. Consequently, the p value was set at < .05. To address the magnitude of the relationship between different types of maltreatment and its severity, we examined partial correlations for the six maltreatment indices adjusted for the other maltreatment indices, within each neuropsychological domain. Because these latter analyses resulted in 48 planned exploratory comparisons, we lowered the p value to <.01 as the threshold for significance.

Results

Maltreatment and clinical characteristics

As seen in Table-1, maltreated children with PTSD showed higher levels of dissociative symptoms, internalizing and total behavior problems on the CBCL, and lower levels of global assessment of function than maltreated children without PTSD and comparison subjects, forming three distinct clinical groups. Externalizing behavior problems on the CBCL were similar between the two maltreatment groups, who were both significantly more symptomatic than the controls. Maltreated children with PTSD also had experienced significantly more lifetime types of maltreatment experiences, greater physical abuse without head trauma, and greater current PTSD symptoms than maltreated children without PTSD. Note SES and caregiver IQ were lower in the maltreated children with PTSD than the controls, but did not differ from the maltreatment group. Non-maltreated children were also more likely to be living with biological parents, while living arrangements did not differ between the two maltreatment groups. Thus, SES, child's current living arrangements, and caregiver IQ were considered as covariates in group analyses.

Group Comparisons

As can be seen in Table 2, the comparison group performed significantly better on most domains than the two maltreated groups, There were no group differences in the Fine-Motor Domain. Follow-up univariate analyses revealed this pattern to be present on many of the measures within each of the domains, with effect sizes ranging from small (Attention) to large (Language). In general, the two maltreated groups performed below the control group, with only one task reflecting a significant difference between the maltreated groups with and without PTSD. Specifically, on the Rey-Osterrieth Complex Figure-Copy Condition, a measure of visuoconstructive abilities, the Maltreated Group with PTSD performed within a deficient range and significantly below both the Maltreated Group without PTSD and the Controls. Effect sizes on the Rey-O fell within the small to moderate range.

Relationship of clinical symptoms with neuropsychological function

As shown in Table-3, the magnitude of the relationship between clinical symptoms and neuropsychological functioning was small. Specifically, the duration of PTSD diagnosis negatively correlated with the Visuospatial Domain (i.e., the longer the duration, the lower the visuospatial function);the Child Dissociation Checklist Score negatively correlated with the Attention Domain (i.e., the more dissociation, the lower the attention); and the Lifetime Summary of Maltreatment Types a youth experienced negatively correlated with the Education Domain (i.e., the more maltreatment types experienced, the lower the education score). Note that PTSD symptoms and parent ratings of internalizing or externalizing psychopathology on the CBCL did not significantly correlate with any of the neuropsychological domains.

The relationship between maltreatment type and severity and neuropsychological function

As shown in Table-4, only the sexual abuse index significantly and negatively correlated with two major neuropsychological domains (Language and Memory) when controlling for all other types of maltreatment and their severity. This suggests that sexually abused children have poorer cognitive outcomes compared to children who experience other forms of maltreatment, with the impact being largely related to receptive language and general memory abilities.

Discussion

The Maltreated+PTSD group showed a clinically distinct profile from maltreated children because the former experienced a greater number of maltreatment types, physical abuse severity, PTSD and dissociative symptoms, lower levels on the Children's Global Assessment Scale and had greater internalizing and total behavior problems compared with the maltreated youth. However, neuropsychological results did not reveal clearly distinct profiles between the two maltreatment groups. Both maltreatment groups performed similarly and significantly worse on IQ, overall academic achievement, and nearly all of the neurocognitive domains except Fine-Motor. Even when testing for PSTD as a continuous variable, there were no correlations between current PTSD symptoms and neuropsychological domains; nor were there correlations with other measures of internalizing or externalizing psychopathology. Experiencing a greater number of maltreatment types was negatively associated with the Academic Achievement Domain, suggesting cumulative effects of trauma unrelated to PTSD. These data support a dynamic Developmental Traumatology Model where an early trauma shared mechanism causes global and multiple neuropsychological deficits that are not related to current PTSD symptoms or psychopathology. This study provides further and more detailed support for a number of studies showing the presence of lower IQ, academic achievement, and neurocognitive abilities in maltreated children that seem unrelated to psychopathology (for reviews see (Hedges & Fu, 2011; Wilson, Hansen, & Li, 2011). These findings have implications for public policy, suggesting that all CPS identified youth should receive a comprehensive examination to determine the integrity of their neuropsychological functioning and core academic skills, and offered appropriate educational and therapeutic services, as needed, regardless of the presence or absence of mental health symptoms.

Despite these findings showing a lower performance in our maltreated groups when compared to controls, our study did show some support for specific negative effects on complex visuoconstructive functions that involve executive function-related components in the maltreated+PTSD group (i.e., a static Developmental Traumatology Model). Visuoconstructive abilities, as measured by the Rey-Osterrith Complex Figure (Copy Condition), comprise not only visual-spatial abilities, but also visual organization and other executive function-related components such as planning (Watanabe et al., 2005), which would be in keeping with the static model of developmental traumatology. In addition, our findings reflected a relationship between maltreatment variables and neurocognitive functioning such that a longer duration of the diagnosis of PTSD correlated with lower visuospatial functions. These findings would be consistent with studies showing smaller posterior corpus callosum in pediatric maltreatment-related PTSD which suggest differences in posterior parietal regions (De Bellis & Keshavan, 2003) and is in accord with our visuospatial findings. Anatomical and functional neuroimaging studies also suggest altered hippocampus function, which is involved in spatial memory, in youth with PTSD (Carrion, Haas, Garrett, Song, & Reiss, 2010; Carrion, et al., 2007). Although our data did not support differences in specific executive functions in the two maltreatment groups (i.e., Attention/Executive), we did see group differences in visual-spatial abilities that involved higher order executive function-related functions, which provide some support for our hypotheses that the developmental traumatology model predicts poorer executive function in the maltreated +PTSD group compared to maltreated youth. A recent study suggests that maltreated youth had poorer performance to an executive function measure composite (composed of working memory, inhibition, auditory attention, and processing speed tasks) after controlling for anxiety, dissociation, SES, and potential traumatic brain injury (DePrince, et al., 2009). Taken together with our data, it seems that the relationship between PTSD status and performance on tasks involving not only visuospatial skills but complex executive functions (e.g., like the Rey Complex Figure: Copy) is multifaceted and not directly related to current PTSD symptoms.

Further, in this study the Child Dissociation Checklist Score was negatively correlated with the Attention Domain. Dissociative symptoms are defined as disruptions in the usually integrated functions of consciousness, memory, identity, or perception of the environment that interferes with the associative integration of information and could potentially interfere with selective attention (Putnam & Peterson, 1994). The neuropsychological underpinnings of dissociation are understudied at the cognitive level in youth; but may be an indirect pathway from trauma, PTSD symptoms, and neuropsychological function. Similar to our data, adults with high scores on the dissociative experiences scale showed more interference in a selective-attention task than those adults with low scores (DePrince & Freyd, 1999). Dissociative symptoms reported during forensic interviews in sexually abused children predicted attention problems at 8–36 month follow-up (Kaplow, Hall, Koenen, Dodge, & Amaya-Jackson, 2008). In this latter study, PTSD only indirectly predicted later attention problems through its relationship with dissociation. Our data support the importance of assessing both neuropsychological function and dissociative symptoms in CPS-identified maltreated children, especially for those being evaluated for attention deficit hyperactivity disorder.

In contrast to our hypotheses, both maltreatment groups performed more poorly on the Memory Domain. The effect size for this finding was large. Some studies (De Bellis, et al., 2009; Samuelson, et al., 2010; Yasik, Saigh, Oberfield, & Halamandaris, 2007), but not all (Beers & De Bellis, 2002), show deficits in verbal and visual memory in pediatric PTSD. Taken together, these data indicate that memory deficits in maltreated children share some common and some distinct mechanism that may be based on both PTSD status and the specific type of memory studied.

Finally, when controlling for all other forms of maltreatment, sexual abuse severity was uniquely associated with a lower performance on the Language and Memory domains. Repeated sexual abuse by a caregiver or other perpetrator may have unique negative effects compared to other forms of maltreatment. Women with substantiated familial childhood sexual abuse, who were studied prospectively from childhood, acquired receptive language at a significantly slower rate throughout development and achieved a lower overall maximum level of language proficiency than sociodemographically similar non-sexually abused females in adulthood (Noll et al., 2010b). Several cross-sectional studies have demonstrated that children and adults with PTSD secondary to childhood sexual abuse show poorer visual and verbal memory compared to those without PTSD (Bremner, Vermetten, Afzal, & Vythilingam, 2004; Moradi, Doost, Taghavi, Yule, & Dalgleish, 1999). However, some studies demonstrated poorer memory skills in adults sexually abused as children regardless of PTSD status (Navalta, Polcari, Webster, Boghossian, & Teicher, 2006; Stein, Hanna, Vaerum, & Koverola, 1999).

This study has several strengths. All maltreated and comparison children were medically screened, healthy, and did not suffer from birth trauma or prenatal alcohol or other substance exposure syndromes, which are commonly seen in maltreated children (Conners et al., 2004; Smith, Johnson, Pears, Fisher, & DeGarmo, 2007) and not addressed in most neuropsychological studies published to date. Surprisingly, there were no group differences between maltreated and non-maltreated children in the Fine-Motor Domain, which has been reported in previous studies (Culp, 1987; Ouyang, Fang, Mercy, Perou, & Grosse, 2008). Fine-motor deficits can occur with prenatal drug exposure or intentional head injury not brought to clinical attention, variables eliminated or minimized in this study. For example, inattention is seen in non-maltreated cocaine-exposed low birth weight children adopted at birth (Chasnoff, 1997; Schneider & Chasnoff, 1992). These types of medical confounds may have influenced previous reports of motor impairment in maltreated children. Furthermore, we excluded IQ < 70 for all subjects. Prospective studies of adults who were abused and neglected before age 11 years demonstrated a mean IQ of 84 with 29.5% having standard scores below 80, and 50% showing reading levels in the deficit range (Perez & Widom, 1994), while the maltreated children in our study had mean IQ’s half a standard deviation higher than in this prospective adult study. In the Mater University Study of Pregnancy, a longitudinal birth-cohort study comprising 7,223 mothers who had enrolled in the study at their first antenatal visit, child abuse and neglect were independently associated with lower scores on the reading component of the Wide Range Achievement Test and the Raven’s Standard Progressive Matrices (Mills, et al., 2011). Our findings in achievement agree with the maltreatment literature and also show that lifetime maltreatment type experiences may cumulatively contribute to educational difficulties. Thus, academic achievement may decline with increasing trauma severity in maltreated children, indicating that educational interventions are needed in maltreated children with or without PTSD and as soon as maltreatment is brought to the attention of authorities. Another strength of this study was that maltreatment data were collected not only from caregiver and youth, but also from multiple sources of archival records. Additionally, our subjects underwent a comprehensive neuropsychological battery of eight major domains. Thus, these data are valuable to maltreatment researchers and policy makers whose major focus is on neuropsychological function and academic achievement and their relationship to brain function and academic outcomes in maltreated children.

This study has several limitations. While our overall sample size was not unreasonably small, the size of each maltreatment group was relatively small and a larger sample size might have uncovered more subtle, but important, differences between the two maltreatment groups. Indeed, with a larger sample size we might have been able to uncover pathways through PTSD symptoms and document the hypothesized relationships between maltreatment indices, PTSD symptoms, and neuropsychological functioning. We were unable to measure timing and duration of all maltreatment experiences. 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. Instead, we created a variable called Lifetime Summary of Maltreatment Types that was a summary of yes/no categories for each of the maltreatment types a youth experienced. Although we used caregiver IQ to control for environmental stimuli in the home and familial factors, the caregivers IQ variable varied in their shared genetic variance (from biological parents to grandparents and in very few cases unrelated caregivers) and the methodology used (either the study generated 2-factor IQ or archival records of full scale IQ of the biological parent). Since the addition of caregiver IQ did not alter the pattern of results, we believe our data are somewhat stronger because the findings persisted when controlling for our caregiver IQ variable. In real world maltreatment research, caregiver IQ was our best measure of environmental stimuli in the home and familial factors. However, it was not meant to be used as a sole measure of genetic risk for cognitive function. Lastly, our study is cross-sectional, and neuropsychological and academic functions in maltreated children will require ongoing study in longitudinal samples to comprehensively inform public policy.

Clinical Implications and Summary

Our study provided additional support for the growing pediatric literature linking maltreatment to comprehensive neuropsychological functions and academic outcomes. This study complements a number of other studies that have documented an array of cognitive impairments in CPS identified maltreated children, but this study expands on previous works by its use of the Developmental Traumatology Model to guide our conceptualization; and by being comprehensive in neuropsychological, trauma, PTSD and dissociation assessment; while controlling for living environment and caregiver IQ, and excluding medical confounds common to CPS identified maltreated youth (e.g., low birth weight, medical problems, head injury, prenatal drug exposure). Our findings have implications for national public education policy, by suggesting that all CPS identified youth receive comprehensive neurocognitive and academic achievement evaluations, with necessary therapeutic and educational services being offered, if needed, regardless of the presence of mental health symptoms. Examination of neuropsychological and academic function in maltreated children regardless of Axis I diagnosis, with a primary goal of implementing evidenced-based interventions, will be critical to informing best practices and associated policies to alleviate the negative neuropsychological consequences of maltreatment in childhood.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors thank the staff the Duke Healthy Childhood Brain Development Developmental Traumatology Research Program and the participants and their families for making this work possible. The manuscript is new and original and it has never been published either electronically or in print.

This work was supported by funding from National Institutes of Health [K24 MH071434 and K24 DA028773 and RO1- MH61744, R01-AA12479, RO1-M

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Table 1

Clinical and demographic characteristics for the non-maltreated children (Group 1), maltreated children without PTSD (Group 2), and maltreated children with PTSD (Group 3).

Variable	Non-Maltreate d (1) N=104	Maltreate d w/o PTSD (2) N=38	Maltreate d w/PTSD (3) N=60	Statistic	p	Pairwise Group Differences*
Child's Age in Years, mean (*sd*)	12.52 (3.04)	11.87 (3.08)	11.74 (3.32)	F(2,199)=1.39	.25	--
Age Range	6.2–17.7	6.3–17.4	6.2–17.8			
Child's current SES, mean (*sd*)	43.31 (10.78)	39.21 (14.83)	34.18 (13.30)	F(2,199)=10.39	.001	3<1
SES Range	14–66	17–63	11–64			
Female/Male	59/45	19/19	37/23	χ^2 =1.30	.52	
Right/Left Handed	97/7	35/3	52/6	χ^2 =.66	.72	
White/Black/Other	54/38/12	15/19/4	31/25/4	χ^2 =3.15	.53	
Child Weight (lbs) mean (*sd*)	115.54 (46.39)	115.05 (48.12)	117.48 (49.38)	F(2,198)=0.04	.96	
Child Height (inches), mean (*sd*)	60.51 (6.86)	59.24 (7.55)	58.52 (6.77)	F(2,198)=1.65	.19	
Living with a Biological Parent/Other Biological Relative/Foster or Adoptive Family	101/0/3	22/3/13	38/4/18	χ^2 =40.79	.001	Note[A]
Caregiver IQ, mean (*sd*)	109.50 (14.30)	106.33 (14.28)	101.37 (13.84)	F(2,187)=5.80	.001	3<1
Caregiver IQ Range	62–133	64–138	66–134			
Children's Global Assessment Scale Score, mean (*sd*)	89.76 (4.94)	68.00 (12.31)	54.60 (9.25)	F(2,199)=373.99	.001	3<2<1
Range	75–98	35–93	40–80			
CBCL Total Score, mean (*sd*)	41.67 (9.84)	55.49 (13.06)	61.61 (9.81)	F(2,197)=73.85	.001	1<2<3
CBCL Total	24–69	24–83	43–79			
Score Range						
CBCL Internalizing Score, mean (*sd*)	45.91 (9.04)	53.81 (12.40)	60.71 (10.34)	F(2,197)=41.25	.001	1<2<3
Internalizing Score, Range	33–72	32–75	43–79			
CBCL Externalizing Score, mean (*sd*)	42.37 (8.36)	55.73 (13.94)	59.59 (11.02)	F(2,197)=58.93	.001	1<2,3
Externalizing Score Range	30–68	34–83	33–82			
Child Dissociative Checklist Score, mean (sd)	0.62 (1.26)	5.32 (5.58)	7.46 (5.41)	F(2,198)=62.7	.001	1<2<3
Range	0–9	0–23	0–26			
Total PTSD Symptoms, mean (*sd*)		3.13 (2.38)	11.47 (2.55)	t(1,96)=16.14	.001	2<3
Range		0–9	6–16			

Variable	Non-Maltreate d (1) N=104	Maltreate d w/o PTSD (2) N=38	Maltreate d w/PTSD (3) N=60	Statistic	p	Pairwise Group Differences*
Lifetime Summary of Maltreatment Types		3.7 (1.47)	4.35 (1.2)	t(1,96)=2.35	.02	2<3
Number Range		1–6	3–6			
Failure to Supervise Index, mean (*sd*)		2.39 (2.01)	2.73 (1.92)	t(1,96)=0.84	.41	
Failure to Provide Index, mean (*sd*)		0.55 (0.95)	0.82 (1.08)	t(1,96)=1.23	.22	
Witnessing Interpersonal Violence Index, mean (*sd*)		3.39 (2.16)	3.73 (2.25)	t(1,96)=0.74	.46	
Physical Abuse Index, mean (*sd*)		1.00 (0.99)	1.73 (1.38)	t(1,96)=2.85	.005	2<3
Emotional Abuse Index, mean (*sd*)		1.32 (1.04)	1.45 (1.00)	t(1,96)=0.63	.53	
Sexual Abuse Index, mean (*sd*)		0.34 (0.48)	0.53 (0.50)	t(1,96)=1.86	.065	

[*] Comparisons for all pairs using Tukey-Kramer HSD q=2.36, p<.05

[A] Correspondence Analyses showing that Group 1 was more likely to live with Biological Parents than Other Biological Relatives/Foster or Adoptive Family; while living arrangements were similar for the Maltreated Groups 2 &3.

Table 2

Neuropsychological outcome measures for the non-maltreated children (Group 1), maltreated children without PTSD (Group 2), and maltreated children with PTSD (Group 3). MANCOVA co-varying for SES, child's current living arrangements (i.e., with biological parent/biological relatives/foster or adoptive family), and caregiver IQ were examined for each Neuropsychological Domain.

Cognitive Domain	Non-maltreated (1)	Maltreated w/o PTSD (2)	Maltreated w/PTSD (3)	Statistic	*p*	Pairwise Group Differences*	Partial Eta 2
Child IQ	108.55 (14.08)	95.05 (10.96)	94.12 (12.89)	F(2,184)=15.83	.001	2,3<1	.147
Fine-Motor				F(8,100)=1.52	.159	--	.109
Finger-Tapping Dominant Hand	101.42 (14.79)	105.47 (6.68)	97.41 (13.03)	F(2,53)=1.40	.255	--	.050
Finger-Taping Non-Dominant	100.62 (14.95)	108.70 (17.31)	92.60 (12.13)	F(2,53)=3.13	.052	--	.106
Grooved Pegboard Test Dominant Hand	94.75 (16.28)	94.89 (11.00)	84.86 (17.83)	F(2,53)=2.06	.138	--	.072
Grooved Pegboard Test Non-Dominant Hand	92.35 (19.55)	86.52 (16.21)	82.68 (20.80)	F(2,53)=1.17	.318	--	.042
Attention				F(4,346)=2.52	.041	--	.028
CPT-II Errors of Omission	101.04 (13.36)	93.20 (18.62)	93.45 (16.52)	F(2,174)=1.24	.291	--	.014
CPT-II Variability	101.96 (15.78)	91.19 (15.34)	90.64 (16.14)	F(2,174)=4.25	.016	2,3<1	.047
Language				F(4,136)=6.66	.001	--	.164
Peabody Picture Vocabulary Test-III	113.58 (13.00)	95.25 (18.58)	95.65 (12.34)	F(2,69)=6.97	.002	2,3<1	.168
CELF-R Concepts & Directions	109.90 (12.35)	94.15 (11.25)	92.70 (11.95)	F(2,69)=10.33	.001	2,3<1	.230
Visuospatial				F(4,134)=4.49	.002	--	.118
Rey-Osterrieth Complex Figure Copy Condition	91.25 (17.26)	93.06 (7.52)	76.64 (22.05)	F(2,68)=4.60	.013	3<1,2	.119
Judgment of Line Orientation	100.58 (15.28)	91.19 (16.35)	84.78 (20.38)	F(2,68)=4.10	.021	3<1	.108
Memory				F(6,134)=3.60	.002	--	.139
TOMAL Paired Recall	109.09 (10.15)	100.45 (10.60)	98.05 (12.95)	F(2,69)=7.80	.001	2,3<1	.184
Symbol-Digit Paired Associate Learning Test Total	101.03 (13.43)	85.93 (23.04)	94.59 (15.12)	F(2,69)=2.82	.066	--	.076
CVLT List A Total	111.25 (12.95)	102.05 (18.88)	104.23 (15.17)	F(2,69)=2.87	.063	--	.077
Executive				F(8,262)=5.60	.001	--	.146
CPT-II Errors of Commission	103.47 (12.35)	100.15 (13.11)	97.91 (13.21)	F(2,134)=2.25	.109	--	.032
Stroop Color/Word Interference	102.43 (9.88)	99.41 (13.86)	103.84 (9.47)	F(2,134)=1.80	.170	--	.026
WJ-III Numbers	106.03 (17.87)	99.83 (11.42)	92.58 (16.92)	F(2,134)=7.08	.001	3<1	.096
WCST Perseverative Reponses	111.70 (15.00)	100.13 (14.62)	99.02 (14.61)	F(2,134)=14.66	.001	2,3<1	.180

Cognitive Domain	**Non-maltreated (1)**	**Maltreated w/o PTSD (2)**	**Maltreated w/PTSD (3)**	**Statistic**	***p***	**Pairwise Group Differences***	**Partial Eta 2**
Academic Achievement				F(4,352)=6.00	.001	--	.064
WJ-III Reading	110.74 (13.39)	99.83 (13.74)	95.33 (14.18)	F(2,177)=8.71	.001	2,3<1	.090
WJ-III Math	109.36 (12.18)	99.69 (12.42)	96.88 (10.15)	F(2,177)=9.80	.001	2,3<1	.100

*Comparisons for all pairs using Tukey-Kramer HSD q=2.36, p<.05

Note: All test scores have been scaled to have a Mean = 100 and a Standard Deviation = 15, with higher scores reflecting a better performance.

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Table 3

Pearson correlations of clinical variables with neuropsychological domains in maltreated children (N=98).

	IQ score	Fine Motor Domain Score	Attention Domain Score	Language Domain Score	Visuo-spatial Domain Score	Memory Domain Score	Executive Domain Score	Academic Domain Score
Total Number of PTSD Symptoms	−.040	−.038	−.088	−.185	.044	−.091	−.090	−.098
PTSD Duration	.079	.121	.137	.053	**−.245** *	.066	.166	−.134
Child Dissociation Checklist Score	.105	.117	**−.211** *	.098	−.022	.042	−.040	−.173
Lifetime Summary of Maltreatment Types	−.026	−.002	−.001	.052	−.108	−.005	.053	**−.264** *
CBCL Internalizing	.150	.280	−.024	.132	−.091	.140	.067	−.009
CBCL Externalizing	.137	.187	−.169	.172	−.038	.044	.069	−.126

Note:

* $p < .05$

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Table 4

Partial correlations of maltreatment indices with neuropsychological domains. Each column represents the correlations of a maltreatment index while controlling for the effects of the other maltreatment indices (N=98).

	Failure to Supervise Index	**Failure to Provide Index**	**Witnessing Interpersonal Violence Index**	**Physical Abuse Index**	**Emotional Abuse Index**	**Sexual Abuse Index**
IQ score	.033	−.087	.064	.071	−.017	−.193
Fine Motor Domain Score	−.158	−.179	.315	.390	−.247	−.073
Attention Domain Score	−.053	−.039	.141	.033	−.037	−.047
Language Domain Score	−.006	−.054	−.037	.031	.155	**−.539****
Visuospatial Domain Score	.092	−.009	−.012	−.035	−.134	−.022
Memory Domain Score	−.012	.026	.016	−.062	.028	**−.497****
Executive Domain Score	−.075	−.014	.146	−.022	.042	−.167
Academic Domain Score	−.012	−.172	.102	−.060	−.051	−.253

Note:

** $p < .01$