Early Maltreatment, Executive Functioning, and the Protective Role of Early Childhood Interventions

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Abstract

Executive functioning, a subset of cognition associated with the prefrontal cortex, is highly influenced by adverse early experiences like childhood maltreatment. However, since the developing brain is adaptive, social support and therapeutic interventions may alleviate some of the negative effects of maltreatment in young children. This senior thesis examines the effects of maltreatment occurring prior to 24 months of age on preschool-aged children's executive functioning, also exploring how home-visiting and center-based childcare programs may improve cognitive outcomes for at-risk children. Data were drawn from a randomized control trial examining the impacts of a statewide home visiting program for adolescent mothers and their children. Findings showed that maltreated children did not exhibit lower executive functioning when compared with non-maltreated children. These findings provide support for resilience following early maltreatment; or conversely, the neurocognitive effects of maltreatment may remain latent until middle childhood or adolescence. Results also indicated that earlier placement in center-based childcare (≤24 months) was associated with higher visuo-spatial working memory, but other domains of executive functioning were not significantly related to center-based childcare participation. These results indicate that center-based childcare may produce domain-specific executive functioning benefits, but more investigation is needed to determine the linkage between center-based childcare and executive functioning.

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Introduction

Multiple studies have found associations between child maltreatment and early cognition, highlighting the adverse effects of chronic stress on young children (Mills et al., 2011). Maltreatment is a significant public health issue affecting approximately 3.9 million children in the U.S. annually, and the stress associated with early maltreatment can have lasting effects on brain structure and function (Administration of Children & Families, 2013; Shonkoff et al, 2009). Executive functioning, a subset of cognition associated with the prefrontal cortex, develops postnatally and is highly influenced by the caregiving environment (Best & Miller, 2010). Children who have experienced abuse and neglect display lower executive functioning when compared with non-maltreated children (DePrince, Weinzierl, Combs, 2009); these early deficits in executive functioning may explain why maltreated children exhibit more behavioral and academic problems in the transition to school (Manley et al., 2013). Since the developing brain is adaptable, social support and therapeutic interventions may alleviate some of the adverse effects of maltreatment in preschool-aged children (Fischer, Stoolmiller, Gunnar, & Burraston, 2008). However, little is known about the impact of community-based interventions and social programming for this population of children, especially in relation to executive functioning. Home visiting and center-based childcare programs are two such interventions that may improve cognitive outcomes for at-risk children. These two models of service delivery have become increasingly available in many areas of the U.S. (The White House, 2013), and there is a critical need to understand how these programs impact young children.

Executive Function: An Overview

Executive functioning (EF) is a subset of cognition associated with the prefrontal cortex and implicated in higher-order thinking. The terms "executive functioning," "executive function," and "executive functions" are synonymous in the research literature and will be used interchangeably in this paper. Executive functioning includes three distinct but interconnected components: working memory, response inhibition, and set shifting/cognitive flexibility (Garon, Bryson, & Smith, 2008). Working memory is defined by remembering information after a short delay. Response inhibition refers to withholding a prepotent or automatic response. Set shifting/cognitive flexibility refers to the ability to attend to different aspects of environmental stimuli and respond accordingly (Garon, Bryson, & Smith, 2008)

Since the prefrontal cortex develops postnatally, these cognitive processes are highly influenced by environmental factors (Best & Miller, 2010). The period between birth and school entry is an especially important time in EF development. The prefrontal cortex experiences significant growth during the preschool years, demonstrating increased neuronal connectivity and metabolic activity between 2 and 4 years (Huttenlocher, 2002; Carlson, 2003). More specifically, the brain undergoes a series of structural changes driven by myelination and synaptic pruning. These two processes are shaped by children's experiences and create a more efficient system of neuronal connections in the brain (Best & Miller, 2010). This period of rapid postnatal growth before school entry provides a window for early experiences to support or hinder EF development.

Although EF is often viewed as a unitary construct with multiple components, there is controversy in the field regarding the existence of a single EF process. Researchers supporting a unitary approach assert that a single EF faculty guides multiple, interconnected cognitive processes (Garon, Bryson, & Smith, 2008). This perspective is supported by numerous studies finding intercorrelations between different measures of EF, along with research showing that a "developmental spurt" in children's EF abilities exists between 3- and 6-years (Carlson, 2010; Carlson, Mandell, & Williams, 2004; Garon, Bryson, & Smith, 2008). In contrast, componential perspectives argue that EF consists of dissociable processes (i.e. working memory, set shifting, and inhibition), and these processes have different developmental trajectories and origins in the brain (Lehto et al., 2003; Carlson & Moses, 2001; Anderson, Levin, & Jacobs, 2002). Recent research has presented a more integrated EF framework, in which EF exists as both a unitary construct and set of dissociable components (Miyake et al., 2000).

EF can also be conceptualized as either "cool" or "hot," which serves as an additional classification system for deconstructing EF tasks. These labels are separate from the three components of EF described above, and indicate the presence of rewards and/or punishments in an EF task. "Cool" EF functions in affectively neutral contexts, in the absence of any direct reward to the participant. Most lab-based measures of EF have traditionally measured cool EF, including the Wisconsin Card Sorting Task, the Color-Word Stroop task, and the Dimensional Change Card Sort (Zelazo & Carlson, 2012). In contrast, "hot" EF operates in motivationally and emotionally significant contexts (Zelazo & Carlson, 2012). There is evidence that hot EF tasks activate different areas of the brain than those involved in cool EF tasks (Zelazo & Carlson, 2012; Hongwanishkul, Happaney, Lee, & Zelazo, 2010). The delay of gratification task, a measure of self-control that requires children to refrain from eating a marshmallow for 15 minutes in order to receive a larger reward, is one frequently cited example of a hot task (Mischel et al., 1989; Zelazo & Carlson, 2012). The presence of a food-based reward in this task adds additional cognitive demands that influence behavior and undermine executive processing. Consequently, hot tasks may be better measures of practical EF skills since decision-making rarely occurs in the absence of motivational or emotional influences (Zelazo & Carlson, 2012).

Importance of Executive Functioning in Academic Settings

Executive functioning is a critical skill for children of all ages, especially upon school entry. While these skills begin to develop in early infancy, the preschool years function as a foundational period in EF development (Garon, Bryson, & Smith, 2008). The ability to plan, inhibit, regulate, attend, and create memories develops during the early childhood period, and these skills become increasingly important when children enter school. Furthermore, early EF performance is a strong predictor of elementary school outcomes, particularly math achievement, reading skills, classroom behavior, and school engagement (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Bull, Espy, & Wiebe, 2008). This linkage between EF and academic achievement persists throughout the school years, with studies finding positive correlations between EF and math, reading, and science ability in adolescent populations (Best, Miller, & Naglieri, 2011; St. Clair-Thompson & Gathercole, 2005). These studies provide evidence for the importance of EF, as well as the need to understand how to support positive EF development throughout childhood.

Social Influences on Executive Functioning Development

EF development is positively associated with aspects of sensitive and responsive caregiving. In one study, children who experienced higher-quality parenting and secure maternal attachment during infancy displayed higher EF and impulse control at 3-years old (Bernier, Carlson, Deschenes, Matte-Gagne, 2012). This study defined "higher-quality parenting" with many of the characteristics associated with sensitive and responsive caregiving, including positive affect, cooperation, encouragement, and emotional engagement (Bernier, Carlson, Deschenes, Matte-Gagne, 2012). Other studies have looked specifically at parental language use and child EF, discovering that the quality of parent-child interactions may influence EF development (Carlson, 2003; Hughes and Ensor, 2009). Positive spoken interactions with caregivers provide children with the verbal skills to internally facilitate their behavior, solve problems, and use EF-related skills like inhibition (Carlson, 2003). Furthermore, scaffolding, a term referring to the way in which caregivers support children's goal-directed activity and provide problem-solving strategies, is associated with EF performance (Carlson, 2003; Hughes and Ensor, 2009). Maternal scaffolding during toddlerhood predicts EF performance at 4-years old (Hughes and Ensor, 2009). Related constructs like maternal autonomy support and mind-mindedness are also linked to EF skills in early childhood (Bernier, Carlson, and Whipple, 2010). These two terms refer to parental behaviors related to encouraging choice, providing appropriate adult intervention, and responding to young children's cues and mental states (Bernier, Carlson, Deschenes, Matte-Gagne, 2012)

In contrast, adverse family circumstances are associated with lower EF performance (Hughes, 2011). Hughes and Ensor (2009) discovered that family chaos and inconsistent parenting were also associated with lower EF scores in 4-year-old children. Familial demographic characteristics like low SES and social disadvantage have also been associated with lower EF (Hughes and Ensor, 2010). In one study, social disadvantage, a construct encompassing income, neighborhood, and use of public benefits, was negatively associated with EF performance in 2-year old children (Hughes and Ensor, 2010). These results suggest that the stress associated with being poor adversely affects EF development, a finding that has been replicated in multiple research studies and across age groups (Raver, Blair, & Willoughby, 2013; Hackman, Gallop, Evans, & Farah, 2015). There is also evidence that the quality of the early childhood home environment mediates the association between SES and EF, which suggests that SES modifies parenting behaviors in ways that affect EF development (Hackman et al, 2015). Economic hardship may adversely influence parents' behaviors and emotions, which in turn decreases the quality of their parenting (Conger & Donnellan, 2007). In summary, while sensitive parenting may positively support EF development, adverse family circumstances may have the opposite effect. Children's cognitive development is influenced by a variety of factors, starting at the individual level and extending to the socioeconomic level.

Biological Predictors of Executive Functioning

In addition to parental influences, there is also considerable individual variation in EF functioning that can be attributed to prenatal substance exposure. Children prenatally exposed to certain drugs like alcohol display lower executive functioning when compared with non-alcohol exposed children (Noland et al., 2003; Kodituwakku, Kalberg, & May, 2001). Children who have fetal alcohol spectrum disorder, a condition resulting from consistent prenatal alcohol consumption, display EF deficits in cognitive flexibility, some aspects of inhibition, set shifting, working memory, and planning (Rasmussen, 2005). Prenatal exposure to cigarettes and marijuana has been linked to poor cognitive outcomes (Fried, Watkinson, & Gray, 2003; Huizink & Mulder, 2006), although the association between these substances and EF is not consistent across all studies (Noland et al., 2003). Cocaine-exposed toddlers may also display lower inhibition and regulatory skills than nonexposed children (Espy, Kaufmann, Gilsky, 1999). Differences in attentional functioning and impulse control have also been documented in school-aged, cocaine-exposed children, showing that prenatal cocaine exposure may have persistent effects on EF (Savage et al., 2005).

Children with certain neurodevelopmental conditions like dyslexia, ADHD, and autism also display lower EF when compared with neurotypical children. For instance, dyslexic individuals show deficits in executive functions related to inhibition, working memory, and problem solving (Brosnan et al., 2002; Reiter, Tucha, and Lange, 2004). Individuals with ADHD may show similar symptoms to those with dyslexia, and the disorders are frequently co-morbid (Gooch, Snowling, & Hulme, 2011). ADHD is closely connected to executive functioning since impulsivity and issues in behavioral inhibition broadly define the diagnosis (Barkley, 1997). Deficits in EF related to ADHD are seen in preschool-aged children (Thorell and Wahlstedt, 2006), as well as adolescents (Toplak, Bucciarelli, Jan, & Tannock; 2008). Lastly, many individuals with autism often experience deficits in EF (Geurts et al., 2004), although some studies report that EF difficulties are not a universal feature of autism and are unrelated to autistic behaviors (Liss et al., 2003). One explanation for this these inconsistencies is the hypothesis that select domains of EF, including working memory and cognitive flexibility, are impaired in children with autism, but inhibition remains unaffected (Geurts et al., 2004). Ultimately, studies linking EF to these aforementioned conditions provide further evidence for the neurobiological origins of EF.

Maltreatment and Early EF Development

In addition to these biological influences, traumatic early experiences also play a large role in the development of EF. Children who have experienced abuse and neglect display lower executive functioning when compared with non-maltreated children (DePrince, Weinzierl, Combs, 2009; Beers and DeBellis, 2002). These early deficits in executive functioning may explain why maltreated children exhibit more behavioral and academic problems in the transition to school (Manley et al., 2013). However, the research literature in this area is limited because the study of EF has historically focused on adults (Garon, Bryson, & Smith, 2008). There are a limited number of studies that have examined the relationship between early maltreatment and executive functioning (DePrince, Weinzieri, & Combs, 2009; Spann, et al., 2014), but very few have specifically examined preschool-aged children. It is unclear whether there is strong linkage between maltreatment and EF, or if the relation between these variables is limited to certain EF domains. Namely, researchers have found non-significant associations between early maltreatment and childhood EF (Pears and Fischer, 2005; Nolin and Ethier, 2007), as well as domain-specific linkages between maltreatment and working memory (Augusti and Melinder, 2013). Since the study of executive functions and childhood trauma is an emerging area of research, there is a need to investigate how early adversity affects this specific area of cognition.

Biomedical models of early maltreatment highlight the deleterious effects of toxic stress on brain development. Toxic stress is a term describing the biological consequences of prolonged adversity (e.g. abuse and neglect) in the absence of protective relationships (National Scientific Council, 2010). More specifically, toxic stress is associated with continuous activation of the stress response system, which increases the production of stress hormones like cortisol, norepinephrine, and adrenaline (Schoncoff & Garner, 2011). Furthermore, maltreated children often have chronically elevated or otherwise atypical cortisol levels (Dozier et al., 2006). Cortisol is normally responsible for stimulating the body's "fight or flight" mechanism, but the dysregulated levels commonly observed in maltreated children inhibit brain development (Music, 2011).

Furthermore, the brain experiences structural changes following toxic stress and chronic cortisol elevation (Toxic Stress, 2014; Schoncoff & Garner, 2011). Maltreated children display abnormalities in brain volume, gray matter, and white matter in several areas of the brain that are highly sensitive to early stress (Hart and Rubia, 2012). Abuse-related deficits appear in the multiple areas of the brain responsible for cognition, including the prefrontal cortex, hippocampus, and corpus callosum (Hart and Rubia, 2012). These three areas of the brain are highly sensitive to early stress (DeBellis, 2001). The hippocampus, an area of the brain responsible for encoding memories, is one region that has received considerable attention in the maltreatment literature (DeBellis, 2001). Maltreatment negatively impacts neurogenesis in the hippocampus, destroying nerve cells and creating impairments in memory and mood-related functions (Music, 2011; Schoncoff & Garner, 2011). These modifications in brain architecture, among others, have implications for cognition and other neurological functions.

Moreover, there is considerable evidence that child maltreatment is associated with lower cognitive functioning (Mills et al., 2011). Maltreated children display lower intellectual capacities, decreased academic achievement, lower IQ, and more difficult classroom behavior when compared with non-maltreated children (DeBellis, Hooper, Pratt, and Woolley, 2009; Manly et al, 2013; Mills et al, 2011). The mechanism behind these relations relates to the timing and nature of early brain development. The early childhood brain is highly malleable and "plastic," so emergent neurocognitive functions are particularly sensitive to chemical changes in the brain (Shoncoff & Garner, 2011). Elevated rates of hormones like cortisol can impair development in key areas of the brain, which leads to decreased cognitive functioning (Arnsten & Goldman-Rakic, 1998; Carrion et al, 2010).

Child maltreatment, which is associated with these adverse cognitive outcomes, is a major public health issue. In 2013, approximately 3.9 million children were subjects of at least one maltreatment report in the U.S (Administration for Children & Families, 2013). The majority of child maltreatment victims experience neglect (78.3%), and the remaining victims experience physical abuse (18.3%) or sexual abuse (9.3%) (Administration for Children & Families, 2013). Children experiencing maltreatment are at-risk for a number of negative outcomes, including poor health, psychosocial problems, lower academic achievement, teen pregnancy, adult criminality, and substance use (Goldman, Salus, Wolcott, & Kennedy, 2003). These issues not only affect individual victims; all levels of society must bear the social and economic costs associated with child maltreatment. In particular, taxpayers are responsible for funding services provided to victims of maltreatment in the education, social services, and justice sectors. Child maltreatment imposes huge financial burdens on federal, state, and local governments, with estimates of up to $124 billion per year (Fang, Brown, Florence, & Mercy, 2012).

Populations Disproportionately Affected by Maltreatment

Certain populations of children are disproportionately affected by early maltreatment. The risk factors for maltreatment victimization are varied and include individual-, family-, and community-level characteristics. The combination of these factors, rather than one single characteristic, increases the likelihood of maltreatment victimization and perpetration (Child Maltreatment, 2014). On an individual level, very young children (i.e. under 4-years-old) and children with special needs experience higher rates of victimization. Parents with histories of maltreatment, substance use, mental health issues are more likely to be perpetrators (Child Maltreatment, 2014). In addition, certain demographic characteristics related to low educational attainment, poverty, single parenthood, and parental age are associated with maltreatment perpetration (Child Maltreatment, 2014). These factors interact with community characteristics, like community violence and neighborhood disadvantage, which also increase the likelihood of abuse and neglect in the home.

Furthermore, the children of teen parents experience elevated rates of maltreatment victimization for a variety of reasons. Young maternal age independently increases the risk of maltreatment perpetration, and other sociodemographic risk factors linked to teen parenthood can further intensify the likelihood of abuse and neglect. For example, teen parents are more likely to be low-income, and an increased likelihood of high school dropout prevents later social and economic mobility. Only 50% of adolescent mothers graduate from high school, compared with 90% of young women who do not have children during adolescence (Teen Pregnancy, 2014). Teenage parents experience higher levels of depression and psychopathology, and an absence of social support and positive familial relationships may also contribute to their compromised mental health (Barnet et al., 1996; Quinlivan, Tan, Steele, & Black, 2003). Furthermore, many teenage mothers have experienced child maltreatment themselves, with multiple studies citing maltreatment history as a risk factor for teen pregnancy (Hillis, et al., 2004; Noll, Shenk, & Putnam, 2008). There is evidence that as many as 50% to 60% of adolescent mothers have histories of childhood abuse (Klein, 2005). Since prior maltreatment influences parenting behaviors, increasing the likelihood of harsh parenting, there is evidence supporting an intergenerational transmission of maltreatment (Bert, Guner, & Lanzi, 2009; Pears & Capaldi, 2001).

These maternal risk factors have implications for parenting practices. Adolescent mothers use more punitive parenting practices, report higher levels of parenting stress, and have more unrealistic expectations for their children when compared with adult mothers (Haskett, Johnson, & Miller, 1994). In one study examining parenting stress in adolescent mothers, as many as one third of teen parents reported clinically significant levels of parenting stress (Larson, 2004). Adolescent mothers are also more likely to endorse harsher discipline strategies like corporal punishment (Haskett, Johnson, & Miller, 1994). These harsh and maladaptive parenting practices can become abusive without early intervention. As a result, it is no surprise that the children of adolescent mothers experience higher rates of maltreatment than the children of adult mothers (Paul & Domenech, 2000). Some studies report that this population of children is twice as likely to experience abuse and neglect when compared with children of adult parents (Raskin, 2013).

The Impact of Interventions on EF

Since the developing brain is "plastic," educational and therapeutic interventions may alleviate some of the adverse effects of maltreatment in preschool-aged children. Children who participate in trauma-focused interventions show increased social competence and more typical stress reactivity (Howell, Miller, Lilly, & Graham-Bermann, 2013; Fischer, Stoolmiller, Gunnar, & Burraston, 2008). In non-clinical populations of preschoolers, certain EF-specific interventions have produced significant improvements in EF performance (Hughes, 2011). These interventions include Head Start REDI and Tools of the Mind, two programs administered in preschool classrooms that address socio-emotional and linguistic skills (Bierman et al, 2008; Diamond, Barnet, Thomas, & Munro, 2007).

Head Start REDI, an intervention that fosters self-regulation, self-awareness, social problem solving, and literacy, has been shown to improve EF in low-income preschoolers (Bierman, et al., 2008). The intervention features the Preschool Paths Curriculum, a socioemotional learning program, as well as other modules focused on language and emergent literacy skills. In a randomized-controlled trial that enrolled approximately 356 four-year-olds from diverse family backgrounds, enrollment in Head Start REDI was associated with higher EF performance (Bierman, et al., 2008). Intervention effects were observed across two aspects of EF defined within this study, cognitive and behavioral performance. Cognitive performance tasks directly measured EF skills, while behavioral performance tasks assessed capacities related to EF (i.e. self-regulation and attention). Despite these results, the effect sizes were relatively small, which raises questions about the utility and practical applications of the intervention. However, the presence of program effects suggests that EF is responsive to classroom-level intervention.

The Tools of the Mind program is another evidence-based intervention that may increase EF skills in preschoolers. This Tools curriculum is informed by Vygotsky's model of EF and its development, a theoretical framework linking the development of EF with increased verbal abilities (Diamond, Barnett, Thomas, & Munro, 2007). Vygotsky argued that children could better regulate their behavior after developing the capacity to engage in private speech. Consequently, the intervention incorporates 40 EF-promoting actives that promote verbal self-regulation, dramatic play, and attention and memory skills (Diamond, Barnett, Thomas, & Munro, 2007). In an evaluation of the program that enrolled 147 preschoolers from a low-income, urban school district, children who enrolled in the Tools program outperformed control children on multiple EF measures. Differences between the Tools and control groups were most pronounced in measures of inhibition, the most challenging domain of EF for this population; performance on tasks that imposed minimal EF demands did not differ between the two groups (Diamond, Barnett, Thomas, & Munro, 2007). These results suggest that complex EF skills can be taught in the context of existing preschools without incurring huge costs or drastically changing curricula.

However, little is known about the impact of community-based interventions (i.e. childcare programs) for maltreated children, especially in relation to executive functioning. Studies looking at center-based childcare for at-risk children have shown promising results, linking childcare with positive developmental outcomes (Molborn & Blalock, 2012; Caughy et al., 1994). In the home visiting literature, children who receive services display more favorable cognitive development and behavior when compared with control children (Olds et al, 2002; Caldera et al, 2007). Since maltreated children are an especially high-risk group, interventions like childcare and home-visitation may serve an important protective function for this population.

Childcare as a Protective Factor

Evaluations of model early childhood programs have demonstrated that high-quality childcare can promote the cognitive development of at-risk children. Two such model early childhood programs include the Carolina Abecedarian Project and the High/Scope Perry Preschool Project. Both programs enrolled preschool-aged children and delivered high-quality childcare services to at-risk populations of children (Barnett & Belfied, 2006). Researchers have evaluated both programs in randomized control trials, and participation in these programs has been associated with positive developmental outcomes throughout the human lifespan. For example, children who participated in the Carolina Abecedarian Project had higher IQ scores starting at 18 months through age 8 when compared with children in the control group (Ramey & Campell, 1984; Campbell & Ramey, 1994). Children in the intervention group also outperformed control group children in both reading and math through the early elementary years, and the cognitive benefits of the intervention were maintained through age 12 (Campbell & Ramey, 1994). Similarly, children who participated in the High/Scope Perry project had higher IQ scores than those in the control group at 3-5 years old, and children receiving the intervention were less likely to repeat a grade or be placed in special education (Schweinhart et al., 2005; Barnett & Masse, 2007). Enrollment in both of these programs has also been associated with positive long-term outcomes into middle adulthood, illustrating how high-quality childcare programs can effectively promote positive development long after families discontinue services.

Despite these positive results, model early childhood programs can be costly and difficult to replicate. The majority of children in the U.S. who attend center-based childcare do not have the opportunity to attend such intensive, high-quality programs as the Carolina Abecedarian project or the High/Scope Perry project. However, researchers have found that enrollment in more commonly utilized community-based childcare programs is associated with positive cognitive outcomes for low-income children in particular (Caughy et al., 1994). For example, a longitudinal study following the children of welfare recipients found that participation in center-based programs had positive effects on child cognition at 2.5 years old and 4 years old (Loeb, Fuller, Kagan, & Carrol, 2004). The effects of center-based care were strongest for children who remained in care across both time points, suggesting that continuity in center-based care produces the most favorable child outcomes for low-income children (Loeb, Fuller, Kagan, & Carrol, 2004). Research focusing specifically on teen parents and their children has produced similar results. In one study using data from the nationally representative Early Childhood Longitudinal Study-Birth Cohort found that the children of adolescent mothers had differing cognitive and behavioral outcomes according to childcare arrangement. Children in center-based had higher reading and behavioral scores at age 4.5 when compared with children in all other care arrangements (Molbourn & Blalock, 2012). Ultimately, these results suggest that center-based care can produce positive cognitive gains in at-risk children (i.e. low-income and/or teen parent), regardless of program quality or intensity.

Theoretical Models of Development

The social-ecological model of development provides support for the compensatory role of these interventions. In this framework, characteristics of the individual, family, community, and society can mitigate the effects of risk factors like maltreatment. According to Bronfenbrenner (1994), development occurs through reciprocal interactions between the individual and environment, demonstrating the bidirectional interplay between nature and nurture. Children exist within a series of nested ecological structures, starting with the microsystem and moving outward to the macrosystem. The microsystem encompasses factors like family, peers, and school, while the macrosystem refers to societal and cultural influences (Bronfenbrenner, 1994). The intermediary levels of this model provide linkages between environments that directly include the individual child (e.g. family), as well as environments that indirectly (e.g. parents' workplaces) influence the child. Ultimately, this model demonstrates that multiple aspects of the social environment influence development through bidirectional processes, highlighting the potential role of interventions in targeting different areas of the developmental system (Sameroff & Fiese, 2000)

The transactional model is a related framework for understanding development within a system. In this model, the combination of an individual and his/her experiences produces specific outcomes (Sameroff & Fiese, 2000). The effects of individual characteristics and the environment are equally weighted, and individuals are never viewed as independent from their family and social context (Sameroff & Fiese, 2000).

Three important terms in this model are the environtype, phenotype, and genotype. Genotype and phenotype relate to genetic material and the expression of certain genes respectively. Environtype refers to the organization of social influences. In the transactional model, the child's behavior at any one time is a product of interactions between the genotype, phenotype, and environtype (Sameroff & Fiese, 2000).

The transactional model also has applications for the analysis and development of interventions designed to improve child outcomes. There are three types of early intervention within the transactional model: remediation, redefinition, and reeducation (Sameroff & Fiese, 2000). In the context of this study, home-visiting and center-based childcare function in distinct ways to improve child outcomes. In home-visiting programs, reeducation acts as the mechanism through which practitioners attempt to effect positive change. The home visitor acts to educate parents about positive parenting strategizes and change caregiving behaviors. In contrast, remediation acts as the theoretical framework for understanding center-based childcare. Remediation attempts to modify the child's characteristics, rather than the caregiving environment, typically through professional involvement (Sameroff & Fiese, 2000). Childcare provides children with the opportunity to interact with responsive caregivers in a stimulating environment, and these influences may act to remediate the effect of adversity.

Drawing from Sameroff's transactional model, this analysis is guided by a transactional-ecological framework of child maltreatment (See Figure 1). Since there are gaps in the maltreatment research literature examining preschool-aged children, a stronger understanding of the linkage between early maltreatment and EF needs to be established. Furthermore, a limited number of studies have examined maltreatment in teenage parent families, and virtually none have examined EF. In addition, no studies to date have investigated the potentially buffering effects of center-based childcare or home-visiting programs in relation to maltreatment. In particular, much of the childcare literature reviews model programs (e.g. Tools of the Mind, Head Start REDI, PATHS), and less is known about community-based programs readily available to most families. This thesis will address these gaps in the literature and attempt to investigate the cognitive effects of maltreatment in a largely understudied population of children.

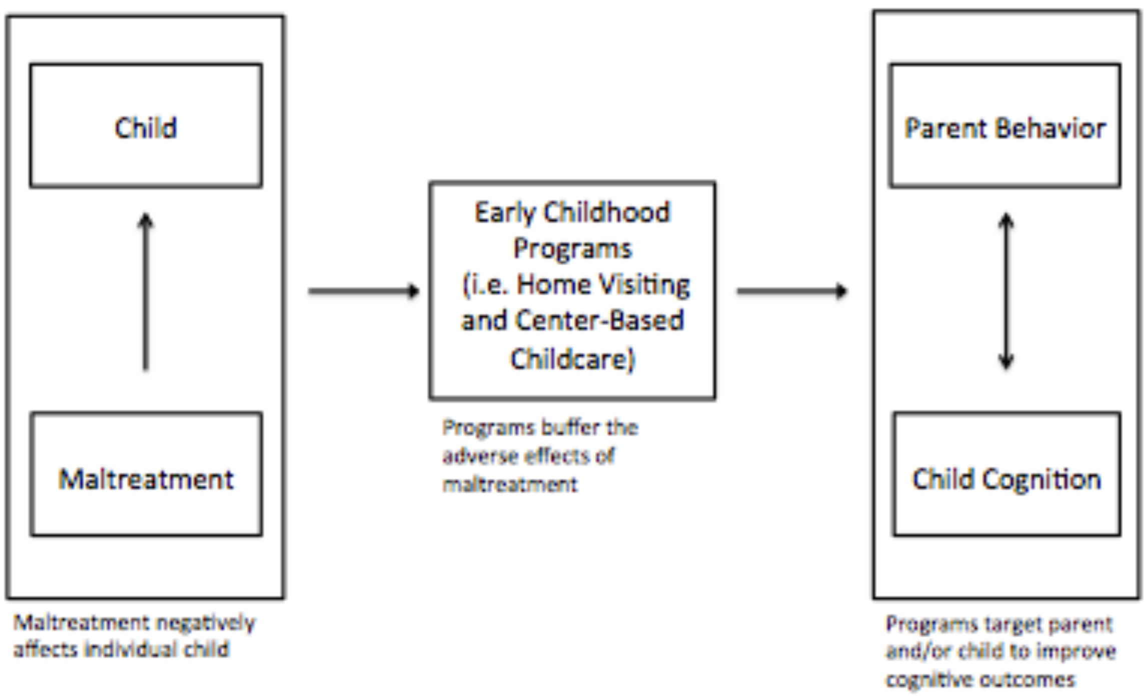

Figure 1: A transactional-ecological framework of child maltreatment, early childhood programs, and cognitive outcomes (Adapted from Katz, 2014).

Research Questions

This thesis will examine the relation between early maltreatment and executive functioning in the preschool years. This project will also investigate the moderating role of newborn home visiting and center-based childcare. The central research questions include the following: 1) Do maltreated children exhibit lower executive functioning when compared with non-maltreated children? The hypothesis is that maltreated children will display lower executive functioning when compared with non-maltreated children. 2) Does participation in Healthy Families Massachusetts moderate the association between child maltreatment and executive functioning? 3) Does participation in center-based childcare moderate the association between child maltreatment and executive functioning? It is also expected that participation in Healthy Families Massachusetts and center-based childcare will buffer the negative effects of maltreatment, resulting in higher executive functioning.

Method

Healthy Families Intervention and Evaluation

The participants for this analysis were children born to teen mothers enrolled in a statewide evaluation of Healthy Families Massachusetts (HFM). HFM is a statewide home visiting program for first-time pregnant and parenting mothers ages 20 and under. The Children Trust, a non-profit organization that manages and funds family support programs in Massachusetts, has provided HFM services to over 27,800 families since 1997 (Tufts Interdisciplinary Evaluation Research, 2013). HFM has the following goals: 1) Optimize early growth and development in infancy, 2) Prevent child abuse and neglect, 3) Promote parental educational attainment and economic self-sufficiency, 4) Reduce rapid repeat pregnancies, 5) Promote parental well-being. The program utilizes a combination of home visits, group activities, goal-setting, phone calls, and referrals to outside resources (e.g. continuing education, public benefits, child care). Mothers may receive HFM services beginning in pregnancy until their child turns three, but they must begin the program before their child's first birthday. The model for HFM is Healthy Families America (HFA), a national home visiting initiative that aspires to promote child well-being and prevent child maltreatment.

Researchers from the Departments of Child Development and Urban and Environmental Policy and Planning at Tufts University have been evaluating HFM since 1997 (Tufts Interdisciplinary Evaluation Research, 2013). The first phase of the Massachusetts Healthy Families Evaluation (MHFE-1) ran from 1997 to 2005. MHFE-1 collected data from 361 HFM participants and used a quasi-experimental, mixed methods design (Tufts Interdisciplinary Evaluation Research, 2013). The second phase of the evaluation, MHFE-2, began in 2007 and will continue data collection and analysis into 2015. MHFE-2 uses a randomized control trial (RCT) design to assess the aforementioned five goals of HFM. MHFE-2 is also investigating potential modifiers of program utilization and impact (e.g. individual, family, community, and program characteristics) and describing program processes (Tufts Interdisciplinary Evaluation Research, 2013). This thesis will focus exclusively on MHFE-2 and utilize data from this particular phase of the evaluation.

The mothers enrolled in MHFE-2 voluntarily requested services from HFM, meaning that they actively sought out services from HFM service providers. HFM initially recruited 837 participants for the study, and 62% (n=517) of moms were randomly assigned to the program group receiving home visiting services (HVS), and 38% (n=320) to the control group (RIO). Mothers in the control group, known as RIO, were only provided with basic information about child development and given referrals to other support programs. Approximately 16% of the initial 837 participants (n=133) withdrew, were never located, or were excluded based on demographic characteristics (Tufts Interdisciplinary Evaluation Research, 2013). Therefore, the final sample of 704 adolescent mothers represents a specific subsample of young mothers who met the following eligibility requirements: 1) Female, 2) 16 years or older, 3) No prior HFM affiliation 4) Fluent in English or Spanish 5) Cognitively able to provide informed consent (Goldberg et al, 2009).

Researchers have collected data from these 704 mothers and their children at four time points to date, and a fifth time point (T5) is currently undergoing active data collection. Researchers began collecting data soon after enrollment in the study (T1).

Following T1, researchers collected data at 12 months post-enrollment (T2), 24 months post-enrollment (T3), and when children were between 4 and 5 years old (T4) (See Figure 2). At each time point, mothers completed a semi-structured 30-minute phone intake interview that included questions about demographics, maternal mental health, utilization of public and social services, father involvement, financial resources, and housing configuration (Goldberg et al, 2009; Tufts Interdisciplinary Evaluation Research, 2013). 684 mothers completed the intake interview at T1, 564 mothers at T2, 594 mothers at T3, and 480 mothers at T4. T5 intake data are not available since data collection is ongoing.

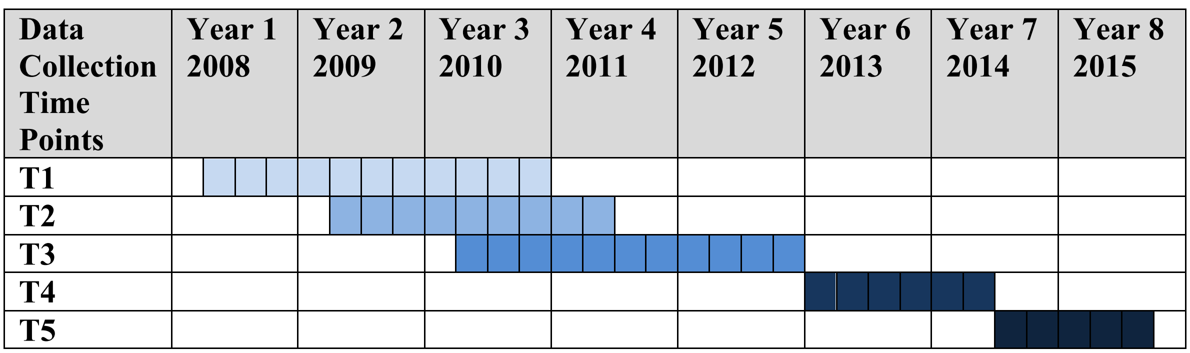

Figure 2: Data Collection Timeframe of the Massachusetts Healthy Families Evaluation (adapted from Tufts Interdisciplinary Evaluation, 2013)

Participants were also given the option of completing a 2-hour in-person interview in addition to the intake interview. Participants were compensated for their time with gifts cards for completing the in-person interview. 472 mothers completed the in-person interview at T1, 400 mothers at T2, 410 mothers at T3, and 430 mothers at T4. At T1 to T3, the research visits included a semi-structured interview, written questionnaires, observations of maternal-child interactions, and questions regarding program outcomes.

Through a combination of quantitative and qualitative methods, the visit was designed to collect information about program services, social relationships, maternal history, educational history, personal functioning/well-being (Goldberg et al., 2009). The collection of this data provided researchers with a deeper understanding of participants' personal, family, and community contexts, allowing them to evaluate the five HFM goals and identify any moderators of program outcomes. At T4, the research visit included the same components, but interviewers also gathered additional child data. The child protocol included a set of 9 psychometric assessments testing receptive language abilities, school readiness, and executive functioning. Four of the T4 executive functioning measures will be described in greater detail in the following sections.

Participant Characteristics

This study draws from a subsample of children (n=430) who participated in the T4 in-person research interview and completed at least one measure in the T4 child protocol. While approximately 430 children completed at least some portion of the T4 child protocol, completion rates vary depending on the measure (DCCS: n=366, Digit Span: n=343, Corsi: n=354). The average age at T4 was 4.9 years. The sample of children represents an even distribution of girls and boys, with slightly more males (52.7%) than females (47.3%). The sample also includes proportionally more non-White participants than in the larger sample of mothers (see Figure 2).

Mothers of children in this subsample also completed the T4 in-person research interview, and they had granted MHFE access to their agency data (i.e. Department of Children and Families). Mothers who did not consent to the sharing of their agency data, which included data related to their children, were excluded from the analysis. On average, mothers were 18.8 years old at the birth of their first child, but ages ranged from 15.1 to 21.4 years. The participants represented a diverse distribution of racial/ethnic groups, with 36.6% identifying as White, 18.9% as Black Non-Hispanic, 35.9% as Hispanic, and 8.1% as non-Hispanic other. The median household income according to census block groups was $47,590. At T1, 56.7% of mothers reported having some/major difficulties covering expenses, and the remaining 38.8% reported having no/very few difficulties. At T1, 36.7% of mothers were still in high school or GED programs, 27.6% of mothers had finished high school/GED programs, 21.8% had dropped out of school, 7.1% were in a training or college program, and 6.8% had finished at least one year of college. Characteristics of mothers and their children are presented in Table 1.

EF Measures

Executive functioning was measured in four ways. The tasks of interest include the Dimensional Change Card Sort, Digit Span, and Corsi Task. These three tasks were analyzed separately since they capture different domains of EF. Table 2 summarizes the EF constructs, corresponding EF measures, and sources of the data.

Dimensional Change Card Sort. The Dimensional Change Card Sort (DCCS) is used to measure cognitive flexibility, a subset of EF, in children between 3 and 5 years old. (Zelazo, 2006; Zelazo et al, 2013). Children are presented with two target cards, one showing a blue rabbit and another showing a red boat, and are instructed to sort cards by different visual characteristics (i.e. color or shape) in three test rounds. The three rounds proceed in the following order: pre-switch phase, post-switch phase, and border version. In the preswitch round, children are instructed to sort cards by color, separating red and blue cards. Children then automatically proceed to the post-switch round and are instructed to sort by shape, separating the rabbits and boats.

If children correctly sort at least 5 out of the 6 cards in the post-switch trials, they pass this section and continue into the border version phase. Most 3-year-olds fail the post-switch phase and continue to incorrectly sort cards by color, but the majority of typically developing 4- and 5-year olds pass this phase (Zelano, 2006). If children proceed to the border version, participants sort by color if cards have borders, and by shape if cards have no borders (Zelazo, 2006). Children who pass the border version must correctly sort 9 out of the 12 cards. The majority of 4-year-olds and half of all 5-year olds fail the border version (Zelano, 2006). Scoring follows Zelazo's (2006) pass/fail coding scheme:

0 = the child failed the pre-switch phase;

1 = the child passed the pre-switch phase but failed the post-switch phase;

2 = the child passed both the pre- and post-switch phases of the standard version but failed the border version;

3 = the child passed both the pre- and post-switch phases and the border version.

Higher scores indicate more advanced cognitive flexibility and EF. In accordance with the work done by Low (2010), this variable will be treated as a continuous during data analysis.

Digit Span Task. The Digit Span task is a test of working memory included in many neuropsychological batteries like the Wechsler Intelligence Scale for Children and the Pediatric Examination of Educational Readiness at Middle Childhood (Richardson, 2007; Wechsler, 1991). There are two subsections, the forward digit span (DF) and the backward digit span (DB). The DF task is considered a pure measure of working memory, while the DB task has additional inhibitory demands (Carlson, 2005). In the DF subsection, children are instructed to repeat sequences of numbers, starting at the 2-digit level and continuing to the 9-digit level. The DB subsection is shorter due to its difficulty level and ends at the 5-digit level. There are 6 items in each digit level, and the child cannot proceed to the next digit level until he/she has produced 4 correct responses. Children who give 3 incorrect responses do not proceed to the next digit level and reach the "ceiling" of that subsection. Preschool-aged children rarely complete all of the digit level lists in each subsection, and the backward digit span is especially difficult for 4-year old children when compared with other EF tasks (Carlson, 2005). This analysis will only use forward digit span scores because many children received a score of 0 in the backward digit span subsection, limiting the variability of scores. This pattern of low variability on the backward digit span task has been observed in other studies testing preschool-aged children (Bull, Espy, & Wiebe, 2008).

Corsi Block Task. The Corsi Block-Tapping Task assesses visuo-spatial working memory in both children and adults (Corsi, 1972). This task utilizes 9 blocks that are arranged in a predetermined sequence on a single sheet of paper. The interviewer and child sit directly across from one another, separated by the sheet of paper and arranged blocks. The blocks are numbered 1-9, and the numbers must only be visible to the interviewer. The interviewer then explains, *"I'm going to tap 2 blocks, and I want you to watch which ones I tap very carefully. When I'm finished, I want you to tap the 2 blocks I tapped in the same order that I tapped them."* The interviewer does two practice sequences, and then proceeds to the test round.

The test round consists of 16 possible trials, increasing in difficulty as the number of blocks increases sequentially from 2 to 9 blocks. The interviewer explains the change in digit level before starting a new digit (e.g. *Okay, now I'm going to tap 3 blocks, and I want you to watch which ones I tap very carefully. When I'm finished, I want you to tap the 3 blocks I tapped in the same order that I tapped them*). If the child incorrectly responds to two consecutive trials within the same digit level (e.g. the child taps the wrong blocks for both 5-digit trials), the interviewer discontinues the game. The child receives a proportion score reflecting the number of correct responses divided by the number of total responses; therefore, the range in scores is 0 to 1. This game is then repeated in backwards order, meaning that the child is instructed to tap the interviewer's block sequence in backwards order. This thesis will only utilize data from the forward Corsi task because backwards task scores within this subsample have limited variability.

Independent Variable Measures

Maltreatment. Data about maltreatment reports, report substantiation, perpetrator identity, and type of victimization was obtained from the Massachusetts Department of Children and Families (DCF). The data used in this analysis will represent maltreatment from birth to T3. Children were 24 months old on average at T3, but the range in ages at T3 is approximately 18 to 48 months. Furthermore, maltreatment cases reported between T3 and T4 are not included in this analysis. This analysis will define maltreatment by the presence of one or more 51A reports, regardless of DCF substantiation. Prior maltreatment research with this sample has defined maltreatment by the same terms because the titles of "unsubstantiated" and "substantiated" reflect institutional limitations in proving "reasonable cause" of abuse and neglect (Easterbrooks et al., 2013; Section

51B, 2014). In particular, the designation of "substantiated" often hinges on the availability of evidence accessible to the DCF worker, rather than the actual presence of harm (Drake & Jonson-Reid, 2000). High levels of recidivism among unsubstantiated cases demonstrate that this population is at high risk for later maltreatment, indicating that these reports are not random or unfounded (Drake, Jonson-Reid, Way, & Chung, 2003) Lastly, there is also evidence suggesting that young children's behavioral and developmental outcomes do not differ according to substantiation status (Hussey et al., 2005), so combining these groups serves to consolidate participants at the highest risk for poor cognitive outcomes.

This analysis also did not differentiate between different types of maltreatment since the vast majority of cases (98%) were related to neglect. The overrepresentation of neglect reflects the general patterning of child maltreatment in the U.S., in which neglect constitutes the most common form of early maltreatment (Administration for Children & Families, 2013). The analysis also did not differentiate between perpetrator identity because mothers were the perpetrators in approximately 75% of substantiated cases. It is likely that unsubstantiated cases would show a similar pattern, but DCF data are not available for those cases.

Center- based childcare participation. Data indicating participation in childcare was collected during the intake phone interviews at Time 2, Time 3, and Time 4. At each time point, mothers answered the question, "Who takes care of your child when they were not able to?" Mothers were given the option of choosing from the following choices: mother stays home with baby, father, maternal grandparents, paternal grandparents, maternal great grandparents, paternal great grandparents, other family, friend, babysitter, family child care provider, child care center, Early Head Start, child care center at school, and other. Mothers were also given the opportunity to indicate how many hours per week their child spent in said arrangement. This analysis will use a recoded binary variable that combines participation in any center-based, center-based care (i.e. child care center, Early Head Start, and child care center at school) for at least 10 hours per week into a single category. Participation in all other childcare arrangements (e.g. grandmother care, maternal care, babysitter care) was collapsed into a separate category reflecting no center-based care attendance.

In order to investigate how continuity in care affects EF outcomes, this analysis also manipulated childcare data to account for time of entry into center-based care. The recoded categorical variable will include the following options: no center-based childcare, T3 attendance only, T4 attendance only, and attendance at T3 and T4. This formation of these categories builds upon an analysis done by Katz (2014) that investigated children's socioemotional and linguistic outcomes in relation to childcare enrollment within the MHFE-2 sample. Katz found that extended participation in center-based care between time points was associated with the most favorable outcomes, suggesting that early time of entry and continuity in care positively impacts development (Katz, 2014).

HFM program enrollment. HFM program enrollment is a dichotomous variable that reflects mothers' initial program assignment into the program (HVS) or control (RIO) group. Mothers who were assigned to the HVS group were given the opportunity to receive services from Healthy Families Massachusetts, and mothers in the RIO group were only given basic information about child development and referrals to other support services. However, this variable does not reflect the intensity or length of service provision, and a large number of moms (22%) in the HVS group received a minimal (<5) number of visits for a variety of reasons. For example, mothers may have prematurely discontinued services because they were unsatisfied with their home visitor, or they may have experienced other circumstantial stressors (e.g. homelessness, domestic violence, unemployment) that required their full attention.

Control Variables

The control variables for all analyses included child sex, child age at T4, maternal depression at T1, HFM program participation, maternal education level at T1, and community cluster. Children's ages were calculated based on maternal reports of their date of birth. Chronological age (i.e. year, month, and day) was calculated in relation to the date of the T4 in-person research interview. Program participation was treated as a dichotomous variable (program or control group) that reflected initial program assignment in order to maintain the intent-to-treat model. Maternal education level at T1 was recoded into a dichotomous variable that differentiated participants who had graduated from high school versus those who had dropped out or were currently enrolled in school.

Maternal depression was quantified with the Center for Epidemiological Studies Depression Scale (CES-D), a self-report measure administered during the T1 intake interview and at all subsequent time points (Radloff, 1977). This questionnaire includes 20 items related to depressive symptoms that mothers respond to with a four-point scale (0= not at all, 3 = a lot). Respondents receive 0-3 points for each item depending on their response (e.g. 3 points for a score of 3), so total scores range from zero to 60.

Respondents with scores of 16 or above are considered at "high-risk" for developing depression (Radloff, 1977)

Lastly, community cluster is a variable that encompasses race and income in neighborhood contexts. The variable includes the following categories: 1) moderate income, homogeneous European American, 2) Low moderate income, ethnically diverse, and 3) low income, minority majority ethnicity (Katz, 2014). The variable is dummy coded into two groups for the analysis, one comparing groups 2 and 1 and another comparing groups 3 and 1 (Katz, 2014). Essentially, this variable will simultaneously account for the influences of race, income, and neighborhood, eliminating the need to control for these factors individually.

Statistical Analysis

Statistical analyses were performed with IBM SPSS version 22.0 using multiple linear regression. Since there were four dependent variables related to different components of executive functioning (DCCS, Less is More, HKTS, and Digit Span), each measure was analyzed in separate linear regression models. The following summarizes the analyses for each research question:

Research Question 1: 1) Do maltreated children exhibit lower executive functioning when compared with non-maltreated children?

In the first research question, maltreatment status acted as the independent variable and executive functioning as the dependent variable. The control variables (i.e. child age, sex, maternal depression, maternal education, HFM program enrollment, and community cluster) were also included as independent variables. Each EF measure (i.e. DCCS, Less is More, HKTS, and Digit Span) was analyzed separately under the same conditions.

Research Question 2: Does participation in Healthy Families Massachusetts moderate the association between child maltreatment and executive functioning?

This question examined HFM participation as a moderator between child maltreatment and EF in a multiple linear regression model. The dichotomous child maltreatment (maltreated/non-maltreated) and HFM participation (HVS/RIO) variables were multiplied together, and then imputed into the linear regression model as a predictor of EF. The control variables (i.e. child age, sex, maternal depression, maternal education, and community cluster) and main effect variables (i.e. child maltreatment and HFM participation) were also included in the model.

Research Question 3: Does participation in center-based childcare moderate the association between child maltreatment and executive functioning?

This question examined center-based childcare participation at T4 as a moderator between child maltreatment and EF in a multiple linear regression model. The dichotomous child maltreatment (maltreated/non-maltreated) and T4 center-based childcare participation (center-based childcare/no center-based childcare) variables were multiplied together, and then imputed into the linear regression model as a predictor of EF. The control variables (i.e. child age, sex, maternal depression, maternal education, HFM participation, and community cluster) and main effect variables (i.e. child maltreatment and center-based childcare participation) were also included in the model.

Results

Preliminary Analyses

Prevalence of maltreatment. Approximately 37% (n=159) of children had at least one DCF report by T3, and the remaining 63% (n=271) had no reports on file. Not all of the DCF reports were considered "substantiated," which means that the department investigated the report and did not find "reasonable cause" of abuse or neglect (Section 51B, 2014). A significant number of participants had "unsubstantiated" reports; approximately 36% (n= 58) of participants with any maltreatment reports had unsubstantiated allegations. Only 24% (n=101) of children had at least one substantiated report, and the remaining 76% (n=329) had no reports or unsubstantiated allegations.

Prevalence of childcare at T3 and T4. The proportion of children enrolled in center-based care and the length of time spent in center-based care changed between T3 and T4. Approximately 35.2% of children were attending center-based childcare at T3, and 47.3% of children were attending center-based childcare at T4. At T3, children attending center care spent an average of 34.8 hours per week in this care arrangement. At T4, children attended center-based childcare for an average of 29.9 hours per week.

Executive functioning performance. EF performance on the three tasks of interest (DCCS, Digit Span, Corsi Task) was generally variable and normally distributed. For the DCCS task, scores ranged from 0-4, and the mean score was 1.32 (SD=0.635). Scores on the Digit Span task ranged from 0-5, and the mean score was 2.34 (SD=0.901). Lastly, scores on the Corsi Task ranged from 0-4, and the mean score was 1.47 (SD=1.09).

Research Question 1: Do maltreated children exhibit lower executive functioning when compared with non-maltreated children?

Hierarchical multiple linear regression was used to test the hypothesis that maltreated children display lower executive functioning skills when compared with non-maltreated children. Each of the three measures of executive functioning (DCCS, Digit Span, Corsi Task) was entered into separate regression models. Table 3 presents the results of these analyses.

Dimensional Change Card Sort (DCCS). Data were analyzed with multiple regression analysis to explore the association between children's DCCS scores and maltreatment, controlling for child sex, child age, maternal depression, HFM program participation, maternal education level, and community cluster. Since this analysis utilized a hierarchical linear regression approach, the control variables were entered into Block 1 and the predictor of interest (any DCF reports over lifetime yes/no) was entered into Block 2. The initial model (Model 1) examined the control variables (child sex, child age, maternal depression, HFM program participation, maternal education level, and community cluster) as predictors of DCCS performance. The overall model was significant, $F\ (8,339)= 6.620$, $p<0.001$, $R^2=0.135$, and predicted 13.5% of the variance in DCCS scores. Within Model 1, child sex, child age, and maternal depression were independently associated with DCCS performance. Specifically, girls had significantly higher scores when compared with boys ($p=0.001$). Age was positively associated with DCCS performance ($p<0.001$), indicating that increased age was associated with higher scores on the task. Maternal depression was negatively related to DCCS performance (p=0.048), showing that increased maternal depression symptomatology was associated with lower DCCS scores.

The final model (Model 2) added the maltreatment variable to determine the relation between maltreatment status and DCCS performance. The overall model was significant, $F\ (9, 338)=5.967$, $p<0.001$, $R^2=0.137$, and predicted 13.7% of the variance in DCCS scores. Similar to Model 1, child sex (p=0.001), child age (p<0.001), and maternal depression (p=0.040) were significant predictors of DCCS scores. However, Model 2 did not predict significantly more variance in DCCS scores compared to Model 1. In Model 2, when controlling for the aforementioned control variables, the relation between maltreatment status and DCCS performance was not statistically significant. Table 3 presents the results of these models.

Digit Span Task. Data were analyzed with multiple regression analysis to explore the association between children's Digit Span scores and maltreatment, controlling for child sex, child age, maternal depression, HFM program participation, maternal education level, and community cluster. The control variables were entered into Block 1, and the predictor of interest (any DCF reports over lifetime yes/no) was entered into Block 2. The initial model (Model 1) in Block 1 examined the control variables (child sex, child age, maternal depression, HFM program participation, maternal education level, and community cluster) as predictors of Digit Span performance. The overall model was significant, $F\ (8, 316)= 3.008$, $p=0.003$, $R^2=0.071$, and predicted 7.1% of the variance in Digit Span scores. Within Model 1, child age and community cluster were independently associated with DCCS performance. Age was positively associated with DCCS performance (p<0.001), indicating that increased age was associated with higher scores on the task. Community Clusters (low moderate income ethnically diverse vs. moderate income homogeneous European American) was negatively related to digit span performance ($p=0.044$), showing that children living in diverse low/moderate-income neighborhoods had lower Digit Span scores compared with children living in white moderate-income neighborhoods. The second model (Model 2) added the maltreatment variable to determine the relation between maltreatment status and Digit Span performance. The overall model was significant, $F(9, 315)=2.765$ $p=0.004, R^2=0.073$ and predicted 7.3% of the variance in Digit Span scores. Similar to Model 1, child age ($p<0.001$) and community cluster ($p=0.042$) were significant predictors of Digit Span scores. However, Model 2 did not predict significantly more variance in Digit Span scores compared to Model 1. In Model 2, when controlling for the aforementioned control variables, the relation between maltreatment status and Digit Span performance was not significant. Table 3 presents the results of these models.

Corsi Block Task. Data were analyzed with multiple regression analysis to explore the association between Corsi scores and maltreatment, controlling for child sex, child age, maternal depression, HFM program participation, maternal education level, and community cluster. Since this analysis utilized a hierarchical linear regression approach, the control variables were entered into Block 1 and the predictor of interest (any DCF reports over lifetime yes/no) was entered into Block 2. The initial model (Model 1) examined the control variables (child sex, child age, maternal depression, HFM program participation, maternal education level, and community cluster) as predictors of Corsi performance. The overall model was significant, $F(8, 328)= 6.042$, $p<0.001$, $R^2=0.128$, and predicted 12.8% of the variance in Corsi scores. Within Model 1, child age, community cluster, and maternal depression were independently associated with Corsi performance. Specifically, age was positively associated with Corsi performance ($p<0.001$), indicating that increased age was associated with higher scores on the task. Community clusters for both comparison groups (low income, minority majority ethnicity vs. moderate income, homogeneous European American and low moderate income, ethnically diverse vs. moderate income, homogeneous European American) were negatively associated with Corsi performance. Specifically, children living in low-income minority neighborhoods had lower Digit Span scores compared with children living in white moderate-income neighborhoods ($p=0.015$). Similarly, children living in diverse low/moderate-income neighborhoods had lower Corsi scores compared with children living in white moderate-income neighborhoods ($p=0.002$). Maternal depression was negatively related to Corsi performance ($p=0.034$), showing that increased maternal depression symptomology was associated with lower Corsi scores. The final model (Model 2) added the maltreatment variable to determine the relation between maltreatment status and Corsi performance. The overall model was significant, $F(9,327)=5.473$, $p<0.001$, $R^2=0.131$ and predicted 13.1% of the variance in Corsi scores. Similar to Model 1, child age ($p<0.001$), community cluster (low income, minority majority ethnicity vs. moderate income, homogeneous European American, $p=0.021$; low moderate income, ethnically diverse vs. moderate income, homogeneous European American, $p= 0.002$), and maternal depression ($p=0.026$) were significant predictors of Corsi scores. However, Model 2 did not predict significantly more variance in Corsi scores compared to Model 1. In Model 2, when controlling for the aforementioned control variables, the relation between maltreatment status and Corsi performance was not statistically significant. Table 3 presents the results of these models.

Research Question 2: Does participation in Healthy Families Massachusetts moderate the association between child maltreatment and executive functioning?

Several hierarchical linear models were constructed to test the moderating role of HFM enrollment between maltreatment and EF. Each EF measure (DCCS, Digit Span, Corsi Task) was entered into a separate hierarchical linear regression model with HFM program enrollment as the predictor of interest. The control variables were the same for all three EF measures and included child sex, child age, maternal education level, community cluster, and maternal depression. Tables 4, 5, and 6 present the results of these analyses.

Dimensional Change Card Sort (DCCS). A linear multiple regression analysis was used to examine HFM enrollment as moderator between maltreatment and DCCS scores. Model 1 tested the control variables (child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of DCCS performance. The overall model was significant, $F(7, 343)=7.823$, $p<0.001$, $R^2=0.120$, and predicted 12.0% of the variance in DCCS scores. Of the control variables, child sex ($p=0.001$), child age ($p<0.001$), and maternal depression ($p=0.048$) were statistically significant. The directionality of these relations was the same as what was reported in research question 1. Model 2 added the HFM program enrollment and maltreatment variables as predictors of DCCS scores. The overall model was significant $F(9, 341)=6.150$, $p<0.001$, $R^2=0.117$, and predicted 11.7% of the variance in DCCS scores. Model 2 did not predict significantly more variance in DCCS scores compared to Model 1. Since the R^2 change was minimal (0.002), the associated significance level for the R^2 change was greater than 0.05 (p=0.675), suggesting that the addition of the maltreatment and HFM variables did not improve the model. Within Model 2, child sex (p=0.001), child age (p.0.001), and maternal depression (p=0.041) remained statistically significant. Model 3 tested the moderating role of HFM on the relation between maltreatment and DCCS scores. The overall model was significant, F (10,340)= 5.519, p<0.001, R^2=0.140, and predicted 14% of the variance in DCCS scores. Like in Models 1 and 2, child sex (p=0.001), child age (p<0.001), and maternal depression (p=0.042) remained statistically significant in Model 3However, the R^2 change was very small (p>0.001) and the associated significance level (p=0.980) indicated that Model 3 did not predict significantly more variance in DCCS scores than Model 2. This data suggests that HFM participation does not moderate the association between maltreatment and EF. Table 4 presents the results of these models.

Digit Span Task. Hierarchical linear regression analysis was used to examine HFM enrollment as moderator between maltreatment and Digit Span scores. Model 1 tested the control variables (child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of Digit Span performance. The overall model was significant, F (7, 317)=3.359, p=0.002, R^2=0.069, and predicted 6.9% of the variance in DCCS scores. Community cluster (low income, minority majority ethnicity vs. moderate income, homogeneous European American) was negatively associated with Digit Span performance (p=0.038), suggesting that low income/minority children have lower Digit Span scores when compared with high income/white children. Age was positively associated with Digit Span scores (p<0.001). Model 2 added the HFM program enrollment and maltreatment variables as predictors of Digit Span scores. The overall model was significant F (9, 315)=2.141, p=0.004, R^2=0.073, and predicted 7.3% of the variance in DCCS scores. However, Model 2 did not predict significantly more variance in Digit Span scores when compared to Model 1, suggesting that the addition of the maltreatment and HFM variables did not improve the model. Within Model 2, child age (p<0.001) and community cluster (p=0.042) remained statistically significant. No main effects were observed for maltreatment or HFM participation. Model 3 tested the moderating role of HFM on the relation between maltreatment and DCCS scores. The overall model was significant, F (10,314)= 2.541, p=0.006, R^2=0.075, and predicted 7.5 % of the variance in Digit Span scores. Like in Models 1 and 2, child age (p<0.001) and community cluster (p=0.042) remained statistically significant in Model 3. However, Model 3 did not predict significantly more variance in Digit Span scores than Model 2. This data suggests that HFM participation does not significantly moderate the association between maltreatment and Digit Span scores. Table 5 presents the results of these models.

Corsi Block Task. Hierarchical linear regression analysis was used to examine HFM enrollment as a moderator between maltreatment and Corsi scores. Model 1 tested the control variables (child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of Corsi performance. The overall model was significant, F (7, 329)=6.585, p<0.001, R^2=0.123, and predicted 12.3% of the variance in Corsi scores. Community cluster was negatively associated with Corsi performance for both comparison groups. Specifically, children living in low-income, majority minority neighborhoods had lower Digit Span scores compared with children living in European American, moderate-income neighborhoods (p=0.012). In addition, children living in ethnically diverse, low/moderate income neighborhoods had lower Corsi scores compared with children living in European American, moderate-income neighborhoods ($p=0.002$). Age was also positively associated with Digit Span scores ($p<0.001$). Model 2 added the HFM program enrollment and maltreatment variables as predictors of Corsi scores. The overall model was significant $F (9, 327)=5.729$, $p<0.000$, $R^2=0.131$, and predicted 13.1% of the variance in Corsi scores. However, Model 2 did not predict significantly more variance in Corsi scores when compared to Model 1, suggesting that the addition of the maltreatment and HFM variables did not improve the model. Within Model 2, child age ($p<0.001$) and both community cluster variables ($p=0.021$; $p= 0.002$) remained statistically significant. No main effects were observed for maltreatment or HFM participation. Model 3 tested the moderating role of HFM on the relation between maltreatment and Corsi scores. The overall model was significant, $F (10,326)= 5.288$, $p<0.001$, $R^2=0.134$, and predicted 13.4 % of the variance in Digit Span scores. Like in Models 1 and 2, child age ($p<0.001$) and both community cluster variables ($p=0.019$; $p=0.002$) remained statistically significant in Model 3. However, Model 3 did not predict significantly more variance in Corsi than Model 2. This data suggests that HFM participation does not significantly moderate the association between maltreatment and Corsi scores. Table 6 presents the results of these models.

Research Question 3: Does participation in center-based childcare moderate the association between child maltreatment and executive functioning?

Enrollment in T4 center-based care. In order to examine the hypothesis that T4 childcare moderates the relation between maltreatment and EF, several hierarchical linear multiple regression models were constructed. Before analyses were conducted, children who were currently in kindergarten were filtered out and excluded from the analysis. Each EF measure (DCCS, Digit Span, Corsi Task) was entered into a separate hierarchical linear regression model with center-based care as the predictor of interest. The control variables were the same for all three EF measures and included HFM program enrollment, child sex, child age, maternal education level, community cluster, and maternal depression. Tables 7, 8, and 9 present the results of these analyses.

Dimensional Change Card Sort (DCCS). Hierarchical linear regression analysis was used to examine center-based care as a moderator between maltreatment and DCCS scores. Model 1 tested the control variables (HFM enrollment, child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of DCCS performance. The overall model was significant, F (8, 296)=3.398, p=0.001, R^2=0.084, and predicted 8.4% of the variance in DCCS scores. Child age was positively associated with DCCS scores (p=0.005). Child sex was also a significant predictor of DCCS scores, indicating that girls had higher DCCS scores compared with boys (p=0.005). Model 2 added the center-based care and maltreatment variables as predictors of DCCS scores. The overall model was significant F (10, 294)=3.172, p=0.001, R^2=0.097, and predicted 9.7% of the variance in DCCS scores. However, Model 2 did not predict significantly more variance in DCCS scores when compared to Model 1, suggesting that the addition of the maltreatment and center-based care variables did not improve the model. Within Model 2, both child age (p=0.009) and child sex (p=0.009) remained statistically significant, and community cluster (low income minority majority vs. moderate income European American) also was statistically significant (p=0.046). No main effects were observed for maltreatment or center-based care. Model 3 tested the moderating role of center-based care participation on the relation between maltreatment and DCCS scores. The overall model was significant, F (11, 293)= 2.885, p=0.001, R^2=0.098, and predicted 9.8 % of the variance in DCCS scores. Like in Model 2, child age (p=0.010), child sex (p=0.006), and community cluster (low income minority majority vs. moderate income European American, p=0.047) remained statistically significant in Model 3. However, Model 3 did not predict significantly more variance in DCCS scores than Model 2. This data suggests that center-based care does not significantly moderate the association between maltreatment and DCCS scores. Table 7 presents the results of these models.

Digit Span Task. Hierarchical linear regression analysis was used to examine center-based care as a moderator between maltreatment and Digit Span scores. Model 1 tested the control variables (HFM enrollment, child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of Digit Span performance. The overall model was significant, F (8, 276)=2.355, p=0.018, R^2=0.064, and predicted 6.4% of the variance in Digit Span scores. Child age was positively associated with Digit Span scores (p=0.002). Model 2 added the center-based care and maltreatment variables as predictors of Digit Span scores. The overall model was significant F (10, 274)=1.939, p=0.040, R^2=0.066, and predicted 6.6% of the variance in

Digit Span scores. However, Model 2 did not predict significantly more variance in Digit Span scores when compared to Model 1, suggesting that the addition of the maltreatment and center-based care variables did not improve the model. Within Model 2, both child age (p=0.002) remained statistically significant. No main effects were observed for maltreatment or center-based care. Model 3 examined the moderating role of center-based care participation on the relation between maltreatment and Digit Span scores. The overall model was significant, $F(11, 273)= 1.934$, $p=0.035$, $R^2=0.072$, and predicted 7.2 % of the variance in Digit Span scores. Like in Models 1 and 2, child age (p=0.002) was statistically significant in Model 3. However, Model 3 did not predict significantly more variance in Digit Span scores than Model 2. This data suggests that center-based care does not significantly moderate the association between maltreatment and Digit Span scores. Table 8 presents the results of these models.

Corsi Block Task. Hierarchical linear regression analysis was used to examine center-based care as a moderator between maltreatment and Corsi scores. Model 1 tested the control variables (HFM enrollment, child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of Corsi scores. The overall model was significant, $F(8, 288)=4.175$, $p<0.001$, $R^2=0.104$, and predicted 10.4% of the variance in Corsi scores. Child age was positively associated with Corsi scores (p=0.001). Maternal depression (p=0.044) and both community cluster variables (p=0.005, p=0.001) were negatively associated with Corsi performance. Specifically, children living in low-income, majority minority neighborhoods had lower Corsi scores compared with children living in European American, moderate-income neighborhoods (p=0.005). In addition, children living in ethnically diverse, low/moderate-income neighborhoods had lower

Corsi scores compared with children living in European American, moderate-income neighborhoods (p=0.001). Model 2 added the center-based care and maltreatment variables as predictors of Corsi scores. The overall model was significant F (10, 286)=3.395, p<0.001, R^2=0.106, and predicted 10.6% of the variance in Corsi scores. However, Model 2 did not predict significantly more variance in Corsi scores when compared to Model 1, suggesting that the addition of the maltreatment and center-based care variables did not improve the model. Within Model 2, child age (p=0.001), both community cluster variables (p=0.007, p=0.001), and maternal depression (p=0.038). No main effects were observed for maltreatment or center-based care. Model 3 tested the moderating role of center-based care participation on the relation between maltreatment and DCCS scores. The overall model was significant, F (11, 285)= 3.112, p=0.001, R^2=0.107, and predicted 10.7 % of the variance in Corsi scores. Like in Model 2, child age (p=0.010), child sex both community cluster (low income minority majority vs. moderate income European American, p=0.007; low income moderate income ethnically diverse vs. moderate income European American, p=0.001), and maternal depression (p=0.38) remained statistically significant in Model 3. However, Model 3 did not predict significantly more variance in Corsi scores than Model 2. This data suggests that center-based care does not significantly moderate the association between maltreatment and Corsi scores. Table 9 presents the results of these models.

Research Question 3: Continuity in Center-Based Care Across T3 and T4

To examine the moderating role of center-based care across multiple timepoints, hierarchical linear regression analysis was used. In order to conduct this analysis, a composite variable was first created to characterize enrollment in center-based care for 10 or more hours at T3 and T4. This variable included the following categories: no center-based care at T3 or T4, center-based care at T3 only, center-based care at T4 only, and center-based care at both T3 and T4. This variable was dummy-coded, and then each dummy variable was multiplied with the maltreatment variable (any DCF reports over lifetime vs. no reports) to create four different interaction terms. In each of the three statistical models, each testing a different EF measure (DCCS, Digit Span, or Corsi), the dummy-coded variables were entered into Block 2 and the interaction terms were entered into Block 3. The reference group for this analysis was no center-based care at T3 or T4, so the dummy-coded and interaction variables for no center-based care were left out of the models. The control variables for this analysis included child sex, child age, maternal education level, community cluster, and maternal depression. Tables 10, 11, and 12 present the results of these analyses.

Dimensional Change Card Sort (DCCS). Hierarchical linear regression analysis was used to examine center-based care at T3 and T4 as a moderator between maltreatment and DCCS scores. Model 1 tested the control variables (HFM enrollment, child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of DCCS performance. The overall model was significant, F (8, 296)=3.398, p=0.001, R^2=0.084, and predicted 8.4% of the variance in DCCS scores. Child age was positively associated with DCCS scores (p=0.005). Child sex was also a significant predictor of DCCS scores, indicating that girls had higher DCCS scores compared with boys (p=0.005). Model 2 added the dummy-coded composite center-based care variables and maltreatment variables as predictors of DCCS scores. The overall model was significant F (12, 292)=2.674, p=0.002, R^2=0.099, and predicted 9.9% of the variance in DCCS scores. However, Model 2 did not predict significantly more variance in DCCS scores when compared to Model 1, suggesting that the addition of the maltreatment and dummy-coded composite center-based care variables did not improve the model. Within Model 2, both child age (p=0.008) and child sex (p=0.006) remained statistically significant, and community cluster (low income minority majority vs. moderate income European American) also was statistically significant (p=0.041). No main effects were observed for maltreatment or any of the dummy-coded variables. Model 3 tested the moderating role of center-based care participation at T3 and T4 on the relation between maltreatment and DCCS scores. The overall model was significant, F (15, 289)= 2.175, p=0.007, R^2=0.101, and predicted 10.1% of the variance in DCCS scores. Like in Model 2, child age (p=0.010), child sex (p=0.007), and community cluster (low income minority majority vs. moderate income European American, p=0.044) remained statistically significant in Model 3. However, Model 3 did not predict significantly more variance in DCCS scores than Model 2. This data suggests that center-based care across T3 and T4 does not significantly moderate the association between maltreatment and DCCS scores. Table 10 presents the results of these models.

Digit Span Task. Hierarchical linear regression analysis was used to examine center-based care at T3 and T4 as a moderator between maltreatment and Digit Span scores. Model 1 tested the control variables (HFM enrollment, child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of Digit Span scores. The overall model was significant, F (8, 276)=2.355, p=0.018, R^2=0.064, and predicted 6.4% of the variance in DCCS scores. Child age was positively associated with DCCS scores (p=0.002). Model 2 added the dummy-coded composite center-based care variables and maltreatment variables as predictors of Digit Span scores. The overall model was marginally significant, F (12, 272)=1.684, p=0.070, R^2=0.069, and predicted 6.9% of the variance in Digit Span scores. However, Model 2 did not predict significantly more variance in Digit Span scores when compared to Model 1, suggesting that the addition of the maltreatment and dummy-coded composite center-based care variables did not improve the model. Within Model 2, child age (p=0.002) remained statistically significant. No main effects were observed for maltreatment or any of the dummy-coded center-based care variables. Model 3 tested the moderating role of center-based care participation across T3 and T4 on the relation between maltreatment and Digit Span scores. The overall model was marginally significant, F (15, 269)= 1.546, p=0.089, R^2=0.079, and predicted 7.9% of the variance in Digit Span scores. Like in Models 1 and 2, child age (p=0.010) was positively associated with Digit Span scores in Model 3. However, Model 3 did not predict significantly more variance in Digit Span scores than Model 2. This data suggests that center-based care across T3 and T4 does not significantly moderate the association between maltreatment and Digit Span scores. Table 11 presents the results of these models.

Corsi Block Task. Hierarchical linear regression analysis was used to examine center-based care at T3 and T4 as a moderator between maltreatment and Corsi scores. Model 1 tested the control variables (HFM enrollment, child sex, child age, maternal education level, community cluster, and maternal depression) as predictors of Corsi scores. The overall model was significant, F (8, 288)=4.175, $p<0.001$, R^2=0.104, and predicted 10.4% of the variance in Corsi scores. Child age was positively associated with Corsi scores (p=0.001). Maternal depression (p=0.044) and both community cluster variables ($p=0.005$, $p=0.001$) were negatively associated with Corsi performance. In particular, children living in low-income, majority minority neighborhoods had lower Corsi scores compared with children living in European American, moderate-income neighborhoods ($p=0.005$). Additionally, children living in ethnically diverse, low/moderate-income neighborhoods had lower Corsi scores compared with children living in European American, moderate-income neighborhoods ($p=0.001$). Model 2 added the center-based care composite and maltreatment variables as predictors of Corsi scores. The overall model was significant $F\ (12, 284)=3.826$, $p<0.001$, $R^2=0.139$, and predicted 13.9% of the variance in Corsi scores. Model 2 predicted significantly more variance in Corsi scores when compared to Model 1, suggesting that the addition of the maltreatment and center-based care composite variables improved the predictability of the model. Within Model 2, child age ($p<0.001$) and both community cluster variables (low income minority majority vs. moderate income European American, $p=0.003$; low/moderate income ethnically diverse vs. moderate income European American, $p=0.001$) remained statistically significant. Maternal depression was marginally significant ($p=0.064$) and maternal education level (additional training beyond HS/GED vs. HS dropout or currently attending HS/GED program, $p=0.041$) was now statistically significant. There was a main effect for T3 center-based care (center-based care at T3 only vs. all other care arrangements, $p=0.003$). In addition, enrollment in center-based care at both T3 and T4 was marginally significant (center-based care at both T3 and T4 vs. all other care arrangements, $p=0.066$). Model 3 tested the moderating role of center-based care participation across T3 and T4 on the relation between maltreatment and Corsi scores. The overall model was significant, $F\ (15, 281)= 3.228$, $p<0.001$, $R^2=0.147$, and predicted 14.7% of the variance in Corsi scores. Like in Model 2, child age ($p<0.001$), maternal education level (additional training beyond HS/GED vs. HS dropout or currently attending HS/GED program, $p=0.046$), and both community cluster variables (low income minority majority vs. moderate income European American, $p=0.003$; low/moderate income ethnically diverse vs. moderate income European American, $p=0.001$) remained statistically significant in Model 3. Maternal depression ($p=0.093$) and T3 Center-Based Care (center-based care at T3 only vs. all other care arrangements, $p=0.061$) were marginally significant. However, Model 3 did not predict significantly more variance in Corsi scores than Model 2. This analysis suggests that center-based care across T3 and T4 does not significantly moderate the association between maltreatment and Corsi scores. Table 12 presents the results of these models.

Discussion

The goal of this analysis was to determine the linkage between maltreatment and executive functioning, and to also test the moderating effects of two intervention strategies (newborn home-visiting and center-based childcare) on the relation between maltreatment and EF. The analysis draws from a sample of children born to teen parents that are high-risk for experiencing maltreatment and for having poor cognitive outcomes. This analysis revealed that 1) maltreatment was not significantly related to EF, 2) HFM enrollment did not significantly moderate the association between maltreatment and EF, and 3) center-based childcare did not significantly moderate the association between maltreatment and EF. However, the analysis revealed that early participation in center-based childcare may be associated with domain-specific EF benefits. Since many of these results disprove the hypotheses discussed earlier, the nature of these findings will be discussed in greater detail in the following section.

Moreover, this analysis contributes to the literature examining the cognitive effects of maltreatment in young children. The linear regression analysis in RQ1 revealed that maltreatment status is not significantly related to EF. Age was significant across all three measures of EF (DCCS, Digit Span Corsi), which suggests that age uniformly influences different aspects of EF. Other control variables were significant for one or two EF measures, including community cluster, maternal depression, maternal education level, and gender. The statistical significance of these control variables demonstrates how contextual factors and adverse circumstances influence EF development (Hackman et al., 2015). The absence of any maltreatment-related effects on EF may be related to the timing of data collection and the constructs used in this analysis.

First, the timing of maltreatment and EF assessment are important features of this analysis. In this analysis, maltreatment is defined as having one or more reports by T3, when children were approximately 24 months old on average. Using a developmental neuroscience framework, the neural and behavioral consequences of maltreatment depend on the stage of brain maturation (Pechtel & Pizzagalli, 2011). Certain brain regions may be more susceptible to the effects of early stress at different times across development (Teicher, Tomoda, & Anderson, 2006). For example, in an analysis of sexual abuse across childhood, researchers have found that sexual abuse in early childhood is associated with reduced hippocampal volume, but sexual abuse during adolescence is associated with reduced prefrontal cortex volume (Teicher, 2005; Teicher, Tomoda, & Anderson, 2006). While sexual abuse is not a specific focus of this analysis since rates of sexual abuse in the sample are very low, this data provides evidence for sensitive periods in trauma exposure and brain development. Based on the timing of trauma exposure, different brain systems are affected in accordance with the sequence of normative development. Since this analysis focuses on maltreatment during infancy and early childhood, brain systems developing at this specific period would be more susceptible to maltreatment. In accordance with the work done Ticher et al (2006), the prefrontal cortex and its associated cognitive processes (including EF) may be more susceptible to traumatic experiences during adolescence rather than during early childhood.

Evidence from developmental neuroscience also suggests that early maltreatment might influence brain development in ways that are only observable in the mature adult brain (Teicher, Tomoda, & Andersen, 2006). In particular, studies examining hippocampal volume in conjunction with childhood maltreatment have hypothesized that structural brain abnormalities only emerge at later stages of brain maturation (Teicher, Tomoda, & Anderson, 2006). The body's response to early traumatic experiences is thought to negatively affect neurogenesis in the hippocampus, an area of the brain responsible for learning and memory (Music, 2011). Researchers have failed to observe any evidence of abnormal hippocampal volume in maltreated children (De Bellis et al, 1999), but there is evidence that adults who have experienced early maltreatment have 15-18% less hippocampal volume than age-matched controls (Teicher, Tomoda, & Andersen, 2006; Vythilingam et al., 2002; Driessen et al., 2000). While this thesis does not explicitly examine brain anatomy, structure is inherently related to function, and these studies suggest that the effects of early maltreatment may not be visible until periods of development beyond the scope of this analysis.

Furthermore, many of the studies examining maltreatment and EF examine older children (>10 years) and adolescents (Wilson, Hansen, & Li, 2011). Comparatively little is known about the effects of maltreatment on EF in preschoolers, so the absence of a significant relation between maltreatment and EF in this analysis neither challenges nor confirms previous research. In a widely cited study examining the neuropsychological functioning of children with maltreatment-related PTSD, maltreated children had lower performance on measures of EF, attention, learning and memory, and visual-spatial function (Beers and De Bellis, 2002). While this study provides meaningful information about the linkage between maltreatment and EF, participants concurrently exhibited PTSD symptoms and were significantly older at EF assessment (M=11.38 years) than the children included in this analysis. It is possible that maltreatment-related deficits in EF are observable in children 10-12 years old, but not yet visible in children 4-5 years old since preschoolers experience such rapid EF growth. Older children may also be exposed to maltreatment in greater quantities, which would amplify the adverse effects of maltreatment if a dose-response relationship exists between maltreatment and EF.

However, there is comparatively more evidence in the literature that maltreatment is linked with poor memory skills (Valentino, Cicchetti, Rogosh, Toth, 2008; De Bellis, Hooper, Spratt, & Woolley, 2009). The absence of a significant relation between maltreatment and both working memory measures (i.e. Digit Span and Corsi Task) is surprising, but child age may again be a major factor in this finding. Virtually no peer-reviewed studies linking maltreatment and memory have specifically examined preschool- and kindergarten-aged children (Macfie, 1999). In one study examining maltreatment and cognition in a sample of 8-12 year old children, the authors observed maltreatment-related deficits in spatial working memory, but not in global EF (August & Melinder, 2013). This suggests that memory is particularly sensitive to maltreatment, possibly more so than any other domain of EF, though no comparable studies exist for younger children. The findings of this thesis suggest that maltreatment may not be associated with working memory in preschool- and kindergarten-aged children, but deficits could emerge as children mature.

In addition, of the few studies that examine maltreatment-related deficits in preschool executive functioning, many examine the foster care population. The sample of children in this analysis is distinct from the foster care population because most children have remained under the care of at least one biological parent or other family member. Foster care may impose additional demands on cognitive development, and the combination of these factors, rather than the initial case of maltreatment, may adversely affect EF development. For example, the disruption of the attachment relationship may impose additional stress on the child, further delaying intellectual and cognitive development (Pears & Fischer, 2005). In addition, the quality of care in foster homes varies, and children in foster care are at high risk for further maltreatment. In a 2013 class action lawsuit against the Massachusetts Department of Children and Families, independent researchers from the Children's Research Center (CRC) found that between approximately 18% of children in MA foster care have subsequent reports of reports of abuse or neglect within 30 months entry into the foster system (Connor v Patrick, 2013). These findings highlight how children in foster care experience an increased risk for further trauma and thus represent a specific subgroup of maltreated children. There is a need to examine the neurocognitive effects of maltreatment outside of the foster care system since many children who experience maltreatment are never placed under state custody (Administration for Children and Families, 2013).

Lastly, maltreatment is defined in this analysis as having one or more DCF report between birth and T3. This analysis also did not differentiate between different types of maltreatment (i.e. physical abuse, sexual abuse, neglect), and there is evidence that different types of maltreatment affect brain and behavior in distinct ways (Beers and De Bellis, 2002; Pears & Fisher, 2005). In addition, the percentage of children classified as "maltreated" in this sample (37%) is likely an underestimate because a significant portion of child abuse goes unreported (Sharples, 2008). There is evidence that only 1 in 10 cases of maltreatment are confirmed by social service agencies, which suggests that the remaining 9 in 10 cases go unreported or are considered unsubstantiated (Sharples, 2008). The children of teen parents are at especially high risk for maltreatment victimization, so it is very likely that the DCF data used in this analysis does not accurately represent the true prevalence of maltreatment in the sample (George & Lee, 1997). Additionally, in order for families to be reported for maltreatment, they will likely have to interact professionals (e.g. doctors, teachers, social workers, law enforcement) or institutions that must abide by mandated reporting laws (Administration for Children and Families, 2014). Professionals make approximately 61.6% of all maltreatment reports, and nonprofessionals (friends, neighbors, relatives) only report 18.6% of cases (Administration for Children and Families, 2014). The discrepancy between these numbers suggests that mandated reporters play a large role in reporting child maltreatment, and families who do not frequently interact with mandated reporters may never be investigated.

This analysis also contributes to the literature examining home visiting as an intervention strategy for at-risk families. The moderation analysis in RQ2 revealed that enrollment in Healthy Families Massachusetts does not significantly moderate the relation between maltreatment and EF. In addition, there were no main effects observed for enrollment in Healthy Families Massachusetts, which suggests that EF performance does not differ according to home visiting program enrollment. However, as discussed earlier, home visiting participation was defined by initial program assignment (intervention or control) at the beginning of MHFE-2. A significant percentage of moms in the program group never received any home visits (10%) or received less than 5 visits (22%). The Children's Trust, the organization responsible for providing HFM services to families across the state, defines full participation in the program as receiving 5 or more visits. This analysis did not delineate participation in HFM using this 5-visit cutoff in order to maintain the integrity of the intent-to-treat model. This approach may have muted the effects of the program, as mothers who received <5 visits would have been grouped together with mothers who received upwards of 40 visits or more. Future analyses may want to differentiate between participants who received 0-4 home visits versus those that received 5 or more home visits.

In addition, the research literature does not provide a clear picture of home visiting as it affects children's cognition. Select studies have found that home visiting is associated with higher intellectual functioning in preschool- and elementary-aged children (Olds et al., 2004), but other studies have found no associations or favorable child outcomes for subgroups of mothers (Olds et al, 2007). Much of the research connecting home visiting and child cognitive outcomes has also focused on children under 24 months old, soon after families have stopped receiving services (Caldera et al., 2007; Peacock et al., 2013). It is possible the cognitive benefits of early home visiting may fade over time as children age. This "fade-out" phenomenon is common across many different types of early childhood interventions, and it may be most salient for cognitive abilities (Barnett and Belfield, 2006; Gomby et al, 1995). This perspective would explain why enrollment in HFM does not produce changes in child EF. Lastly, there is also evidence that child cognitive outcomes differ depending on whether families are visited by professionals or paraprofessionals (Sweet & Appelbaum, 2004). In one meta-analysis of the home visiting literature, children visited by professionals (i.e. nurses or social workers) had better cognitive outcomes than those of children visited by paraprofessionals (Sweet & Appelbaum, 2004). Since HFM utilizes a paraprofessional model, the program model may not be conducive to promoting EF in children.

The examination into center-based childcare also yielded limited significant results, but there was a significant relation between T3 care and visuo-spatial working memory, as well as a marginally significant relation between T3/T4 care and visuo-spatial working memory. These results support the hypothesis that earlier entry into care may produce the best outcomes for at-risk children (Barnett & Belfield, 2006). Furthermore, there is evidence in the research literature that earlier entry into center-based care is linked with positive academic and psychosocial outcomes into the early elementary years (Field, 1991). However, studies examining differences in child outcomes based on time of entry into center care have been mixed, and some researchers have reported that earlier entry into nonparental care is associated with poor child cognition (Baydar & Brooks-Gunn, 1991). This analysis suggests that earlier entry into center-based care may be positively associated with one aspect of EF, but other domains (i.e. cognitive flexibility and auditory working memory) are neither positively nor negatively affected by center-based care. Since these three domains of EF may develop at different rates and in slightly different parts of the brain, this finding supports the existence of dissociable EF processes. As discussed previously, researchers have debated whether EF is a unitary or dissociate construct (Garon, Bryson, & Smith, 2008).

This analysis also did not address issues of childcare quality, and the literature suggests that childcare quality (i.e. high vs. low) is a consistent predictor of child outcomes (NICHD, 2002). There is evidence that the quality of childcare has the greatest influence on child outcomes, regardless of hours spend in care, stability in care, and type of care (Fuller, Kagan, Caspary, & Gautheir, 2002). Quality is typically defined along two dimensions, process quality (i.e. relationship between child and caregiver) and structural characteristics of the childcare setting (Fuller, Kagan, Caspary, & Gautheir, 2002). High quality settings will typically provide an array of age-appropriate programming designed to improve children's problem-solving, socio-emotional, and language skills. Low quality settings may fail to engage children in stimulating and educational activities, or teachers may be unresponsive to children's needs (Barnett & Belfield, 2006). Among at-risk and low-income populations of children in particular, enrollment in high quality care has been associated with better school readiness and learning (Fuller, Kagan, Caspary & Cautheir, 2002).

Despite the benefits of high-quality center-based care, low-income families disproportionately send children to lower quality childcare arrangements (Fuller, Kagan, Caspary & Cautheir, 2002; Adams & Rohacek, 2002). The cost of high-quality center-based care is prohibitive for many low-income families, with annual estimates of $12,176 per child in Massachusetts (Boston Globe, 2014). Since the children in this analysis are predominantly low-income, many children in the sample may have been attending low-quality centers. There is evidence that enrollment in low-quality center-based care may even be linked to negative child behavioral and cognitive outcomes (Votruba-Drzal et al., 2010). Since quality data was never collected for MHFE-2, there was no way to integrate quality measurements into this analysis. The variation in childcare quality in the sample likely affected the results, possibly concealing the positive outcomes associated high-quality care.

Limitations

There are a number of limitations to consider in this study relating to sampling, program delivery, measurement, and data analysis. Firstly, the maternal participants voluntarily requested to receive services from HFM, so the sample is not generalizable to the entire population of teen parents and their children in Massachusetts. It is possible that the most at-risk families were uninformed or uninterested in requesting services from HFM, and they would automatically be excluded from participating in the study. In addition, this analysis does not incorporate measures of program fidelity or dosage for HFM. As mentioned previously, approximately 22% of participants received less than 5 home visits, and future research may incorporate indicators of program dosage in the analysis. Participants who received less than 5 home visits were included in the intervention group, and these participants likely weakened the program effects.

In regards to the measurement of EF, the assessments used in this analysis (DCCS, Digit Span, and Corsi) can be scored and analyzed in multiple ways. The scoring system for DCCS used in this analysis follows guidelines put forth by Zelano (2006), who was responsible for initially creating the task. However, the task can also be operationalized as a continuous score reflecting the total number of correct trials, as well as a dichotomous pass/fail variable. Similarly, Digit Span and Corsi scores are often analyzed as "ceiling digit" values that distinguish the participant's highest digit level completed successfully. This analysis used total score values, rather than ceiling digit scores, because they were most normally distributed. If any of the three EF measures had been defined and coded differently, the results may have changed. In particular, the scoring criteria used in this analysis limited the variability in scores, which subsequently decreased the likelihood of finding significant results.

In addition, this analysis does not fully encapsulate the full scope of EF. Out of the three domains of EF (i.e. cognitive flexibility, working memory, and inhibition), this thesis focuses exclusively on cognitive flexibility and working memory. Measures of inhibition were collected during T4, but the distributions of inhibition scores were either bimodally distributed or skewed. Therefore, any measures of inhibition were impossible to analyze with hierarchical linear regression and were excluded from the final analysis. Future research on this topic should incorporate measures of inhibition to gain a more comprehensive picture of EF. Similarly, measures of “hot EF” were never included in the analysis due to measurement and distribution issues. There is evidence that hot tasks may capture more practical EF abilities, and the absence of a hot measure in this analysis may limit the generalizability of these findings to everyday contexts that require EF skills (Zelazo & Carlson, 2012).

In regards to the maltreatment and childcare data, many of the limitations were reviewed earlier in the discussion section. Since maltreatment was defined as having any DCF reports between birth and T3, reports filed between T3 and T4 were not included in the analysis. Therefore, the prevalence of maltreatment in the sample is likely an underestimate, as there might be unreported cases of maltreatment in the sample or cases reported after T3. The exclusion of these cases would have weakened the effects of maltreatment in the sample. In addition, participation in center-based childcare did not include measures of quality, and participation in different types of center care settings (i.e. preschool, Head Start, childcare) was collapsed into a single center-based care variable. It is possible that different types of center-based care affect EF development in distinctive ways, and the current analytic model would conceal these differences.

Research and Policy Implications

Although the results of this analysis suggest that early maltreatment is not associated with lower EF, more research is needed to explore how early maltreatment (<24 months) affects cognition in preschool-aged children. In particular, there is a need to study preschool-aged children since many studies examine older children. It is possible that the cognitive effects of maltreatment are not observable until later in childhood when the brain is more mature. Future research should examine the relation between EF and maltreatment when children in this sample are older. In addition, future research with this sample may include maltreatment cases beyond T3, incorporating all maltreatment cases between birth and school entry. Since EF develops rapidly between 3 and 5 years old, it is possible that this age range is an especially sensitive period in EF development.

This analysis also suggests that early enrollment in center-based childcare (≤24 months) may produce the best cognitive outcomes for the children of teen parents. This result supports the expansion of existing early childhood programs serving infants and toddlers (e.g. Early Head Start), as well as the creation of additional affordable and high-quality childcare centers. The cost of center-based childcare for infants and toddlers is currently inaccessible for many low-income families, even with the assistance of childcare vouchers available to families earning less than 85% of the statewide median income (Glynn, 2012). Funding for vouchers has increased since the creation of the Child Care and Development Fund in 1990 and the passage of the Personal Responsibility and Work Opportunity Reconciliation Act of 1996, but funding is still limited. States limit voucher eligibility in order to ration funds, and the majority of eligible families (86%) do not receive vouchers (Glynn, 2012). States need to maintain funding for these voucher programs and create policies that increase childcare accessibility to low-income families.

Existing center-based childcare programs may also considering adopting evidence-based interventions specifically designed to improve child EF. One of the reasons enrollment in HFM did not produce gains in EF may be related to the nature of the intervention; HFM does not explicitly attempt to promote childhood EF in its program model. Other interventions implemented directly within childcare programs have been shown to promote EF skills in preschool-aged children, and these programs can be implemented without incurring huge costs or employing additional personnel. These interventions can take many different forms, and some of most widely cited classroom-based programs include Tools of the Mind, Head Start REDI, Promoting Alternative Thinking Strategies (PATHS), and the Chicago School Readiness Project (CSRP) (Diamond & Lee, 2011). There are a number of other more alternative evidence-based interventions that utilize different modalities, ranging from computerized training, aerobic exercise, martial arts, and mindfulness education (Diamond & Lee, 2011). Since EF is such an important skill in the transition to elementary school, childcare teachers should consider adopting any of these interventions in their classrooms.

Since maltreatment is a public health issue, this thesis also has implications for the prevention of maltreatment and the utilization of intervention services. For example, the HFM program serves a high-risk population of parents (i.e. teen families) to promote positive parenting practices and decrease the incidence of maltreatment. The program is traditionally categorized as a secondary prevention strategy since HFM targets high-risk parents and aims to prevent maltreatment from initially occurring (ACF, 2015). However, this analysis tested the role of HFM as a tertiary prevention activity since the guiding theoretical framework (See Figure 1) theorized that HFM mitigated the negative consequences of maltreatment. Since the results of this analysis indicated that HFM did not significantly moderate or “buffer” the adverse effects of maltreatment, the program may be more effective as a secondary prevention strategy. Other evaluations of home-visiting programs have shown that program utilization is associated with reductions in child abuse and neglect incidence, confirming that the home-visiting model may be more conducive to the secondary prevention of maltreatment (Olds et al., 1997).

Conclusion

These findings contribute to the literature examining the neurocognitive effects of childhood maltreatment. Much of the literature linking maltreatment and EF examines older children or children in the foster care system, or focuses more broadly on the connection between early life stress and general cognitive functioning (Pechtel & Pizzagalli, 2010). By examining preschool-aged children, who also are the children of teen parents, this analysis provides a unique perspective. The children of teen parents are high-risk for a variety of negative cognitive, psychosocial, and health outcomes, and researchers are still beginning to identify the mechanisms behind these adverse associations (Brooks-Gunn, 1986). This thesis also critically examines two early childhood programs, home visiting and center-based childcare, that are widely utilized by families nationwide. These two program models have been common intervention strategies for at-risk families, but less is known about how they may affect the development of EF.

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Table 1

Participant Demographics

Sample Characteristic	Values
Child characteristics (n=430)	
Sex (%)	
Male	52.7
Female	47.3
Ethnicity (%)	
Non-Hispanic/Latino	48.6
Hispanic/Latino	39.1
Multi-ethnic	11.6
Race (%)	
White	31.0
Black or African American	14.0
Multi-racial	19.0
Other	33.0
American Indian/Native American/ Alaska Native	1.4
South Asian	1.1
East Asian	0.4
Age at T2 (months)	12
Age at T3 (months)	24
Age at T4 (years)	4.9
Maternal characteristics (n=430)	
Race/Ethnicity (%)	
White	36.6
Black non-Hispanic	18.9
Hispanic	35.9
Non-Hispanic other	8.1
Household income ($)	47,590
Education level at T1 (%)	
Enrolled in high school/GED program	36.7
Finished high school/GED program	27.6
Dropped out of school	21.8
Enrolled in training/college program	7.1
Finished at least 1 year of college	6.8
HFM Program Assignment (%)	
Program Group	61.5
Control Group	38.5

Table 2

Summary of Measures

Construct	**Measure**	**Measure Description**	**Source**
Maltreatment	At least one report of child maltreatment in lifetime	Dichotomous	Department of Children and Families data
Center-Based Childcare Participation	Center care enrollment	Categorical	Massachusetts Healthy Families Evaluation T3 data
Healthy Families	Program or control group	Dichotomous	
Executive Functioning	Dimensional Change Card Sort (DCCS)	Continuous	Massachusetts Healthy Families Evaluation-2 T4 data
	Digit Span	Continuous	
	Corsi Task	Continuous	

Table 3

Hierarchical Multiple Linear Regression Analysis Examining the Relation Between Maltreatment and Executive Functioning

	DCCS		Digit		Corsi	
	M1	M2	M1	M2	M1	M2
Intercept	-.420 (.343)	-.405 (.344)	.506 (.532)	.483 (.533)	-1.355 (.603)	-1.334 (.604)
HFM Program Participation	-.016 (0.065)	-.015 (.066)	-.076 (.100)	-.075 (.100)	.165 (.114)	.166 (.114)
Child Sex	.215 (.065)**	.214 (.065)**	.033 (.099)	.033 (.099)	-.061 (.113)	-.062 (.113)
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.082 (.079)	-.082 (.079)	-.243 (.120)*	-.245 (.120)*	-.418 (.137)**	-.418 (.137)**
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.144 (.080)†	-.137 (.081)†	-.171 (.123)	-.183 (.123)	-.342 (.140)*	-.328 (.141)*
Child Age	.362 (.067)***	.355 (.068)***	.418 (.104)***	.429 (.105)***	.666 (.118)***	.653 (.119)***
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.031 (.081)	-.025 (.081)	-.080 (.124)	-.090 (.125)	-.252 (.141)†	-.242 (.141)†
Completed HS or GED vs. No GED/HS Diploma or Dropout	.096 (.088)	.097 (.088)	.054 (.135)	.051 (.135)	-.177 (.153)	-.177 (.153)
Maternal Depression	-.007 (.003)*	-.007 (.003)*	-.005 (.005)	-.004 (.005)	-.012 (.006)*	-.013 (.006)*
Maltreatment		.061 (.069)		-.097 (.106)		.116 (.120)
R^2	.135	.137	.071	.073	.128	.131
df (Residual)	339	338	316	315	328	327
ΔR^2		.002		.002		.002
df (ΔR^2)		1		1		1

Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 4

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of HFM Enrollment on the Relation between Maltreatment and DCCS Performance

	M1	M2	M3
Intercept	-.433 (.338)	-.412 (.346)	-.412 (.346)
Child Sex	.214 (.065)**	.213 (.065)**	.213 (.065)**
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.083 (.079)	-.082 (.079)	-.082 (.079)
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.144 (.080)†	-.137 (.081)†	-.137 (.081)†
Child Age	.363 (.067)***	.355 (.068)***	.355 (.068)***
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.032 (.081)	-.025 (.082)	-.025 (.082)
Completed HS or GED vs. No GED/HS Diploma or Dropout	.096 (.088)	.097 (.088)	.097 (.088)
Maternal Depression	-.007 (.003)*	-.007 (.003)*	-.007 (.003)*
Maltreatment		.061 (.069)	.079 (.107)
HFM Enrollment		-.015 (.066)	-.004 (.081)
HFM/Maltreatment Interaction			-.029 (.138)
R^2	.135	.137	.137
df (Residual)	340	338	337
ΔR^2		.002	.000
df (ΔR^2)		2	1
Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001			

Table 5

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of HFM Enrollment on the Relation between Maltreatment and Digit Span Performance

	M1	M2	M3
Intercept	.446 (.526)	.483 (.533)	.520 (.535)
Child Sex	.030 (.099)	.033 (.099)	.035 (.099)
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.249 (.120)*	-.245 (.120)*	-.245 (.120)*
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.172 (.122)	-.183 (.123)	-.182 (.123)
Child Age	.421 (.104)***	.429 (.105)***	.427 (.105)***
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.082 (.124)	-.090 (.125)	-.089 (.125)
Completed HS or GED vs. No GED/HS Diploma or Dropout	.053 (.135)	.051 (.135)	.056 (.135)
Maternal Depression	-.005 (.005)	-.004 (.005)	-.004 (.005)
Maltreatment		-.097 (.106)	-.190 (.164)
HFM Enrollment		-.075 (.100)	-.129 (.123)
HFM/Maltreatment Interaction			.157 (.211)
R^2	.069	.073	.075
df (Residual)	317	315	314
ΔR^2		.004	.002
df (ΔR^2)		2	1

Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 6

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of HFM Enrollment on the Relation between Maltreatment and Corsi Performance

	M1	M2	M3
Intercept	-1.224 (.597)	-1.334 (.604)	-1.389 (.605)
Child Sex	-.059 (.113)	-.062 (.113)	-.066 (.113)
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.406 (.137)**	-.418 (.137)**	-.417 (.137)**
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.344 (.140)*	-.328 (.141)*	-.332 (.141)*
Child Age	.659 (.118)***	.653 (.119)***	.655 (.119)***
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.248 (.141)†	-.242 (.141)†	-.242 (.141)†
Completed HS or GED vs. No GED/HS Diploma or Dropout	-.178 (.153)	-.177 (.153)	-.183 (.153)
Maternal Depression	-.013 (.006)*	-.013 (.006)*	-.013 (.006)*
Maltreatment		.116 (.120)	.275 (.186)
HFM Enrollment		.166 (.114)	.261 (.142)†
HFM/Maltreatment Interaction			-.267 (.238)
R^2	.123	.131	.134
df (Residual)	329	327	326
ΔR^2		.008	.003
df (ΔR^2)		2	1
Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001			

Table 7

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of Center-Based Childcare at T4 on the Relation between Maltreatment and DCCS Performance

	M1	M2	M3
Intercept	.158 (.413)	.154 (.411)	.145 (.412)
HFM Enrollment	.028 (.070)	.039 (.069)	.038 (.070)
Child Sex	.196 (.069)**	.191 (.069)**	.192 (.069)**
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.119 (.085)	-.135 (.085)	-.132 (.085)
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.163 (.086)†	-.173 (.086)*	-.173 (.087)*
Child Age	.236 (.084)**	.219 (.084)**	.219 (.084)*
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.038 (.085)	-.042 (.086)	-.040 (.086)
Completed HS or GED vs. No GED/HS Diploma or Dropout	.083 (.094)	.080 (.093)	.079 (.093)
Maternal Depression	-.005 (.004)	-.005 (.004)	-.005 (.004)
Maltreatment		.103 (.073)	.129 (.107)
Center-Based Childcare at T4		.108 (.069)	.125 (.084)
Center-Based Childcare at T4/Maltreatment Interaction			-.050 (.146)
R^2	.084	.097	.098
df (Residual)	296	294	293
ΔR^2		.013	.000
df (ΔR^2)		2	1

Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 8

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of Center-Based Childcare at T4 on the Relation between Maltreatment and Digit Span Performance

	M1	M2	M3
Intercept	.592 (.655)	.594 (.656)	.526 (.657)
HFM Enrollment	-.106 (.108)	-.107 (.108)	-.109 (.108)
Child Sex	.005 (.107)	.006 (.107)	.014 (.107)
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.232 (.131)†	-.234 (.132)†	-.215 (.132)
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.184 (.134)	-.192 (.136)	-.190 (.135)
Child Age	.404 (.132)**	.410 (.133)**	.410 (.133)**
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.059 (.132)	-.068 (.134)	-.056 (.134)
Completed HS or GED vs. No GED/HS Diploma or Dropout	.123 (.146)	.121 (.146)	.120 (.146)
Maternal Depression	-.006 (.005)	-.006 (.006)	-.006 (.006)
Maltreatment		-.091 (.114)	.079 (.170)
Center-Based Childcare at T4		.000 (.108)	.100 (.131)
Center-Based Childcare at T4/Maltreatment Interaction			-.308 (.228)
R^2	.064	.066	.072
df (Residual)	276	274	273
ΔR^2		.002	.006
df (ΔR^2)		2	1
Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001			

Table 9

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of Center-Based Childcare at T4 on the Relation between Maltreatment and Corsi Performance

	M1	M2	M3
Intercept	-.436 (.733)	-.445 (.735)	-.483 (.738)
HFM Enrollment	.152 (.121)	.152 (.122)	.152 (.122)
Child Sex	-.154 (.120)	-.154 (.120)	-.150 (.120)
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.512 (.146)**	-.508 (.147)**	-.499 (.148)**
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.427 (.150)**	-.413 (.153)**	-.412 (.153)**
Child Age	.488 (.148)**	.484 (.149)**	.485 (.149)**
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.267 (.148)†	-.256 (.150)†	-.252 (.150)†
Completed HS or GED vs. No GED/HS Diploma or Dropout	-.165 (.163)	-.165 (.163)	-.166 (.164)
Maternal Depression	-.012 (.006)*	-.013 (.006)*	-.013 (.006)*
Maltreatment		.103 (.127)	.184 (.185)
Center-Based Childcare at T4		-.022 (.122)	.029 (.149)†
Center-Based Childcare at T4/Maltreatment Interaction			-.151 (.253)
R^2	.104	.106	.107
df (Residual)	288	286	285
ΔR^2		.002	.001
df (ΔR^2)		2	1

Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 10

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of Center-Based Childcare at T3 and T4 on the Relation between Maltreatment and DCCS Performance

	M1	M2	M3
Intercept	.158 (.413)	.103 (.420)	.113 (.424)
HFM Enrollment	.028 (.070)	.038 (.070)	.037 (.070)
Child Sex	.196 (.069)**	.190 (.069)**	.187 (.069)**
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.119 (.085)	-.135 (.085)	-.126 (.086)
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.163 (.086)†	-.181 (.088)*	-.178 (.088)*
Child Age	.236 (.084)**	.226 (.085)**	.222 (.085)*
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.038 (.085)	-.050 (.087)	-.049 (.087)
Completed HS or GED vs. No GED/HS Diploma or Dropout	.083 (.094)	.085 (.094)	.084 (.095)
Maternal Depression	-.005 (.004)	-.005 (.004)	-.005 (.004)
Maltreatment		.098 (.074)	.113 (.130)
T3 Center-Based Care Only		.062 (.111)	.050 (.137)
T4 Center-Based Care Only		.112 (.086)	.144 (.104)
T3 and T4 Center-Based Care		.158 (.100)	.138 (.120)
T3 Center-Based Care Only/Maltreatment Interaction			.035 (.228)
T4 Center-Based Care Only/Maltreatment Interaction			-.106 (.184)
T3 and T4 Center-Based Care/Maltreatment Interaction			.059 (.204)
R^2	.084	.099	.101
df (Residual)	296	292	289
ΔR^2		.015	.002
df (ΔR^2)		4	3

Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 11

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of Center-Based Childcare at T3 and T4 on the Relation between Maltreatment and Digit Span Performance

	M1	M2	M3
Intercept	.592 (.655)	.475 (.670)	.450 (.674)
HFM Enrollment	-.106 (.108)	-.108 (.108)	-.108 (.109)
Child Sex	.005 (.107)	.002 (.107)	.007 (.108)
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.232 (.131)†	-.231 (.133)†	-.200 (.134)
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.184 (.134)	-.206 (.138)	-.197 (.138)
Child Age	.404 (.132)**	.425 (.134)**	.418 (.134)**
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.059 (.132)	-.081 (.136)	-.069 (.136)
Completed HS or GED vs. No GED/HS Diploma or Dropout	.123 (.146)	.134 (.148)	.132 (.148)
Maternal Depression	-.006 (.005)	-.005 (.006)	-.004 (.006)
Maltreatment		-.101 (.115)	.004 (.212)
T3 Center-Based Care Only		.152 (.174)	.081 (.216)
T4 Center-Based Care Only		.031 (.136)	.140 (.162)
T3 and T4 Center-Based Care		.091 (.156)	.106 (.188)
T3 Center-Based Care Only/Maltreatment Interaction			.173 (.354)
T4 Center-Based Care Only/Maltreatment Interaction			-.374 (.292)
T3 and T4 Center-Based Care/Maltreatment Interaction			-.060 (.318)
R^2	.064	.069	.079
df (Residual)	276	272	269
ΔR^2		.005	.010
df (ΔR^2)		4	3

Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 12

Hierarchical Multiple Linear Regression Analysis Examining the Moderating Effects of Center-Based Childcare at T3 and T4 on the Relation between Maltreatment and Corsi Performance

	M1	M2	M3
Intercept	-.436 (.733)	-.862 (.735)	-.830 (.741)
HFM Enrollment	.152 (.121)	.159 (.120)	.164 (.121)
Child Sex	-.154 (.120)	-.168 (.118)	-.168 (.119)
Low Moderate Income/Ethnically Diverse vs. Moderate Income/Homogeneous European American	-.512 (.146)**	-.493 (.145)**	-.460 (.147)**
Low Income/Minority Majority Ethnicity vs. Moderate Income/Homogeneous European American	-.427 (.150)**	-.457 (.152)**	-.446 (.152)**
Child Age	.488 (.148)**	.533 (.148)***	.522 (.148)***
Additional Training Beyond HS/GED vs. No GED/HS Diploma or Dropout	-.267 (.148)†	-.305 (.149)*	-.298 (.149)*
Completed HS or GED vs. No GED/HS Diploma or Dropout	-.165 (.163)	-.177 (.162)	-.117 (.163)
Maternal Depression	-.012 (.006)*	-.011 (.006)†	-.010 (.006)†
Maltreatment		.076 (.125)	.052 (.220)
T3 Center-Based Care Only		.573 (.191)**	.450 (.240)†
T4 Center-Based Care Only		.073 (.148)	.138 (.181)
T3 and T4 Center-Based Care		.315 (.170)†	.246 (.208)
T3 Center-Based Care Only/Maltreatment Interaction			.333 (.388)
T4 Center-Based Care Only/Maltreatment Interaction			-.229 (.314)
T3 and T4 Center-Based Care/Maltreatment Interaction			.190 (.342)
R^2	.104	.139	.147
df (Residual)	288	284	281
ΔR^2		.035*	.008
df (ΔR^2)		4	3

Key: †p<0.10, *p<0.05, **p<0.01, ***p<0.001