USING NEUROPSYCHOLOGICAL ASSESSMENT TO UNTANGLE THE HETEROGENEOUS EFFECTS OF CHILD MALTREATMENT

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Abstract

Child maltreatment (CM) includes physical, sexual, and emotional (i.e., psychological) abuse and neglect, and is a pervasive issue in our society. CM can cause a myriad of potentially devastating life-long outcomes. Research has repeatedly demonstrated negative impacts in emotional, social, and behavioral domains of functioning. Recent research has shown similar impacts on cognitive and executive functioning. This study examined the complex interactions and heterogeneous effects of CM on functional outcomes, while tightly controlling for many confounding variables (e.g., head injury, seizures, substance use) not commonly restricted in research. A cross-sectional design was used to establish baseline clinical and neuropsychological profiles of maltreated individuals during adolescence, a period of heightened neuroplasticity when many cognitive effects of CM can first be observed. Performance on validated and reliable standardized measures was compared to measure norms, or age, socioeconomic, and sex matched controls to indicate significant differences. This study also examined the effect of overall CM severity across types (e.g., abuse, neglect), as well as severity within specific CM type on select variables of cognitive performance. Consistent with hypotheses, results demonstrated lower overall CM group performance on tasks of executive functioning. Within group differences were also evidenced by a strong relationship between severity of CM and lower sustained attention. Effects of specific CM type severity were demonstrated where neglect predicted lower sustained attention performance. Study results contribute to growing knowledge regarding CM outcome heterogeneity, and support the need for tightly controlled longitudinal and developmentally focused studies to advance CM research.

Keywords: child maltreatment, severity, developmental outcomes, cognitive, executive, domains of functioning

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CONTENTS

Child maltreatment (CM) refers to adverse events including sexual, physical, and emotional abuse, as well as neglect (Kim, Wildeman, Jonson-Reid & Drake, 2016). Estimates of CM prevalence indicate over a third of children in the United States (U.S.) will experience some form of maltreatment in their lifetime (Kim, Wildeman, Jonson-Reid & Drake, 2016). CM experiences can lead to negative and cumulative effects at the level of the individual, family, and community level, and be passed from one generation to the next (Cicchetti, 2013). A substantial body of research has focused on the negative emotional, behavioral, and social factors associated with CM (James & Mennen, 2001; Thomaes et al., 2012). Additional studies have identified long-term negative impacts on cognitive and executive domains appearing over time (De Bellis, Woolley, & Hooper, 2013; DePrince, Weinzierl, & Combs, 2009; Gould et al., 2012). Results have been linked with structural, chemical, and functional changes occurring in the brain throughout development following such stressful events (De Bellis, Woolley, & Hooper, 2013; DePrince, Weinzierl, & Combs, 2009; Gould et al., 2012; Kirke-Smith, Henry, & Messer, 2014), as well as impacts caused by chronic stress response systems and allostatic load (Cicchetti, 2013). Cumulatively, these changes underscore the need for early, effective, and informed interventions to reduce or halt such impacts prior to the formation of life-long functional difficulties (Cicchetti, 2013; Renner & Slack, 2006).

It has proven difficult to target interventions for this population as the negative effects of CM exhibit significant heterogeneity across the population. Specifically, expected outcomes may or may not be immediately evident within individuals; instead, outcomes may manifest over time or increase in unexpected directions (Cohen & Mannarino, 2000; Manly, Cicchetti, & Barnett, 2008). Presentation differences appear to be based on numerous factors including CM specific variables such as type of CM event (e.g., sexual, physical, or emotional neglect and/or

abuse) and severity of experience (Cohen & Mannarino, 2000; Manly, Cicchetti, & Barnett, 2008; Pears, Kim, & Fisher, 2008). Additionally, the functional effects of CM are often expressed to a greater degree after major periods of development, or in rarer cases, not at all (Cicchetti, 2013; Cook et al., 2017). Several confounding and often co-occurring factors (e.g., head injuries, seizures, early illnesses, substance use, major psychopathology, neurodevelopmental or cognitive disorders) can further exacerbate or mimic these outcomes (Bowie & Harvey, 2006; Brown, Tapert, Granholm, & Delis, 2000; Covassin & Elbin, 2010; Hoogman, van de Beek, Weisfelt, de Gans, & Schmand, 2007; Huizink & Mulder, 2006; Kodl & Seaquist, 2008; Schretlen & Shapiro, 2003; Vingerhoets, 2006). Additionally, resilience factors such as a having a supportive and educated parent, and higher socioeconomic status and intellectual functioning can help buffer the effects of maltreatment experiences and contribute to normative and adaptive functioning (Cicchetti, 2013; Flores, Cicchetti, & Rogosch, 2005). These heterogeneous results underscore the specific need for research to explore functional differences within tightly controlled samples during periods of increased neuroplasticity and refinement. This line of inquiry, paired with further investigation of adaptive and maladaptive CM profiles and moderators of greatest impact has the potential to inform early intervention research by identifying CM profiles and functional targets (e.g., aspects of cognitive or executive functioning) most likely to be impacted and/or to demonstrate differential responses to treatment. Furthermore, the identification and development of treatments informed by such research will likely decrease long-term negative outcomes, the perpetuation of CM cycles, and intergenerational transmission effects.

Domains of Functioning Impacted by Maltreatment

The immediate and long-term outcomes of CM have been researched in depth over the past five decades (Cicchetti & Toth, 2005). Deficits in social, emotional, and behavioral functioning occur rapidly following CM events, and can lead to serious long-term effects (Alink, Cicchetti, Kim, & Rogosch, 2012; Cicchetti & Toth, 2005). These functional changes have been linked with increased risk for psychopathology including depression, anxiety, and posttraumatic stress (PTSD) symptoms (Alink et al., 2012; Cicchetti & Toth, 2005; Teicher & Samson, 2013), and have evidenced amplified and negative influence over other domains of functioning including academic and school success, and cognitive and executive functioning (Cowell, Cicchetti, Rogosch, & Toth, 2015; De Bellis, Woolley, & Hooper, 2013).

Amplified risk for functional difficulties may stem, at least in part, from the cognitive sequelae of CM. A smaller, although important line of research has identified several specific cognitive processes influenced over time by CM (De Bellis et al., 2013; Gould et al., 2012). Executive function systems are often the most strikingly impacted domain in this population by adulthood (De Bellis et al., 2013; Teicher, Samson, Anderson, & Ohashi, 2016). Executive function refers to the higher order cognitive processes that aid in regulating emotions and behavior (Lewis-Morray et al., 2012). Executive function deficits in this population have commonly included decreased attention, planning, cognitive flexibility, inhibitory control, and working memory skills, as well as decreased processing speed (Gould et al., 2012; Lu et al., 2017; Mills et al., 2011; Mittal, Griskevicius, Simpson, Sung, & Young, 2015). Those with a history of CM often experience greater difficulty accessing cognitive abilities (e.g., abstract thinking, problem solving, language, memory) due to these negative effects on executive functioning processes. Additionally, cognitive functioning is directly impacted by CM events as

evidenced by children with a history of CM scoring between half to one full standard deviation below same aged peers on measures of IQ (De Bellis et al., 2013). However, studies involving adult participants do not report these differences relative to controls, suggesting CM effects on IQ may normalize with age and/or there is a sensitive window in development for associated connectivity (Twamley, Hami, and Stein, 2004). Other cognitive processes exhibit long-term effects by adulthood, including deficits in expressive and receptive language, reasoning, and verbal and visual memory (De Bellis et al., 2013; Spratt et al., 2012). Resultant neurocognitive difficulties have been shown to influence social communications and interactions, and abstract thinking and learning. Children with a history of CM also commonly demonstrate lower academic functioning and school success (e.g., reading skills, grades) compared to same aged peers (De Bellis et al., 2013), which may be related to the initial disruption of these processes and the higher order abilities necessary for successful learning and performance in academic settings. Research has indicated 66 percent of matched control groups complete high school, as compared to only 42 percent of those with a history of CM (Perez & Widom, 1994). These differences in cognitive, executive, and academic functioning have been found even after controlling for commonly occurring confounding factors: risk and adversity such as caregiver education level and IQ, early medical conditions, traumatic brain injuries (TBI), socioeconomic status (SES), and anxiety (Deprince, Weinzierl & Combs, 2009; Perez & Widom, 1994). Meanwhile, heightened trauma symptomology increases the undesirable cognitive outcomes resulting from CM experiences (De Bellis et al., 2013; Deprince et al., 2009); in particular trauma reactivity has been closely associated with difficulties with inhibitory control, a major underlying component of many executive functions.

Underlying Neurobiological Mechanisms of Child Maltreatment

Neuroimaging and biophysiological studies have found altered neurobiological processes in individuals with a history of CM (DeBellis et al., 2013; Teicher et al., 2016). The hypothalamic-pituitary-adrenal (HPA) axis, the primary stress response system involving the central nervous and endocrine systems, has been implicated in altered affective and cognitive processing in individuals who have experienced CM (Teicher et al., 2016). This system is involved in mounting a stress response, as well as maintaining diurnal rhythm. Over and/or under activation of the HPA axis following stressful CM experiences can lead to changes in neurotransmitter and hormonal levels. Specifically, initial periods of HPA axis hyper activation can flood the body with high levels of circulating cortisol. In many cases, flattened diurnal cortisol patterns emerge over time in those with a history of CM (Cicchetti, 2013). These flattened profiles are believed to be the result of chronic stress, where the body's attempt to regulate periods of hyper activation results in overall under activation of the stress-response systems and higher allostatic load (Cicchetti, 2013). Periods of heightened stress reactivity and resultant cortisol responses have the potential to damage developing brain areas over time, especially those structures more susceptible given their high numbers of glucocorticoid receptors (e.g., amygdala, hippocampus, prefrontal regions; Alink et al., 2012; Andersen & Teicher, 2009; Cicchetti, 2013; Hostinar, Sullivan, & Gunnar, 2014). Such damage offers a neurobiological explanation of the significant memory, executive function, and inhibitory difficulties experienced by this population by adulthood.

Research has also indicated structural and functional changes to brain anatomy over time, including connectivity, in those with a history of CM, attributable to the altered activation of stress response systems and exhibited chemical changes (DeBellis et al., 2013; Teicher et al.,

2016). Specifically, emotion discrimination and regulation deficits are evidenced through affected fronto-limbic neural circuits. The amygdala, responsible for emotional control and processing, evidences greater neurotransmission of dopamine, resulting in over activation and increased sensitivity to negative stimuli and experiences. At the same time, areas of the prefrontal cortex responsible for attentional and regulatory executive functions (i.e., orbital and ventromedial structures) demonstrate decreased dopamine neurotransmission and hypo activation (DeBellis et al., 2013; Teicher et al., 2016). Additional areas of the prefrontal cortex involved in cognitive/inhibitory control and attention regulation (i.e., dorsolateral and inferior prefrontal cortices and the anterior cingulate cortex), exhibit smaller overall volumes, and increased levels of dopamine neurotransmission, which result in heightened activation during and increased difficulties with tasks involving inhibition and attentional control (DeBellis et al., 2013; Teicher et al., 2016). Lastly, the hippocampus, involved in learning and memory, the cerebellum, involved in motor coordination and responses, including meteoric inhibition, and the corpus callosum, involved in integrating functions between hemispheres, evidence smaller overall volumes and white matter density in adult survivors of CM (De Bellis et al., 2013; Gould et al., 2012; Mills et al., 2011; Teicher et al., 2016). Overall these findings indicate greater activation of these areas is necessary for those with a history CM to perform intended tasks (e.g., inhibiting and regulating responses and attention, learning new information, communicating, reasoning) compared to peers. In addition, damaged connectivity and a more reactive and overloaded stress-response system can lead to difficulties learning and completing age-appropriate tasks as these areas come online.

Variability in Outcomes of Child Maltreatment

Many studies have investigated the cognitive effects of CM, however, studies exploring reasons for the heterogeneity of such outcomes are limited. Research examining this heterogeneity in response to trauma has the potential to lead to effective treatment models and intervention development to reduce the long-term and generationally-spanning effects of CM (Foa, Riggs, Massie, & Yarczower, 1995; Zandberg, Rosenfield, McLean, Powers, Asnaani, & Foa 2016). Additionally, individuals who exhibit stronger, earlier negative responses to adverse events (e.g., trauma symptoms) commonly respond with the most magnitude to intervention (. Therefore, improving the ability to identify these individuals and apply such treatments is critical. Developmental timing has been proposed as one such factor contributing to the impact of CM on neural functioning (Cook et al., 2017; De Bellis et al., 1999; De Bellis et al., 2002; Paus, 2005). Adolescence, generally thought to be when social identify is formed and higher-level cognitive processes are achieved (Paus, 2005), is a period when many of the neural effects of CM can first be observed in comparison to peers (Cook et al., 2017). One proposed mechanism is insult during prefrontal cortex maturation via synaptogenesis and pruning (De Bellis et al., 1999). Similarly, neuroimaging research has found latent structural alterations in hippocampal areas in early adulthood (De Bellis et al., 2002). Combined, these findings indicate the functional differences attributed to these systems are likely influenced by periods of neuroplasticity and maturation manifested by adulthood (Cook et al., 2017). While research on the effects of CM in adolescence is increasing, the number of studies is limited and continues to lack adequate sample sizes and comparison methods. As such, this population merits additional investigation to elucidate possible mechanisms and processes underlying the heterogeneity of CM outcomes, and intervention points most salient to life-long improvement.

Specific effects of CM severity have also been found, where more severe CM experiences (e.g., inability to provide food versus inability to clean clothing regularly; physical violence toward a child versus threatened violence) contribute to post traumatic stress (PTS) symptom potency and negative cognitive outcomes (Cohen & Mannarino, 2000; Manly, Cicchetti, & Barnett, 2008; Pears et al., 2008). For example, individuals who have experienced CM events of greater severity demonstrate more substantial PTS symptoms and difficulties with verbal and visual memory, attention, executive functioning, and lower overall IQ scores than individuals who have experienced CM events of lesser severity (Cohen & Mannarino, 2000; Manly, Cicchetti, & Barnett, 2008; Gould et al., 2013; Pears et al., 2008; Perna & Kiefner, 2013). Additionally, effects of CM type on functioning have been indicated, with abuse related events associated with heightened maladaptive responses (e.g., hyper arousal, increased reactivity and distractibility in response to environmental stimuli and cues) and poorer inhibition, and verbal, visual, and spatial memory (Gould et al., 2013; Perna & Kiefner, 2013). Comparatively, neglect specific events have been related to poorer academic achievement, attention, visual-motor integration, learning, and language (De Bellis et al., 1999; Nolin & Ethier, 2007). Many of these differences have been found in adult samples that have not controlled for commonly occurring and confounding variables known to mimic or exacerbate CM outcome effects. For example, head injuries, seizures, early illnesses (e.g., meningitis), substance use, major psychopathology, and neurodevelopmental or cognitive disorders often imitate or contribute to similar neuropsychological outcomes as CM experiences themselves (Bowie & Harvey, 2006; Brown, Tapert, Granholm, & Delis, 2000; Covassin & Elbin, 2010; Hoogman, van de Beek, Weisfelt, de Gans, & Schmand, 2007; Huizink & Mulder, 2006; Kodl & Seaquist, 2008; Schretlen & Shapiro, 2003; Vingerhoets, 2006).

Not all variables related to CM outcome heterogeneity are negative; in fact, some resulting effects are positive and may be adaptive depending on context. For instance, those with a history of CM may exhibit difficulties on inhibitory tasks requiring internal monitoring of activity requirements, while their increased vigilance may allow them to outperform peers on similar tasks involving external prompts and reinforcement (Mackiewicz Seghete et al., 2017; Mackiewicz Seghete et al., 2018). Additionally, some individuals demonstrate normative and/or adaptive functioning across domains contrary to of presumed negative outcomes. Such performance has been attributed to the dynamic process of resilience, by which the circumstances, contexts and resources of an individual (e.g., presence of a supportive adult, psychological interventions, parental education, coping skills, socioeconomic status (SES), intellectual functioning) can interact to promote and influence successful adaptation following adverse experiences (Cicchetti, 2013; Flores, Cicchetti, & Rogosch, 2005). Overall, the significant heterogeneity in CM outcomes underscores the need for studies to investigate these variables using tightly controlled samples. This line of research promises to more accurately explore the distinct functional effects of CM events and evaluate whether they are adaptive, maladaptive, or contextually dependent. Furthermore, by accounting for confounding heterogeneity the potential contribution of factors specific to CM exposure (e.g., severity, type of CM) may be further elucidated. Future studies and interventions informed by this research would lead to more accurate profiles of CM and solidify treatment targets and developmental periods most responsive to intervention.

Current Study

The primary aim of this study was to evaluate the impact of CM on standardized clinical and neuropsychological measure performance using a tightly controlled design to fill an

important gap in the literature and address heterogeneity within the population. This project also specifically recruited adolescents to address a significant gap in our understanding of the effects of CM during development compared to research with adult populations. Adolescence is a unique period of neurodevelopmental maturation where patterns of cognitive deficits between childhood and adulthood may be bridged. This study uniquely controlled for many key, confounding factors (e.g., TBI, significant substance use/exposure, major developmental or psychotic disorders, major medical illnesses) known to mimic or exacerbate neurodevelopment and functioning. This rigorous exclusion process allowed for more control over group level comparisons and consequent identification and measurement of cognitive outcome heterogeneity compared to previous work, as well as individual variables contributing to such heterogeneity. Many historical studies have covaried for a few of these potentially moderating variables and still found cognitive functioning deficits in adult samples. These deficits likely occur due to the early and severe nature of CM events on development. Consistent with these findings, those with a history of CM were expected to demonstrate significant negative impacts to certain aspects of cognitive functioning, despite exclusion of many variables known to exacerbate such impacts, and the use of an adolescent instead of adult sample. Specific patterns of cognitive performance, including negative, neutral, and positive, were proposed in an attempt to differentiate between the expected adaptive and maladaptive impacts of CM events, as well as effects of developmental timing between adolescence and adulthood. Specifically, we hypothesized our sample would demonstrate below average performance on standardized neuropsychological measures of higher order executive and functioning (i.e., working memory, sustained attention, discriminability, verbal switching fluency, verbal information learning, and abstract perceptual intelligence skills). This hypothesis was developed in accordance with

previous research, which has indicated long-term skill deficits in these areas first manifesting in periods of high neuroplasticity and maturation, as well as the large impact of trauma on inhibitory capabilities. Average performance on measures of categorical fluency and crystalized vocabulary were expected compared to measure norms. While previous studies have indicated expressive and receptive language deficits in those with a history of CM related to comprehension and integration of verbal information (Nolin & Ethier, 2007; Schwab & Lew-Williams, 2016), they have not indicated specific difficulties related to vocabulary knowledge or rote word production tasks, which involve a more automatic process of habitual memorization and recall. Lastly, adolescents were hypothesized to demonstrate above average performance on a task of reinforced response inhibition. This prediction was developed based on previous research suggesting heightened alertness to the environment and cues displayed within this population may lead to contextual adaptation and increased performance on reinforced tasks.

The second aim of the study was to investigate the effect of severity of CM on cognitive functioning in a tightly controlled sample. It was hypothesized increased severity of CM experiences would be negatively related to performance on measures of cognitive processing. These predictions were based on previous work showing neurobiological changes and detrimental outcomes in systems especially sensitive to experiences of early adversity (e.g., executive functioning and prefrontal systems), and the detrimental effects of CM severity across domains. Specifically, higher CM severity was expected to be associated with poorer sustained attention and perceptual intelligence performance. Furthermore, neglect specific severity was expected to predict lower perceptual intelligence compared to abuse experiences. This difference was hypothesized based on previous research demonstrating an interaction between the overall deprivation associated with such events, including reduced interactions and sustained

attention with caregivers, and low-stimulation environments (e.g., lack of toys, books, and other visual learning stimuli), as well as the reduced need to develop, sustain, and implement visual-perceptual skills within such contexts. Moreover, severity of physical and sexual abuse experiences was expected to demonstrate the greatest impact on sustained attention compared to neglect experience severity. Previous research has proposed the heightened vigilance and reactivity stemming from physical and sexual abuse events may be present only for high-stress stimuli or emotionally salient activities, and may otherwise cause detrimental attentional effects in other, day-to-day environments (e.g., classrooms) and tasks. Additional, exploratory analyses were conducted to investigate the potential moderating effects of other, individual level risk factors (i.e., SES, depressive symptomology, sex) on cognitive performance. These were specifically chosen based on previous work demonstrating lower SES, female sex, and increased depressive symptomology as potential risk factors for poorer cognitive functioning (Merrick, Ford, Ports, & Guinn, 2018; Wu et al., 2004).

Methods

Participants

The study included 68 adolescents (73.9% female), 13-17 years of age (M = 14.90, SD = 1.11), and one parent/legal guardian (N = 68). Adolescents were categorized into two groups: adolescents with a history of CM (N = 45) and a control group of adolescents without a history of trauma (N = 23). Participants were recruited through a large, academic medical center in a major metropolitan area in the Pacific Northwest, the greater metropolitan community, and a local child advocacy center. Recruitment was conducted in two parts: CM group and control participants for a larger, federally funded study with a neuroimaging component; CM group only, in an effort to increase power for related analyses and further investigate CM specific

effects. Inclusion criteria for the full study and CM only analyses included no history of a developmental (e.g., Autism Spectrum Disorder) or psychotic disorder (e.g., schizophrenia), no major medical illnesses (e.g., diabetes), no head injury with loss of consciousness (LOC) greater than two minutes, an Intelligence Quotient (IQ) greater than or equal to a Standard Score of 80, no known prenatal exposure to alcohol or drugs, no current, significant substance use, English proficiency, and having a parent/legal guardian over the age of 18. Inclusion criteria for the full study was more selective due the neuroimaging component and also included no current use of medications that could affect the central nervous system, reported history of bipolar I or psychotic disorder in biological parents, irremovable metal on the body or other MRI contraindications, left-handedness, uncorrectable vision or hearing impairments, and pregnant youth. For both studies, adolescents were included in the CM group if they met criteria based on variables described in the measures section below. The control group had no reported history of trauma, per Criterion A of the DSM-IV-TR (American Psychiatric Association, 2000). Every parent/legal guardian and all participants over 15 years of age provided written informed consent; participants under 15 years of age provided written informed assent. Participants were compensated monetarily.

Procedures

Parent and adolescent consent and child assent (i.e., participants 15 years and younger) was collected separately, prior to concurrent and independent (in separate rooms) interview sessions. As this was part of a larger, federally funded study, sessions included additional clinical and neuropsychological measures not described within the current study. Interview sessions lasted approximately 2.5 hours and included a semi-structured interview and several self-report measures (described below). Adolescents also completed the computerized

Childhood Trauma Questionnaire (CTQ), while parents completed the Hollingshead SES measure. If participants were eligible for control or CM groups following this session (i.e., no presence of strict exclusion criteria discussed above), adolescents were scheduled for a subsequent assessment session on a different day, which lasted approximately three hours. During this session, they were administered standardized clinical and neuropsychological study measures. Parent and adolescent participants were compensated $30 for initial interview sessions, and adolescents were compensated an additional $50 upon completion of the subsequent assessment.

Measures

Demographic measures. An interview was conducted with both parent and adolescent participants to collect information on familial history of mental health and substance use, adolescent mental health history, and demographic information including the adolescent's age, race, ethnicity, and sex. Parents completed the Hollingshead Four-Factor Index of Socioeconomic Status (Hollingshead SES; Hollingshead, 1975) to indicate familial SES. Parent employment, marital status, educational attainment, and occupation were used to determine SES. The Hollingshead SES has high predictive and concurrent validity with coefficients ranging from .73-.84 (Gottfriend, 1985).

Child maltreatment. History of CM was assessed using multiple measures. The Child Trauma Questionnaire (CTQ; Bernstein & Fink, 1998) is a 28-item retrospective self-report measure that uses a 5-point Likert scale to detect presence and severity of abuse and neglect experiences. This measure provides total severity scores, as well as cut off values for five types of CM (i.e., physical and emotional neglect, and physical, emotional, and sexual abuse). The CTQ has been shown to be valid and reliable, demonstrating excellent internal consistency (*r*'s =

.81-.95; Scher, Stein, Asmundson, McCreary, & Forde, 2001). The computerized questionnaire was self-administered to best-capture sensitive information. An adolescent was considered to have a history of CM if totals exceeded cut-off scores for any type of CM on the CTQ. Neglect and abuse specific composites were created to investigate relationships between CM type severity and cognitive performance. All subscales were standardized. The three abuse subscales (i.e., emotional abuse, physical abuse, and sexual abuse) were summed to form a standardized abuse composite, and the two neglect subscales (i.e., emotional neglect and physical neglect) were summed to form a standardized neglect composite.

Adolescents and parents were electronically administered corresponding self and parent-report versions of the University of California at Los Angeles Post-Traumatic Stress Disorder Reaction Index (UCLA PTSD index; Steinberg, Brymer, Decker, & Pynoos, 2004). This measure served as a secondary assessment of physical and sexual abuse, and as a rule-out measure to ensure criteria A from the DSM-IV-TR (APA, 2000) was not endorsed for any other type of trauma. If the parent or adolescent endorsed criterion A for PTSD on the UCLA Index for physical or sexual assault, they were considered to have a history of CM. Trauma symptomatology for the study was assessed using the Trauma Symptom Checklist for Children (TSCC) (see below; Briere, 1996) as the UCLA PTSD index does not include neglect related symptoms. The UCLA PTSD index has demonstrated good to excellent internal consistency ranging from .88-.91 (Steinberg et al., 2013).

Cognitive measures.

IQ. The Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) Matrix Reasoning (MR) and Vocabulary (VOC) subtests served as measures of perceptual intelligence and crystalized vocabulary knowledge, respectively. These subtests were used to determine a 2-

factor Full-Scale IQ (FSIQ) score, which in turn was used to indicate whether exclusionary criteria of an IQ score ≥ 80 was met. The WASI has been normed and successfully used with participants 6-90 years old. The WASI has fairly high internal consistency, with an alpha value of .86 for the MR subtest and .88 for the VOC subtest, and supported convergent validity for the FSIQ (Wechsler, 1999).

Working memory. The Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, et al., 2003) Digit Span (DS) subtest was used to measure auditory working memory. This measure has been normed for use with children 6-16 years old and exhibits high internal consistency, with an alpha value of .87 for the DS subtest, and high concurrent validity with other measures of auditory working memory (Williams, Weiss, & Rolfhus, 2003). As norms only include those up to age 16, 17 year-olds were not included in analyses involving this measure (n = 4).

Verbal learning and memory. Total Learning, Delayed Recall, and List A Recognition scores from the Rey Auditory Verbal Learning Test (RAVLT; Schmidt, 1996), normed for ages 7-89, were used to measure verbal learning, memory, and recognition, respectively. This measure has demonstrated high internal consistency within selected scales (Delayed Recall r = .79; List A Recognition r = .81; Total Learning r = .86; Magalhães, Malloy-Diniz, & Hamdan, 2012). Additionally, it is closely correlated (r's = .5-.65) with the California Test of Verbal Learning – Children's Version (CVLT-C; Schmidt, 1996).

Attention and executive function. The Delis-Kaplan Executive Function System (DKEFS; Delis, Kaplan, & Kramer, 2001) Verbal Fluency subtest category and category switching conditions were administered to measure semantic search strategies, cognitive flexibility, and switching. The DKEFS is normed for individuals 8-89 years old. The category

switching/category fluency contrast score was used to assess whether participants demonstrated increased, reduced, or consistent performance on tasks requiring word generation based on overlearned concepts, versus those involving additional executive function components (i.e., cognitive flexibility, switching). The individual subtests used to derive this score have demonstrated reliabilities ranging from .53-.76 (category fluency) and .37-.68 (category switching; Delis et al., 2001). The contrast score itself has exhibited reliability ranging from .31-.46 across age groups (Crawford, Sutherland & Garthwaite, 2008). While reliability levels for these tests are generally lower than desirable, they are comparable to many other tests of executive function (e.g., Wisconsin Card Sorting Task), which commonly measure a wide spectrum of complex and effortful processes, making within measure consistency difficult.

The Hit Rate Block Change (HRBC) and Detectability subscales from the Conners' Continuous Performance Test – Second Edition (CCPT-II; Conners, 2000), normed for ages 6 and older, were used to assess executive function and cognitive components of sustained attention and discriminability skills, respectively. Discriminability relies heavily on inhibitory skills, as it indicates the proportion of correct targets endorsed over the number of incorrect targets (false positives) endorsed. The Variability scale was used to indicate if differences in reaction time influenced other performance scores. These scales have demonstrated marginal to very high internal reliability (HRBC r = .95; Detectability r = .83; Variability r = .66), with supported convergent validity (Epstein, Johnson, Varia & Conners, 2001).

A computerized, manual-response version of the classic Stroop task (Stroop, 1935) was used to assess inhibition. On each trial, participants selected the ink color of a word using a color-coded computer keyboard, while ignoring the word. For incongruent trials, participants selected an ink color that conflicted with the presenting word (e.g., the word "red" printed in

blue ink). For neutral trials, participants selected the ink color of a neutral word (e.g., "add" printed in blue ink). Incongruent and neutral words were balanced for length and frequency. Two blocks of the task were completed, an equal block that included 50% incongruent trials and 50% neutral trials, and an unequal block that included 75% incongruent trials and 25% neutral trials (Banich et al., 2007). The blocks allow for assessment of inhibition in the context of a reinforced task-set (unequal) and unreinforced task set (equal), and have been used successfully in previous studies (Banich et. al, 2007). The primary outcome was interference on the equal and unequal blocks, respectively, for correct trials. Interference was calculated by subtracting correct trial neutral response times (RTs) from correct trial incongruent RTs, then dividing by correct trial neutral RTs ((incongruent RTs - neutral RTs)/neutral RTs). This measure provides an improved assessment of inhibition compared to other measures, such as the DKEFS Color-Word Interference subtest, as it controls for overall response time within an individual; additionally, it is able to assess how performance is influenced by reinforcement.

Clinical measures.

Psychiatric history. DSM-IV-TR Axis I Disorders experienced within the previous year were assessed using the Diagnostic Interview Schedule for Children (DISC; Fisher et al., 1997). The DISC is an electronically administered self and parent-reported psychiatric interview containing 358 stem questions and nearly 1,300 contingent questions, normed for ages 9 to 17 years. Adolescents and parents separately completed corresponding measures about the presence or absence of mental health disorders in the adolescent over the past year. Both adolescents and parents initially completed the Diagnostic Predictive Scales (DPS; Lucas et al., 2001) to determine DISC module administration. This measure was also used to indicate whether DSM-IV exclusionary criteria for a psychotic disorder had been meet. All modules indicated on the

DPS were administered. The DISC PTSD module was administered to all participants. The DPS has achieved good to excellent sensitivity and specificity (ranging from 0.72-0.99; Leung et. al, 2005). DISC interrater reliability ranges from .94-1.00 (Costello, Edelbrock, Dulcan, Kalas, & Klarie, 1984).

Substance use. Adolescents were asked questions regarding their current substance use during the initial phone screen to determine whether substance use exclusion criteria were met. Standards developed and used in a large consortium study by leading researchers in adolescent substance use were implemented to indicate the possibility of neurotoxicity according to age (Brown et al., 2015; see supplemental attachment 1); individuals above this level of use were excluded.

Traumatic brain injury history. The Ohio State University Traumatic Brain Injury Identification Short Form (OSU TBI; Corrigan & Bogner, 2007) was used to assess and exclude based on significant head injury. This researcher-administered interview form includes five "yes" or "no" questions pertaining to potential head injuries experienced over the lifetime. If a head injury was endorsed on this measure, an additional four questions were asked regarding whether LOC occurred at time of injury, length of LOC, if memory loss occurred, and whether the LOC was due to drug overdose or choking. This measure has demonstrated high inter-rater reliability for detecting a lifetime history of TBI (*r's* = .85-.93; Corrigan & Bogner, 2007).

Trauma symptoms. The Trauma Symptom Checklist for Children's (TSCC; Briere, 1996) Posttraumatic Stress scale (PTS) was used to assess trauma symptomology over the last six months. This 54-item clinical measure has been normed and successfully used with ages 8-16 years and 17 year-olds with normative adjustments (Briere, 1996; Nilsson, Wadsby, & Svedin, 2008). It includes six subscales, with responses based on a 4-point Likert scale. The

PTS scale has an internal consistency of .85, and TSCC clinical scales exhibit high content, convergent, and discriminant validity with alpha coefficients ranging from .77-.89 (Briere, 1996).

Depressive symptoms. The Children's Depression Inventory (CDI; Kovacs, 1993) total score was used to measure overall depressive symptoms. This 27-item subjective clinical measure has been normed and successfully used with ages 7-17 years. Respondents are provided with a group of three sentences and asked to choose the one that best describes how they have felt in the past two weeks. The CDI has demonstrated high internal consistency and discriminability between depressed and non-depressed patients with alpha coefficients ranging from .71-.89 (Penk, Robinowitz, & Wierzbicki, 1987).

Anxiety symptoms. The Revised Children's Manifest Anxiety Scale – Second Edition (RCMAS-2; Reynolds & Richmond, 2008) total score was administered to measure current symptoms of anxiety. This 49-item measure is normed for ages 6-19 years (Reynolds & Richmond, 2008) and includes "True" or "False" response options. The RCMAS-2 has shown high internal consistency, with a total score alpha of .92.

Statistical Analysis

Prior to conducting planned analyses, data were examined for integrity including missingness, inaccurate data, and adherence to statistical assumptions. Normality, linearity, homoscedasticity of variance, and outliers were visually inspected using probability plots, histograms, regression graphs, and frequency distributions. All analyses were performed according to field standard practices and values (Field, 2013). All statistical analyses were conducted using IBM SPSS Version 25 (2017). IRB approval for a few additional clinical measures was obtained after study initiation; as such, data for these measures were missing in

totality for some participants (see Table 1). Data from the CCPT-II was also missing for one participant due to technical issues during administration. Missing data were omitted rather than imputed in an effort to distinguish sample specific differences both between participants and from population norms and as the missing data was not systematic in nature. Skewness and kurtosis were measured by the Shapiro-Wilk test for normality where significance of $p < .05$ indicated non-normal data. Several variables (i.e., Hollingshead SES, WASI MR, RAVLT Verbal Memory and Learning, Neglect, Abuse, and overall CM Severity composites) were identified as non-normal and evidenced skew and kurtosis. These results were anticipated given the high degree of impact severity has been shown to play on individuals within previous work (Cohen & Mannarino, 2000; Manly, Cicchetti, & Barnett, 2008; Pears et al., 2008). While this may have increased the chance of type 1 error within analyses involving severity, it also has a higher likelihood of capturing those individuals who weight overall maltreatment outcomes due to the severity or significance of their experience and associated magnitude of outcomes; as such, these specific variables were not transformed. WASI MR, Hollingshead SES, and RAVLT Verbal Memory variables were transformed to meet normality assumptions as they were used with primary analyses of the study as potential outcome variables. Scores ≥ 3 standard deviations above or below the mean were considered extreme or inaccurate outliers and excluded from t-test analyses where they could greatly influence the group mean (i.e., one case from CPT Variability, and one from the RAVLT Memory and Learning analyses). Influential cases were checked for accuracy and potential impact on data using tests of case diagnostics including Cook's Distance and DFBeta, where values greater than one were cause for concern; no additional cases were removed. Data additivity and linearity was assessed using the Durbin-Watson test; all resulting values were under two.

Aim 1. Pearson's bivariate correlations were conducted within the CM group to examine intercorrelations between variables of interest (e.g., performance across domains of functioning). One sample- t-tests were calculated to compare CM group performance to standardized population norms for all normalized cognitive measures. While population norms were expected to include individuals with a history of CM, it was hypothesized significant variability would exist between these norms and the mean performance of the sample including only individuals with a history of CM. Bonferroni multi-comparison corrections were applied for conducted tests, and indicated a new required test significance of $p < .007$.

As the Stroop task used in the study was not standardized, performance of a smaller subsample of individuals with a history of CM was compared to a matched Control group. As scores were not age normed, Pearson's bivariate correlations were performed to indicate whether age significantly influenced scores. Two (Group: CM, Control) x 2 (Block: Unequal, Equal) repeated measures ANCOVAs with age as a covariate were planned if age was found to be significant, and repeated measures ANOVAs were planned to conserve power if age was not significant. Analyses were conducted for both interference and accuracy scores to indicate whether accuracy potentially accounted for inhibitory performance.

Aim 2. Pearson's bivariate correlations were conducted within the CM group to examine potential impacts of CM severity on cognitive functioning. Neglect and abuse specific hierarchical linear regressions were calculated to examine whether variability in cognitive performance was related to severity of different types of CM. Exploratory hierarchical linear regressions were then calculated within the CM group to evaluate whether SES or depressive symptoms moderated CM severity on cognitive functioning. All variables were standardized prior to entry. Predictions were developed based on existing research and variables were entered

in order of anticipated highest influence: SES or total depressive symptoms (CDI), and overall CM severity were entered into the first and second blocks respectively. An interaction term was then calculated (SES x CM severity, and CDI X CM severity) and entered into the third block.

Results

Preliminary Analyses

Participant demographics. No significant demographic differences were found between the CM group and controls, including age, socioeconomic status (SES), sex, education, race, and ethnicity (*p*'s = .09-.95; see Table 1). Expected group differences were found for depression (CDI) and PTS symptoms (TSCC), as well as CM type severity, with heightened symptomatology in the CM group, with the exception of physical abuse severity where only seven participants met the cut-off score.

Within measure correlations. Given multiple measures were calculated from the RAVLT, correlations between all three conditions (i.e., verbal learning, delayed recall, recognition) were investigated. All measures were significantly related to each other (*r's* = .58 and .63*; p's* = .00). As such, a composite measure of memory and learning was created by adding all three variables together for a total sum, and then averaged; the resulting composite was standardized and used in further analyses.

Correlations between CCPT-II measures of sustained attention (HRBC) and discriminability (Detectability) were also explored. These measures were not significantly correlated ($r = .25$, $p = .10$); therefore, both measures of interest were examined independently. The Variability scale from this measure was examined as a potential explanation of sustained attention and/or inhibitory performance and found to be significantly correlated with sustained attention (HRBC; $r = .42$, $p = .00$), and trending for discriminability (Detectability; $r = .30$, $p =$

.051). This relationship may be better attributed to the propensity for overall attentional and inhibitory difficulties within this population. These challenges likely contribute to increased response times and/or commission of responses to faster stimuli blocks, and thus influence Variability scores rather than vice versa. When evaluated further, Variability was unrelated to CM severity (p = .41); as such, it was not included in additional analyses.

Between measure correlations. Within bivariate correlations, PTS symptoms (TSCC) were positively related to depression (CDI r = .52, p = .001) and anxiety (RCMAS r = .61, p = .000) symptoms. Increased PTS symptoms were also related to decreased category performance on verbal fluencies (DKEFS r = -51, p = .01). The PTS scale was the only clinical measure significantly related to other cognitive and psychiatric variables of interest. This is consistent with previous literature, indicating trauma reactivity prompted by CM events can lead to elevated psychiatric symptoms and decreased cognitive performance even in adolescence (De Bellis et al., 2013; Deprince et al., 2009; Schalinski et al., 2016). As anxiety was believed to be a product of this interaction, and not involved in additional hypotheses, it was removed from further analyses.

Population Comparisons for Normed Neuropsychological Assessments

On one-sample t-tests (see Table 2), the CM group demonstrated significantly greater crystalized vocabulary knowledge performance than population norms (WASI VOC; M = 56.71, SD = 8.2, t = 5.49, p = .000). In contrast, the CM group exhibited significantly lower performance than population norms on a measure of category fluency as compared to category switching (DKEFS Verbal Fluency Contrast; M = 8.84, SD = 2.62, t = -3.06, p = .005), and on discriminability (CPT Detectability; M = 54.55, SD = 6.86, t = 4.39, p = .000). The CM group demonstrated performance commensurate with the population mean on measures of auditory working memory (WISC DS), verbal learning and memory (RAVLT composite), perceptual

intelligence (WASI MR), and sustained attention (CPT HRBC). Bonferroni corrections were applied given repeated sampling, resulting in a new required significance value of $p = < .007$.

Stroop performance. Age was not significantly related to interference or accuracy scores on the Stroop task (*p's* = .21-.88); as such, it was excluded from further analyses to conserve power. A 2 (Group: CM, Control) x 2 (Block: Unequal, Equal) repeated measures ANOVA for interference was conducted to investigate performance differences between and within groups. A significant main effect of Group was found, with adolescents in the CM group demonstrating greater interference across equal ($M = 0.27$, $SD = 0.18$) and unequal blocks ($M = 0.13$, $SD = 0.19$; $F(1, 47) = 4.23$, $p = .04$). Neither a main effect of Block ($p = .16$), nor interaction effect ($p = .50$) was found. An additional 2 (Group: CM, Control) x 2 (Block: Unequal, Equal) repeated measures ANOVA was conducted to assess the potential influence of accuracy on interference performance. Neither significant main or interaction effects ($p = .21$-.68) were found for either group. Additionally, group differences were not indicated ($p = .29$).

Childhood Maltreatment Heterogeneity Analyses

Child maltreatment severity. Pearson's bivariate correlations were conducted to examine relationships between variables of interest (see Table 3). Increased CM severity was negatively related to sustained attention (CPT HRBC; $r = .36$), but not related to perceptual intelligence (WASI MR; $r = -.27$). Additional, exploratory analyses were conducted to investigate whether additional, significant differences between cognitive performance and norms were attributable to CM severity. These analyses included crystalized vocabulary (WASI VOC; $r = .10$), verbal fluency (DKEFS Verbal Fluency Contrast; $r = -.28$), working memory (WISC-IV DS; $r = -.22$), discriminability (CPT Detectability; $r = .30$) or verbal learning and memory composite (RAVLT; $r = -.28$) variables, which were not significantly related to CM severity.

Abuse and neglect. Hierarchical linear regressions were calculated to investigate theory driven abuse and neglect severity hypotheses. Variables were entered in separate blocks in order of theorized effect on the dependent variable with those of highest proposed impact entered into later blocks. Specifically, abuse was expected to be associated with sustained attention more than neglect due to heightened reactivity to and distraction from the environment, while neglect severity was expected to be more predictive of perceptual intelligence than abuse due to associated deficits in visual experiences, and stimuli needed to activate and develop such processes). This was in an effort to account for the separate effects of each variable on individual models. Results of the first hierarchical linear regression indicated abuse severity did not significantly predict perceptual intelligence (WASI MR) at step one (β = -0.26, $t(42)$ = -1.75, p = .09); neglect severity was also not significant when added at step two (β = -0.08, $t(41)$ = -0.45, p = .66). In the second regression, neglect was a significant predictor of sustained attention (CPT HRBC) at step one (β = .42, t (41) = 3.00, p < .01), explaining 17.9% of the variance ($F(1, 41)$ = 8.97, p < .01). Abuse was not a significant predictor when added at step two (β = -0.02, t (40) = -0.12, p = .92).

Exploratory moderation analyses. As tests were age standardized and largely unequal proportions of female to male participants were recruited resulting in a lack of power to investigate sex specific contributions to performance, only SES was run as an additional demographic variable to test for potential moderation effects. Hierarchical linear regression analyses were conducted; SES and overall CM severity were entered into the first and second blocks, respectively. An interaction term was then calculated (SES x CM severity) and entered into the third block. SES did not exhibit a main effect on measures of perceptual intelligence or sustained attention. CM Severity did not exhibit a main effect on perceptual intelligence but did

have a main effect on sustained attention (CPT HRBC β = .36, $t(40) = 2.47$, $p < .05$) as expected. The interaction term was not significant for either analysis indicating SES did not moderate the relationship between CM Severity and either outcome variable. Depression (CDI) was also run as a potential, exploratory moderator in the same way due to its known impacts on cognitive functioning, but was not found to influence the relationship between CM severity and perceptual intelligence or sustained attention (WASI MR β = .08, $t(42) = 0.51$, $p = .62$; CPT HRBC β = .06, $t(41) = 0.38$, $p = .71$), and did not exhibit significant interaction terms (WASI MR: CDI X CM Severity $\beta = .31$, $t(40) = 1.60$, $p = .12$; CPT HRBC: CDI X CM Severity β = .24, $t(39) = 1.03$, $p = .09$).

Discussion

This study examined performance differences between a tightly controlled adolescent population with a history of CM and national norms on standardized clinical and neuropsychological measures. It was hypothesized many domains of functioning would be negatively impacted by CM events in comparison to norms, despite removal of several potentially confounding variables and use of an adolescent sample. Additionally, average or above average performance was predicted on select cognitive measures due to potential proposed patterns of strengths in addition to deficits. Overall, predictions of clinical performance were founded. Significant differences in anxiety, depression, and post-traumatic stress symptomology were demonstrated between control and CM groups, with CM participants exhibiting heightened difficulties. Additionally, significant correlations between measures were identified within the CM group: PTS symptoms were positively related to symptoms of depression and anxiety, and negatively related to verbal fluency performance. It appears trauma reactivity stemming from these adverse events may have contributed to an increased risk for elevated psychiatric

symptoms and decreased cognitive performance by adolescence. These findings are consistent with previous work with adults, as well as work demonstrating inhibitory and connectivity difficulties in systems overloaded from stress (De Bellis et al., 2013; Deprince et al., 2009; Schalinski et al., 2016).

Effects of CM on functioning. It was hypothesized the CM group would demonstrate a specific pattern of strengths and weaknesses on standardized neuropsychological measures of cognitive functioning, compared to population norms. Generally, results indicated these predictions were in the expected direction only for an executive functioning task of discriminability. Specifically, adolescents with a history of CM performed worse than measure norms on this task. This is consistent with past work showing worsened performance of less tightly control adult CM samples compared to controls with regards to inhibitory control and attention (Gould et al., 2012; Lu et al., 2017; Mills et al., 2011). It is likely that these difficulties and related trauma responses later coalesce and contribute to further impairments. Significant differences were found between the CM group and population norms on additional measures, although in unexpected directions. For example, the CM sample performed significantly and unexpectedly above measure norms on a task of crystalized vocabulary knowledge, although they were hypothesized to perform within the average range. It is likely some demographic resilience factors, such as SES and parental education, which were consistently higher in the current sample than population norms, could explain this unanticipated finding. These demographic variables may indicate the positive influence of additional knowledge and resources, such as tutors, books, and educational programming on vocabulary development. The CM group also unexpectedly demonstrated significantly lower performance than measure norms on a simpler and more rote task of verbal categorical fluency versus a more complex task of

executive function that included switching performance. It may be the CM group benefitted from the process of continually updating task goals when switching between tasks. Specifically, through updating from one process to the next (e.g., switching from one category of responses to another), they were provided with cues as to what they were doing, which likely increased their ability to monitor their performance and maintain attention throughout the task. Conversely, the more basic task of category fluency did not include switching, and as such likely they did not engage this ongoing process of updating. Our finding is consistent with previous research demonstrating a tendency for this group to update rather than clear information, and to benefit from reinforced task demands and reminders in adult samples (Mackiewicz Seghete et al., 2017; Mackiewicz Seghete et al., 2018). These results lend addition evidence to ongoing research, aiming to identify how executive function performance can be different across contexts and tasks.

Results from the matched group analysis of response inhibition indicated adolescents with a history of CM exhibited heightened inhibitory difficulty on tasks, which included interference in the form of competing information from the environment, as compared to controls. Generally, these outcomes indicate difficulties largely associated with executive functioning within this sample. This makes sense as the biophysiological structures, mechanisms, and pathways involved in inhibition commonly exhibit the largest effects of CM experiences in adult samples, and are most likely to be observed within tightly controlled participants undergoing rapid neurodevelopment. It may be the increase of dopamine to the prefrontal cortex and the reduction of GABA to cortico-subcortical areas commonly experienced after CM events leads to poorer control of prepotent meteoric responses, such as an increase of commission errors on measures of discriminability (Barker, et al., 2015; Hermans et al., 2018).

Such inhibitory difficulties would be expected to persist and grow in comparison to controls over time, becoming more pronounced and consistent with many studies indicating inhibitory difficulties in adults who have experienced CM. These differences may be due to the continued effects of stress reactivity and cortisol elevations to these already overloaded areas, which undergo prolonged development and have high numbers of glucocorticoid receptors (Teicher et al., 2016).

Effects of CM severity. Overall, the study's secondary hypothesis that severity of CM would significantly impact cognitive functioning at a within group level, was partially supported. Results indicated higher levels of CM severity were significantly associated with worsened sustained attention, which is consistent with historical work measuring maltreatment severity as related to executive functions in less tightly controlled, adult samples (Lu et al., 2017). Severity of CM experiences did not predict any other cognitive outcome variable within our sample, which may be attributable to a lack of individuals who endorsed severity levels greater than one standard deviation above the group mean ($N = 5$).

Hierarchical liner regressions were conducted to explore within group differences in performance as influenced by specific CM type (e.g., abuse or neglect) severity; significant although unexpected results were obtained. Specifically, greater abuse severity was hypothesized to predict poorer sustained attention over neglect severity due to an expected, detrimental influence of heightened arousal and hypervigilance to other, external stimuli. Conversely, results indicated greater neglect severity predicted poorer sustained attention, while abuse severity did not. It may be the overall dampened and lessened development occurring in neglect experiences, including reduced time and interactions with caregivers, could lead to later deficits in sustained attention and inhibitory skills, especially when encountering stimuli and

contexts not provided in earlier periods. Comparatively, abuse severity effects may not be displayed as prominently in highly controlled environments involving tasks of cool executive function (i.e., top down process that is driven by affectively neutral contexts), which lack many external and emotionally salient inputs, especially in the case of participating in a novel task which could promote attention in itself. The differentiation between hot (i.e., top down process that is driven by motivation or affect) and cold executive function is proposed to occur within and be largely influenced by adolescent developmental processes, stages, contexts and adaptations (Zelazo & Carlson, 2012). Specific delays in hot executive function development have been identified in adolescents with physical or sexual abuse histories when compared to cold executive functioning skills, and have resulted in greater measured attentional impairment in adolescents (Zelazo & Carlson, 2012). Therefore, had this study measured hot instead of cold executive function the impact of abuse specific events on attention may have become significant.

Greater neglect severity was hypothesized to predict poorer perceptual intelligence over abuse severity in our second analysis, due to the decreased visual stimulation, caregiver interactions, and resources available in such situations. In contrast, while greater abuse severity trended toward predicting increased perceptual intelligence, neglect severity did not. This converse finding may implicate the pathway for neglect severity impact lies more heavily in sustained attention and related skill development rather than perceptual abilities. In fact, visual skills may be more necessary and used more frequently by children who are left unattended by parents in order to achieve their needs. Additionally, heightened arousal and hypervigilance to the environment could lead to an overall increase in and positive influence of perception-based skills, rather than proposed maladaptive or selective, stress-induced reactivity to such stimuli. Within our sample, physical (N = 7) and sexual abuse (N = 10) had overall low endorsement

rates. It may be these specific CM experiences have a greater impact on perceptually-based skills than other forms of abuse; as such, higher recruitment and specific testing of these types of CM might have produced more significant findings.

While SES and depressive symptoms were also investigated as potential exploratory moderators of the association between CM severity and cognitive functioning, neither significantly impacted this relationship. It should be noted, however, this was a tightly controlled sample and half of recruitment was performed with additional, strict imaging study eligibility criteria (e.g., no current use of medications that could affect the central nervous system, or reported history of bipolar I or psychotic disorder in biological parents). These exclusions likely resulted in a sample with reduced risk for lower familial SES due to improved parental functioning, and lessened psychiatric symptom severity as evidenced by a lack of use or need for medications, compared to other CM samples. Without these exclusions, results may have indicated significant, negative moderations consistent with previous studies.

Development and resilience. While deficits in executive function were found within our population, other, unexpected results were also obtained compared to previous research with adult populations. Some of these findings may be attributable to age and developmental trajectories of measured skills and neurobiological processes as stated above. Additionally, contexts, task demands and rehearsal of skills for necessary and daily tasks can look very different between adolescence and adulthood. For example, differences in ability to use working memory and other skills associated with a learning environment may become more prominent between individuals with and without CM histories over time. It may be that individuals with CM histories lose ability for unpracticed skills at a faster rate than individuals without such a

history. Additionally, it could be the impact of chronic stress response systems require additional time throughout neuroplasticity and connectivity processes to affect such skills.

While developmental processes and contexts and commonly co-occurring and confounding variables could explain some of the difference found between proposed impacts and study results, it is likely resilience also played a significant role within our sample. Resilience has generally been described as the ability to adapt, recover, and function in the face of significant stress, such as adversity or trauma (Masten, 2001). Many individuals within our adolescent sample were able to function at an average or above average level on tasks measuring skills and abilities expected to show deficits. It is likely resilience factors within this sample, such as higher parent education, parent support, pre-CM intellectual functioning and learned skills, and SES, contributed to adolescent ability to overcome negative effects associated with CM experiences. It was beyond the scope of the current project to investigate the moderating effect of resilience on CM outcomes; however, future analyses are planned. Additional studies exploring the effect of CM using a resilience model, rather than a traditional psychopathology perspective, may lead to better identification and promotion of adaptive processes, thereby improving long-term and intergenerationally-spanning outcomes within this population.

Diversity Considerations

While there are no differences in abuse rates across non dominant cultures, ethnic minorities are over represented within the child welfare system and underrepresented in research (Naughton, 1997). Studies involving participants from dominant and nondominant cultures have shown CM outcomes, intervention effects, and the variables that moderate and/or mediate such effects are similar across cultures (Naughton, 1997). Additionally, non-dominant cultures have shown much higher rates of attrition and missingness of data in historical studies, potentially due

to participation barriers and/or past harm stemming from other scientific studies (Leong & Kalibatseva, 2011; Snowden, 2003). As such, there is a clear need for increased efforts to include and consider these diverse populations within CM research. This study aimed to recruit a diverse sample including recruitment efforts to present at and speak with children and families at two local organizations with predominately African American and Latinx clientele. Study recruitment resulted in 35.3% of participants who identified as a race other than "White" or "Caucasian," which indicated heightened racial diversity within this sample as compared to the local metropolitan area (77.4% Caucasian; U.S. Census Bureau, 2017). Furthermore, cases of missingness and attrition within this sample were investigated and found to be unrelated to diversity factors. Recruitment efforts produced a predominately female population (75%), despite efforts to recruit an equal representation of sex. Study results indicated potential effects of sex, specifically with males exhibiting a tendency to outperform females on a measure of perceptual intelligence. It is possible this finding is related to higher prevalence rates of physical abuse within males, or underreporting of sexual abuse, and resultant visual hypervigilance, as discussed above. For example, out of the 17 participants that endorsed physical or sexual abuse in our sample, only 3 were male. Unfortunately, recruitment of male participants in this population is plagued with difficulties. Research has suggested that under reporting related to common socially-maintained male stereotypes, such as a need for increased self-reliance and masculinity, as well as a decreased lack of inquiry and awareness of adults to potential abuse of males contribute to these difficulties (Spartaro, Moss & Wells, 2001). Such factors make it difficult to study effects of CM experiences on individuals who identify as male, although such information could greatly aide in informing prevention and intervention efforts.

Limitations and Future Directions

Due to tight recruitment control, resulting sample size limited power and capacity for in-depth, nuanced analyses. With additional power and equal recruitment of both matched control and CM groups, further differences in performance may have been indicated within this sample. For example, group level performance did not differ from standardized norms as hypothesized on many measures (i.e., auditory working memory, verbal learning and memory, perceptual reasoning, sustained attention). This lack of significance may be attributable to the difficulty of comparing a sample of individuals who have all experienced CM events to population norms, as these norms can include individuals who may or may not have also experienced CM. Recruitment of additional, tightly-controlled CM and control groups would allow for other powered matched group analyses, avoiding this potential confound. Additionally, continued efforts should be made to recruit participants experiencing many different forms of CM, as well as equal male and female groups to further investigate potential causes of CM outcome heterogeneity.

Null results achieved in this study may have also been attributable in part to the influence of development on brain structures and processes. Specifically, changes to structures and connectivity continue to occur after chronic exposure to stress, affecting development of prefrontal and hippocampal areas into mid adulthood (Teicher et al., 2016). These processes are just beginning to emerge in adolescence and are more difficult to measure throughout earlier time periods. Longitudinal studies would be better equipped to explore these potential systemic effects than the current cross-sectional design. Additionally, studies exploring the moderating influence of resilience factors on expected outcomes following CM experiences may clarify some of the unexpected findings in the current study.

Lastly, tightly controlled CM samples are desirable for developing initial baseline CM treatment profiles; strengths of this approach include being able to selectively study aspects and outcomes specific to the individual and their personal CM experience. While many studies have attempted to covary for potential moderating factors, deficits in cognitive function continue to be identified likely due to the early and severe nature of CM specific events. Baseline profiles developed from projects involving tightly controlled samples would be extremely valuable for their tailoring potential; that is, their ability to supplement known impacts of CM with those of additional moderating variables and interactions specific to the individual. Results obtained from such work could lend insight into potentially sensitive developmental period to alter trajectories or provide buffer zones for the expected negative, and lifelong impacts proposed by typical dose/gradient models of CM. In summary, work using this tightly controlled group is especially important as it may elucidate variables that have been protective and promotive to this point, and how we as professionals can work to promote such processes throughout chronic stress-response and neuroplastic effects.

Conclusion

Results of this study indicated even within a population tightly controlled for confounding variables (e.g., TBI, significant substance use/exposure, major developmental or psychotic disorders, major medical illnesses), adolescent individuals with a history of CM exhibit significant difficulties with executive function, consistent with similar work involving adult participants. Additionally, many common CM related deficits found within adult populations were not demonstrated within the current adolescent sample, indicating later developmental, confounding, or resilience factor contributions are responsible for additional changes in functioning over time. CM severity demonstrated further and specific within group

effects on sustained attention skills. Lastly, effects of severity by type of CM were indicated, as greater neglect specific severity predicted poorer sustained attention. Overall, these findings lend some insight into the heterogeneity of CM outcomes. Additionally, they underscore the need for future, tightly controlled longitudinal studies with larger, more diverse samples within periods of rapid neuromaturation to identify models to address the effects of CM on development. These results, in turn, will inform the advancement of future interventions most likely to create lasting positive change within this population, and contribute to protective efforts and consequent prevention of future abuse cycles.

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Table 1.

Descriptive Statistics for Adolescents with Childhood Maltreatment (CM) and Controls

	CM				Control			
Variable	n	M	SD	% missing	n	M	SD	% missing
Adolescent Age	45	14.91	1.10	0	23	14.81	1.14	0
Hollingshead Index	45	30.87	16.09	0	22	24.18	11.07	0
CDI Total Score	45	56.91**	14.46	0	22	46.64	13.07	4
TSCC Posttraumatic Stress	38	50.21*	10.55	16	14	42.43	6.85	39
RCMAS Total Score	36	52.89*	13.39	20	14	44.57	10.85	39
CTQ Physical Neglect Severity	45	0.28**	1.09	0	23	-0.54	0.45	0
CTQ Emotional Neglect Severity	44	0.38**	1.04	2	23	-0.73	0.22	0
CTQ Emotional Abuse Severity	44	0.36**	1.01	2	23	-0.68	0.10	0
CTQ Physical Abuse Severity	44	0.17	1.20	2	23	-0.32	0.15	0
CTQ Sexual Abuse Severity	44	0.19*	1.19	2	23	-0.36	0.00	0
Variable	n	%			n	%		
Adolescent Sex – Female[a]	33	73.3			18	78.3		
White or Caucasian	30	66.7			14	60.9		
Asian	1	2.2			1	4.3		
Black or African American	2	4.4			1	4.3		
Multiple	8	17.8			7	30.4		
Spanish/Hispanic/Latino	2	4.4			0	0		

Notes. [a] Participants identified as only female or male within this sample

** $p < .05$; ** $p < .01$*

Table 2.

Functional One Sample T-Tests for Adolescents with Child Maltreatment (CM)

Measures	M	SD	Comparison Value	95% CL for Mean Difference	t	df
WASI-II Vocabulary	56.71	8.2	50	4.25, 9.18	5.49*	44
CPT Detectability	54.55	6.86	50	2.46, 6.63	4.40*	43
WASI-II Matrix Reasoning	52.69	8.45	50	0.15, 5.23	2.13	44
CPT HRBC	50.13	8.48	50	-2.45, 2.71	0.10	43
RAVLT Memory and Learning	-0.07	2.65	0	-0.87, 0.72	-0.19	44
DKEFS VF Contrast	8.84	2.62	10	-1.94, -0.37	-2.96*	44
WISC Digit Span	9.62	3.22	10	-1.35, 0.59	-0.79	44

Notes. HRBC – Hit rate block change

** Bonferroni correction applied, p < .007*

Table 3.

Intercorrelations of Maltreatment Severity and Selected Adolescent Functional Variables in the Childhood Maltreatment Group

Variable	1	2	3	4	5	6	7	8
1. WASI Vocabulary	-	.20	.11	-.10	.04	.32*	.02	.10
2. WASI Matrix Reasoning		-	.20	-.26	.53**	.36*	.18	-.27
3. RAVLT Memory & Learning Composite			-	-.35*	-.43**	.04	.15	-.28
4. CPT Detectability				-	.25	-.18	-.42**	.30
5. CPT Hit Rate Block Change					-	-.11	-.06	.36*
6. WISC Digit Span						-	.27	-.22
7. DKEFS Verbal Fluency Contrast Score							-	-.28
8. CTQ Maltreatment Severity								-

Notes. * $p < .05$; ** $p < .01$