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Child maltreatment and executive function development throughout adolescence and into young adulthood

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Abstract

Child maltreatment impacts approximately one in seven children in the United States, leading to adverse outcomes throughout life. Adolescence is a time period critical for the development of executive function, but there is little research examining how abuse and neglect may differently affect the developmental trajectories of executive function throughout adolescence and into young adulthood. In the current study, 167 adolescents participated at six time points from ages 14 to 20. At each time point, adolescents completed behavioral tasks measuring the three dimensions of executive function (working memory, inhibitory control, and cognitive flexibility). Neglect and abuse in early life (ages 1–13) were reported at ages 18–19. Unconditional growth curve models revealed age-related improvement in all three executive function dimensions. Conditional growth curve models tested the prospective effects of recalled neglect and abuse on the developmental trajectories of executive function. The results revealed that neglect was associated with developmental changes in working memory abilities, such that greater levels of neglect during ages 1–13 were associated with slower increases in working memory abilities across ages 14–20. These findings highlight the adverse consequences of early neglect experiences shown by delayed working memory development during adolescence into young adulthood.

Keywords: Abuse; executive function; growth curve models; neglect; working memory

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Introduction

Adolescence is the critical period for both executive function development and the emergence and development of psychopathology in part due to the fact that it is during adolescence when the prefrontal cortex is most actively developing (Powers & Casey, 2015; Steinberg, 2005). Further, adolescence is a time when neurobiological and social factors involved in executive function and psychopathology seem particularly malleable. These factors include many changes such as decreasing involvement from parents, the occurrence of puberty, and synaptic pruning and plasticity that allow adolescents' brains to be more susceptible to their life experiences (Blakemore & Choudhury, 2006; Steinberg, 2005). Given the significant role of executive function in risk taking and in the trajectories toward psychopathology (Nigg, 2017), these developmental changes create a time period that is crucial to examine in order to better understand how healthy development occurs and may be impacted. For the current study, we investigate the consequences recalled childhood maltreatment may have on the developmental trajectories of executive function throughout adolescence and into young adulthood.

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Relationships between a child and their parent lay the foundation for the development of executive function abilities, and maltreatment may hinder it (Lund et al., 2020; Schroeder & Kelley, 2009). Thus far, the literature lacks studies that examine developmental trajectories of executive function throughout adolescence, and also importantly how they are related to child maltreatment. Child maltreatment impacts a large number of children, affecting approximately one in seven children in the United States (Finkelhor et al., 2015). Child maltreatment leaves enduring impacts on an individual's physical, emotional, cognitive, and behavioral functioning (Cicchetti, 2016). In particular, literature documents that adults who experienced childhood maltreatment have deficiencies in executive function abilities (Masson et al., 2015; Nikulina & Widom, 2013).

Executive function development during adolescence

Executive function involves many higher-order cognitive skills, such as goal-directed behavior, representational capacity, planning, memory, and inhibitory control (Calkins & Marcovitch, 2010). According to Miyake et al. (2000) theoretical model, executive function abilities include the updating and monitoring of information (working memory), the ability to inhibit dominant responses (inhibitory control), and the capacity to switch between different tasks or between mental sets (cognitive flexibility). These three abilities are distinct, yet highly correlated, and are believed to integrate together to demonstrate the latent construct of executive function (Friedman & Miyake, 2017; Xu et al., 2013).

Developmentally, evidence suggests that the degree of unity or diversity of these abilities varies from age to age, dependent upon the type of task (Best & Miller, 2010). As children transition to adolescence, the development of the prefrontal cortex leads executive function to maturity (Klingberg et al., 2002; Kwon et al., 2002) and executive function splits into the three-factor structure that includes working memory, inhibitory control, and cognitive flexibility. Indeed, cross-sectional studies suggest that executive function abilities conformed to a two-factor structure during childhood, but a three-factor structure by middle adolescence (Lee et al., 2013). For example, working memory and inhibitory control are not separable in younger children but they separate into their two distinct categories as children grow and reach middle adolescence (Shing et al., 2010). Another cross-sectional study reported that executive functions (working memory, inhibitory control, and cognitive flexibility) differentiated rapidly during early childhood and into school-age years, steadily continuing this pattern of differentiation into adolescence (Karr et al., 2022). Importantly, regardless of differentiation patterns, past findings converge to suggest that adolescence is a time when executive functions continue developing due to the maturation of the prefrontal cortex throughout an individual's early 20s.

A recent meta-analysis based on two large longitudinal and two large cross-sectional samples reported that performance on diverse executive function tasks (i.e., working memory, inhibitory control, cognitive flexibility, attention, and planning) consistently improves rapidly between the ages of 10 and 15, improves gradually between the ages of 15 and 18, and then stabilizes between the ages of 18 and 20 (Tervo-Clemmens et al., 2023). However, we note that the tasks used in this study included multiple tasks of working memory and inhibitory control, but measurement of cognitive flexibility was limited to only one task (i.e., latency from the DKEFS Trail Making Test) in one cross-sectional data set. More importantly, there have been some inconsistencies in prior research when considering developmental patterns of the individual components of executive functions. There is evidence from cross-sectional research indicating age-related improvement in both working memory (Ferguson, 2021; Simmonds et al., 2017) and inhibitory control (Ferguson, 2021) in adolescence and young adulthood. Findings from longitudinal studies, albeit rare, are generally consistent with cross-sectional findings, showing that working memory abilities increase from ages 3 to 19 (Ahmed et al., 2022) and that inhibitory control abilities increase from ages 9 to 26 (Ordaz et al., 2013).

Cognitive flexibility, on the other hand, has been found to reach maturity earlier (i.e., by middle adolescence) than working memory and inhibitory control. It has been found that there are age-related increases in cognitive flexibility abilities until age 15, but not between ages 15 and 21 (Huizinga & van der Molen, 2007) or between ages 17 and 19 (Taylor et al., 2015). As such, although the current literature suggests growth in working memory and inhibitory control throughout adolescence into young adulthood and growth in cognitive flexibility until middle adolescence, studies regarding developmental patterns of executive function beyond middle adolescence are lacking. Importantly, we note that the findings are primarily based on cross-sectional examination of age differences instead of within-person developmental patterns.

Child maltreatment and executive function

Parenting and the environment in which a child develops are crucial for the development of executive functions (Fay-Stammbach et al., 2014). Early in life, a child relies on their parent to generate learning and provide social interactions. In cases of abuse or neglect, a child often does not get the necessary guidance they require from their parent to successfully develop adequate executive function abilities. It has been proposed that a lack of cognitive and social stimulation in childhood (measured via child interview and self-report measures) leads to worse executive function abilities (i.e., working memory, inhibitory control, monitoring, and organization) among adolescents, as reported by parents (Sheridan et al., 2017). Growing up in a state of chronic stress, such as in a neglectful or abusive home, may also alter the development of the prefrontal cortex, which then increases the risk for deficits in executive functions (Lund et al., 2020). During adolescence, when there is already a slower-developing cognitive control system and a faster-growing socioemotional system, as proposed by the dual systems model (Casey et al., 2008; Steinberg, 2008), it is critical for individuals to have adequate executive function abilities to navigate new situations. There is also evidence suggesting that the prefrontal cortex has one of the most protracted developmental periods, and thus is especially vulnerable to chronic stress and traumatic experiences (Sapolsky, 2017; Wilson et al., 2011), such as childhood maltreatment.

Within the current literature regarding the link between maltreatment experiences and brain development, it has been proposed that deprivation and threat have different influences on brain development. Specifically, the Dimensional Model of Adversity and Psychopathology (Sheridan & McLaughlin, 2014) proposes that exposure to deprivation is linked to reductions in thickness and volume of areas of the association cortex most often recruited for processing complex cognitive inputs, as well as reduced performance on cognitive tasks that depend on these brain areas (e.g., executive function). On the contrary, exposure to threat is linked to altered neural circuits in the hippocampus, amygdala, and ventromedial that underlie emotional learning. The idea is that aspects of executive function associated with prefrontal cortex functioning may be particularly vulnerable to *deprivation* of material resources, cognitive stimulation, and social-educational interactions.

Within the current literature on maltreatment, however, studies simultaneously examining both neglect (i.e., deprivation) and abuse (i.e., threat) are rare and the findings regarding the roles of neglect and abuse on executive function have been mixed. Additionally, most prior studies examining the effects of abuse and neglect focused solely on one specific component of executive function. Past research has shown mixed support for the Dimensional Model of Adversity and Psychopathology. A study of children who were adopted because of early-life caregiver deprivation showed that inhibitory control is impaired by early deprivation experience, as indicated by poor inhibitory control performance and aberrant neural activation in the regions involved in inhibitory control (inferior prefrontal cortex) and conflict monitoring (dorsal anterior cingulate gyrus) (Mueller et al., 2010). Furthermore, childhood maltreatment derived from court-substantiated cases, specifically neglect rather than abuse, predicted worsened cognitive flexibility) later in life (Nikulina & Widom, 2013). In a sample of adolescents, neglect (measured via child interview and self-report measures) was associated with lower levels of parent-reported inhibitory control but not working memory while controlling for the effects of abuse. In this study, abuse (measured via child interview and self-report measures) was not predictive of executive function abilities (Sheridan et al., 2017). Findings from these studies are consistent with the Dimensional Model of Adversity and Psychopathology.

Contrary to the Dimensional Model of Adversity and Psychopathology, it has been suggested that worsened working memory performance may occur in those who have experienced threat due to hypervigilance towards danger that results in difficulties in memory (Steele, 2002). For example, 8- to 12-year-olds who experienced abuse (assessed via a parent-report measure) did significantly worse on a working memory task compared to children who had not experienced abuse (Augusti & Melinder, 2013). Neuroimaging studies also present evidence of threat effects on neural activation and structure in the brain regions underlying executive function. In a longitudinal study simultaneously evaluating the effects of abuse and neglect on brain activation during inhibitory control, abuse (but not neglect; as measured by self-report) was related to accelerated neurodevelopment of brain regions involved in cognitive control (e.g., frontoparietal regions) (Kim-Spoon et al., 2021). Thus, although this study is not directly investigating executive function behavioral performance, the results indicate that it was abuse (threat) rather than neglect (deprivation) that was associated with neural development of cognitive control. Similarly, structural neuroimaging research reveals that abuse experiences are associated with the sizes of brain regions underlying cognitive abilities involved in declarative memory. For example, hippocampal and corpus callosum volumes measured during young adulthood were significantly related to abuse experiences prior to age 16 (retrospective reported abuse via interview; Andersen et al., 2008).

Further, although not directly measuring neglect by caregivers per se, studies on the effects of material deprivation suggest an association between poverty and enhanced cognitive flexibility. For example, a meta-analysis reported that individuals who grew up in low-income families showed better cognitive flexibility compared to those who grew up in high-income families (Mittal et al., 2015). There was no significant difference between the two groups with regard to inhibitory control. In contrast to this observation, a meta-analysis by Johnson et al. (2021) revealed that childhood and adolescent experiences of deprivation (i.e., institutionalization, foster care, food insecurity, and emotional and physical neglect), were more likely to be associated with deficits in working memory and inhibitory control of executive function, compared to threat (i.e., emotional, physical, and sexual abuse and violence to exposure). However, there was no difference between the effects of neglect and abuse on cognitive flexibility, showing that both neglect and abuse were associated with worsened cognitive flexibility abilities. Taken together, these studies imply that adverse experiences encompassing abuse and neglect may not universally impair executive function.

We note that, except several studies (Kim-Spoon et al., 2021; Nikulina & Widom, 2013; Sheridan et al., 2017), most previous studies measured solely abuse or neglect instead of simultaneously considering abuse and neglect to evaluate their relative effects. Given the high co-occurrence of abuse and neglect (Manly et al., 2001), the significant effects of neglect or abuse reported in those studies may also reflect, in part, the effects of the other. Altogether, the existing literature does not consistently support the Dimensional Model of Adversity and Psychopathology regarding the effects of abuse and neglect on executive function with respect to behavioral performance as well as underlying neural mechanisms. Even when the findings were consistent with the Dimensional Model of Adversity and Psychopathology, the majority of the prior studies considered only abuse or neglect, instead of evaluating the unique effect of abuse or neglect in the presence of the other. As such, further work is needed to disentangle differential effects of abuse and neglect on the developmental trajectories of executive function. Given the mixed literature on the effects of neglect and abuse on executive function, including specific components, the goal of the current study was to examine how neglect and abuse may differentially affect executive function as a whole as well as its individual components.

Present study

The aim of the current study was to examine the change in the developmental trajectories of executive function within and between individuals throughout adolescence and into young adulthood and to examine the effects recalled child maltreatment may have on these developmental trajectories. The current study used data from six time points across adolescence and into young adulthood (ages 14 through 20) with approximately one year between time points. In accordance with the Dimensional Model of Adversity and Psychopathology (Sheridan & McLaughlin, 2014), the specific aims of this study were to examine how neglect and abuse in childhood (i.e., ages 1–13) may differentially predict the growth trajectories of executive function during adolescence and into young adulthood. We examined the effects of abuse and neglect on both overall executive function and specific components of the executive function due to the following reasons: First, there is the empirical evidence of the three-factor structure of executive function by middle adolescence (Lee et al., 2013) supporting the three theoretical components of executive function (Friedman & Miyake, 2017; Miyake et al., 2000). Second, the theoretical proposition argues that executive function can be a result of a conceptually and anatomically distributed control system instead of hierarchical architecture (Friedman & Miyake, 2017; Zink et al., 2021).

We propose a theoretical hypothesis that, while there would be positive growth in overall executive function, childhood neglect (rather than childhood abuse) would be associated with low initial levels and slower growth rates, as is consistent with the Dimensional Model of Adversity and Psychopathology. For individual components of executive function (working memory, inhibitory control, and cognitive flexibility), we expected positive growth in abilities and we explored the effects of neglect and abuse on the initial levels and growth rates of each component of executive function. Considering the mixed findings in the literature, no specific hypotheses on the effects of neglect versus abuse on the individual components were formulated.

Method

Participants

The current study used six waves of data that were collected as part of a longitudinal study in a community-based sample. Adolescent participants and their caregivers were recruited from a southeastern state in the United States via email, flyers, and word-of-mouth (i.e., snowball sampling). All procedures were approved by the institutional review board of the university and written informed consent or assent was received from all participants. The sample includes 167 adolescents (47% females) and their primary caregiver (82% biological mothers, 13%

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biological fathers, 5% other). At Time 1, adolescents were between the ages of 13 and 14 ($M = 14.067$, SD = 0.540 for Time 1, $M = 15.045$, $SD = 0.541$ for Time 2, $M = 16.079$, $SD = 0.546$ for Time 3, $M = 17.017$, $SD = 0.552$ for Time 4, $M = 18.89$, $SD = 0.618$ for Time 5, $M = 20.171$, $SD = 0.631$ for Time 6). Due to the interruption in data collection during COVID-19, participants ranged from age 19 to 20 at Time 6. The options for race were Black, White, Latino or Hispanic, Biracial or Multiracial, Asian or Asian American, Native Hawaiian or Other Pacific Islander, American Indian/Alaska Native, or other. At the study's onset, adolescents identified as White (79%), Black (11%), and other (10%), which was representative of the region in which data was collected. For modeling purposes, race was re-coded to be dichotomous, with 0 indicating White and 1 indicating non-White. At Time 1, 157 families participated. At Time 2, 10 families were added to account for attrition between Times 1 and 2, yielding a final sample of 167 parent-adolescent dyads. There were 157 participants at Time 1, 150 at Time 2, 143 at Times 3 and 4, 126 at Time 5, and 122 at Time 6. There were 138 participants who provided data on the Maltreatment of Abuse and Chronology Scale. Caregivers' self-reported annual household income was measured using a 15-point scale (1–15) from "None" to "$200,000 or more". Information on the number in the household was used with income and poverty threshold levels designated by the US Census Bureau to calculate income-to-needs ratios.

Attrition analyses were performed utilizing a general linear model (GLM) univariate procedure to examine if there were systematic procedures for any missing data. The results of the GLM indicated that the rate of participation (calculated as the ratio of years participated to years invited to participate) was not significantly associated with demographic variables of sex, race (White vs. non-White), and income-to-needs ratio ($p = .719–.764$) or by study variables of maltreatment and executive function ($p = .109–.697$).

Measures

Maltreatment (neglect and abuse)

Recalled maltreatment was measured with the Maltreatment and Abuse Chronology of Exposure scale (MACE; Teicher & Parigger, 2015). MACE was assessed on a computer because this format is less intrusive for sensitive topics, such as maltreatment (Dillman et al., 2009). MACE uses 52 items to examine the severity of exposure to various types of maltreatment throughout childhood (ages 1–18). At Times 5 and 6 (ages 18–19), adolescents retrospectively reported at which ages they experienced the events. The maximum scores from the two time points were used. Recalled neglect (hereafter, neglect) was made up of the two subscales of emotional neglect (5 items) and physical neglect (5 items). Recalled abuse (hereafter, abuse) was made up of the four subscales of sexual abuse (7 items), verbal abuse (4 items), physical abuse (6 items), and non-verbal abuse (6 items). Items included "Intentionally pushed, pinched, slapped, kicked, etc." (physical abuse), "Swore at you, called you names, said insulting things" (verbal abuse), "You had to wear dirty clothes" (physical neglect), and "Parents made inappropriate sexual comments or suggestions to you" (sexual abuse). The analyses in the current study utilized maltreatment that occurred from ages 0–13 that was perpetrated by caregiver figures with the exception of sexual abuse. The subscale scores were scaled with an algorithm provided by Teicher and Parigger (2015), with higher scores indicative of more severe maltreatment. Existing literature indicates excellent test-retest reliability (Teicher & Parigger, 2015). The subscale items were used for confirmatory factor analysis (CFA), and the factor scores for neglect and abuse were extracted.

Executive function

An executive function composite was created for each of the six time points and made up of three behavioral tasks that aim to assess the constructs underlying executive function: working memory, inhibitory control, and cognitive flexibility (Miyake et al., 2000). First, working memory was measured using the Stanford-Binet memory for digits (SBMD: Roid, 2003). Specifically, the measure in which participants were instructed to repeat back a series of numbers backward was used. Second, inhibitory control was measured using the Multi-Source Interference Task (MSIT: Bush et al., 2003) in which participants were presented with a series of 3 digits, 1 of which was different. Participants were told to choose the identity (not the position) of this different number. In the neutral condition, the target number is congruent with the position of the number (e.g., "1" is in the first position of this sequence "122"). In the interference condition, the target number is not congruent with the position of the number (e.g., "1" is not in the first position of this sequence "212"). To examine task performance, reaction time, which is commonly utilized in adolescent samples (e.g., Fitzgerald et al., 2010), was used. Third, cognitive flexibility was measured with the Wisconsin Card Sorting Task (WCST: Heaton & Staff, 2003) in which participants are instructed to sort cards based on number, color, and shapes based on rules that change throughout the task. The number of perseverative errors was used, which are when participants continue to follow the wrong rule (i.e., perseverance), as a measure of cognitive flexibility. See Supplemental Materials for additional information on the executive function tasks.

Composite constructs have been found to be best represented using a simple aggregation (such as the mean) of executive function scores (Willoughby & Blair, 2016). To create the composite for executive function, MSIT and WCST items were reverse coded so that higher scores indicated better executive function, consistent with SBMD. Then, we used Time 1 as the "reference-time" (Little et al., 2006) and standardized the scores of SBMD, MSIT, and WCST using their own means at Time 1. For example, WCST at each time was standardized by subtracting the mean from Time 1 and dividing it by the standard deviation of Time 1. Then, the component scores (SBMD, MSIT, and WCST) were averaged for each Time. An exploratory factor analysis using SPSS was completed to evaluate the percentage of variances explained as well as the factor loadings. The percentage of variance explained ranged from 39.760 to 44.622, and the factor loading ranged from .693 to .864 for SMBD, from .547 to .674 for MSIT, and from .433 to .699 for WCST.

Data analytic plan

Descriptive statistics were examined for the normality of distributions and outliers for all variables. Skewness and kurtosis were also examined for their acceptable levels (less than 3 and 10, respectively; Kline, 2011). WCST exhibited kurtosis of greater than 10, and we used the maximum likelihood including robust standard errors (MLR) which employs a sandwich estimator to arrive at standard errors robust to the nonnormality of observations. Multivariate General Linear Modeling (GLM) analyses tested for the effects of demographic covariates (e.g., income, sex, and race). Full information maximum likelihood

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(FIML) estimation procedure was used to allow for missing data, as this method uses all information of observed data (Arbuckle, 1996) and has greater statistical efficiency for computing standard error compared to mean-imputation, list-wise, and pairwise deletion methods (Wothke, 2000). FIML is recommended when the data are missing at random. (MAR: Schafer & Graham, 2002). Little's MCAR test (Little, 1988) indicated that the patterns of missingness on study variables resembled missing completely at random patterns ($\chi^2 = 81.604$, $df = 79$, $p = .398$ for the executive function composite; $\chi^2 = 75.095$, $df = 79$, $p = .604$ for SBMD; $\chi^2 = 92.405$, $df = 72$, $p = .053$ for MSIT; $\chi^2 = 66.630$, $df = 79$, $p = .838$ for WCST).

Growth curve models were estimated using M*plus* version 8 (Muthén & Muthén, 1998-2017). First, unconditional growth curve models were used for the executive function composite and individual executive function components to evaluate the patterns of developmental trajectories across six time points. The first latent factor was the intercept, and all of the factor loadings were fixed to one. The second latent factor was the slope, which was indicative of the growth of the function and changes over time. Nested model comparisons were utilized to identify the best-fitting growth trajectories using the Satorra-Bentler scaled correction factor (Satorra & Bentler, 2010). The no-growth, linear growth, and latent basis growth models were compared. In the no growth model, it is assumed that there is a non-significant change in the slope. In the linear growth model, it is assumed that there is a linear pattern of growth, and the factor loadings were fixed to 0, 1, 2, 3, 4, and 5. The latent basis growth model allows the data to estimate the shape of the growth trajectories by fixing the first time point to 0 and the last time point to 1 while allowing the other 4 time points to be freely estimated. Model fit indices were examined by chi-square value, degrees of freedom, the corresponding p-value, Root Mean Square Error of Approximation (RMSEA), and the Confirmatory Fit Index (CFI). RMSEA values of less than .08 were considered acceptable and CFI values that are greater than .90 were considered acceptable fits (Little, 2013). The chi-square difference test was used to compare the nested models and the models that were most parsimonious and with acceptable fits were chosen as the best-fitting models.

Next, conditional growth curve models were tested to examine whether neglect and abuse are differentially related to the intercept and slope factors of executive function (i.e., four separate models of executive function composite and the three individual executive function components). The best-fitting models from the unconditional growth curve models were used, with neglect and abuse as predictors. This conditional growth curve model is depicted in Figure 2. Given that our models assessing executive function tasks were exploratory, results of these analyses are reported at a significance level of $p < .05$ without multiple comparison corrections (Bender & Lange, 2001) as well as with false discovery rate (FDR) corrections (Benjamini & Hochberg, 1995).

Table 1. Descriptive statistics for subtypes of maltreatment, executive function composite, executive function components, sex, and race

	M	SD	Min	Max
Emotional Neglect	1.739	2.328	0.000	10.000
Physical Neglect	1.029	1.844	0.000	6.000
Verbal Abuse	2.391	3.524	0.000	10.000
Non-Verbal Abuse	2.116	2.509	0.000	10.000
Physical Abuse	3.152	2.794	0.000	10.000
Sexual Abuse	0.514	1.505	0.000	7.000
EF Composite T1	−0.004	0.657	−2.050	1.660
EF Composite T2	0.475	0.565	−1.350	2.010
EF Composite T3	0.734	0.585	−1.010	2.120
EF Composite T4	0.988	0.623	−1.160	2.570
EF Composite T5	1.188	0.619	−0.250	2.660
EF Composite T6	1.180	0.570	−0.280	2.390
SBMD T1	5.561	1.752	2.000	10.000
SBMD T2	5.826	1.902	3.000	11.000
SBMD T3	6.106	2.090	2.000	11.000
SBMD T4	6.732	2.306	2.000	12.000
SBMD T5	7.248	2.442	3.000	12.000
SBMD T6	7.148	2.222	2.000	12.000
MSIT T1	−0.477	0.085	−0.679	−0.180
MSIT T2	−0.405	0.071	−0.631	−0.241
MSIT T3	−0.367	0.069	−0.548	−0.191
MSIT T4	−0.338	0.067	−0.519	−0.080
MSIT T5	−0.308	0.062	−0.456	−0.152
MSIT T6	−0.300	0.061	−0.462	−0.173
WCST T1	−7.350	4.135	−32.000	−3.000
WCST T2	−5.523	2.839	−28.000	−2.000
WCST T3	−4.944	2.220	−22.000	−2.000
WCST T4	−4.823	2.243	−19.000	−1.000
WCST T5	−4.827	1.524	−12.000	−2.000
WCST T6	−4.738	1.442	−12.000	−2.000
Sex (0 = male, 1 = female)	0.473	0.501	0.000	1.000
Race (0 = White, 1 = Non-White)	0.198	0.399	0.000	1.000

Note. EF = Executive function; WCST = Wisconsin Card Sort Task; MSIT = Multi-Source Interference Task; SBMD = Stanford Binet Memory for Digits; T = Time.

Results

Descriptive statistics for all study variables are presented in Table 1 and correlations for all study variables are presented in Supplemental Materials, Table S1. There were 64 participants who reported having experienced neglect, 94 participants who reported having experienced abuse, and 58 who experienced both abuse and neglect, across ages 1 to 13. The results from the multivariate GLM testing demographic covariates showed that race was significantly associated with the executive function composite, SBMD, and WCST ($F = 2.503$, $p = .029$; $F = 2.419$, $p = .034$, and $F = 2.713$, $p = .019$, respectively); thus, race was added as a covariate to the model with the executive function composite and to the models with the individual components of SBMD and WCST. Race was not significantly associated with MSIT ($F = 1.098$, $p = .372$) and thus was not included in those models. The other demographic variable (i.e., income-to-needs ratio) was not significantly associated with the executive function composite and each of the executive function components ($F = 0.298–1.245$, $p = .133–.936$), and thus were not included in the growth curve models.

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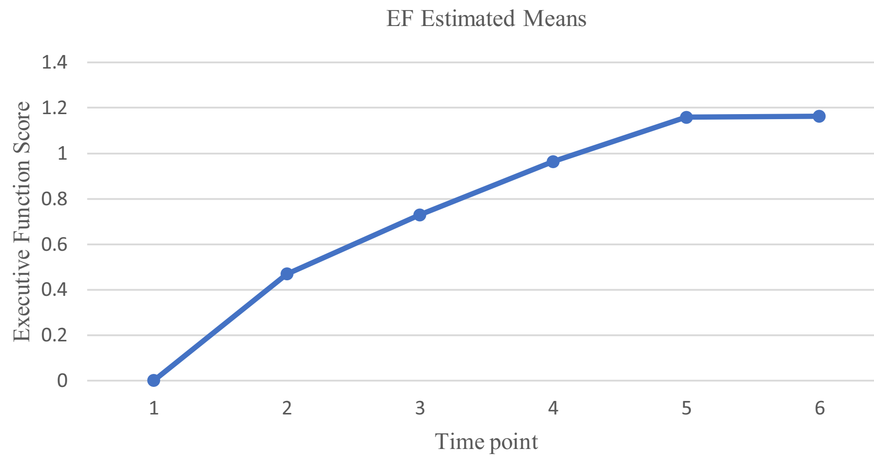

Figure 1. The shape of the growth curve trajectory of the executive function composite. EF = executive function.

Executive function composite

Unconditional growth curve model

Three alternative models were so that the shape of the executive function composite could be determined (see Supplemental Materials, Table S2). A latent basis growth model provided the best fit ($\chi^2 = 26.327$, $df = 17$, $p = .069$, RMSEA = 0.057, CFI = .979) (see Figure 1 for the trajectory shape of the growth curve based on the estimated means). The executive function composite showed growth from Times 1 through 5, and then leveled off between Times 5 and 6. There was significant variance of the intercept ($\sigma = 0.280$, $SE = 0.045$ $p < .001$) and slope ($\sigma = 0.186$, $SE = 0.046$, $p < .001$), indicating significant individual differences in initial levels and growth in executive function abilities. The mean of the slope was positive and significant, indicating that executive function abilities increased over time ($M = 1.155$, $SE = 0.050$, $p < .001$). The mean of the intercept was not significantly different from zero ($M = -0.007$, $SE = 0.052$, $p = .898$).

Conditional growth curve model

A conditional growth curve model was used to examine the associations between maltreatment (neglect and abuse) and executive function growth factors. The model examining the effects of neglect and abuse on the composite of executive function demonstrated acceptable fit ($\chi^2 = 44.365$, $df = 29$, $p = .034$, RMSEA = 0.056, CFI = .966). However, none of the regression paths estimating the effects of neglect and abuse on the growth factors of executive function were statistically significant (see Table 2 for estimates). The intercept and slope factors were negatively correlated with each other, indicating that those whose were higher at Time 1 showed slower increases over time. Additionally, neglect and abuse were positively correlated with each other indicating that those who experienced neglect were more likely to experience abuse.

Working memory (SBMD)

Unconditional growth curve model

For SBMD, a latent basis growth curve model provided the best fit ($\chi^2 = 15.100$, $df = 17$, $p = .588$, RMSEA = 0.000, CFI = 1.000) (see Table S2; see Figure S1 for the shape of the growth curve of the estimated means). SBMD showed growth from Times 1 through 5, and then a slight decrease between times 5 and 6. There was significant variance for the intercept ($\sigma = 1.768$, $SE = 0.289$, $p < .001$) and slope ($\sigma = 0.742$, $SE = 0.326$, $p = .023$), indicating significant individual differences in initial levels and growth in working memory. The means of the intercept ($M = 5.555$, $SE = 0.135$, $p < .001$) and slope ($M = 1.399$, $SE = 0.145$, $p < .001$) were significantly different from zero, indicating that working memory abilities increased over time.

Conditional growth curve model

The model examining the effects of neglect and abuse on SBMD demonstrated acceptable fit ($\chi^2 = 34.444$, $df = 29$, $p = .223$, RMSEA = 0.034, CFI = .988). Neglect was a significant predictor of the slope of SBMD, indicating that greater levels of neglect were associated with slower increases in SBMD (see Table 3 for estimates). Race was a significant predictor of the slope of SMBD indicating that non-White adolescents exhibited slower increases (see Table 3 for estimates). The intercept and slope factors were positively correlated with each other, indicating that those whose were higher at Time 1 showed steeper increases over time. Additionally, neglect and abuse were significantly correlated with each other.

Inhibitory control (MSIT)

Unconditional growth curve model

For MSIT, a latent basis growth model provided the best fit ($\chi^2 = 32.892$, $df = 17$, $p = .012$, RMSEA = 0.075, CFI = .947) (see Table S2; see Figure S2 for the shape of the growth curve of the estimated means). MSIT showed growth between all six time points. There was significant variance for the intercept ($\sigma = .005$, $SE = 0.001$, $p < .001$) and for the slope ($\sigma = 0.005$, $SE = 0.001$, $p < .001$), showing that there were individual differences in initial levels and growth of inhibitory control. The means of the intercept ($M = -0.478$, $SE = 0.007$, $p < .001$) and slope ($M = 0.180$, $SE = 0.008$, $p < .001$) were significantly different from zero, indicating that inhibitory control abilities increased over time.

Conditional growth curve model

The conditional growth curve model that examined the effects of neglect and abuse on MSIT demonstrated acceptable fit ($\chi^2 = 43.038$, $df = 25$, $p = .014$, RMSEA = 0.066, CFI = .942). However, none of the regression paths estimating the effects of neglect and abuse on the growth factors of MSIT were statistically significant (see Table 4 for unstandardized estimates). The intercept and slope factors were not correlated with each other, indicating that rate of change across time was not related to the baseline level. Neglect and abuse were significantly correlated with each other.

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Table 2. Results of conditional growth curve models of abuse and neglect effects on the executive function composite

		Executive Function			
Parameters	Estimate (Est; b)	Standardized Estimate (β)	Std. Error (SE)	Est/SE	*p*
Factor Loadings					
EF Slope → Time 1	0 =	.000			
EF Slope → Time 2	0.409	.302	.032	12.687	< .001
EF Slope → Time 3	0.643	.478	.030	21.306	< .001
EF Slope → Time 4	0.853	.622	.028	30.362	< .001
EF Slope → Time 5	0.007	.714	.032	31.070	< .001
EF Slope → Time 6	1 =	.710			
Regression effects on slope					
Abuse → EF Slope	−0.075	-.121	.074	−1.021	.307
Neglect → EF Slope	−0.060	-.120	.059	−1.012	.312
Race → EF Slope	0.034	.032	.104	0.329	.742
Regression effects on intercept					
Abuse → EF Intercept	0.039	.052	.072	0.550	.582
Neglect → EF Intercept	0.013	.021	.055	0.237	.813
Race → EF Intercept	−0.166	-.125	.130	−1.270	.204
Factor covariances					
EF Intercept ↔ EF Slope	−0.104	-.470	.040	−2.591	.010
Abuse ↔ Neglect	0.198	.332	.057	3.456	.001

Note. EF = Executive Function. *p* values correspond with the unstandardized estimates.

Table 3. Results of conditional growth curve models of abuse and neglect effects on working memory, as measured by the stanford binet memory for digits

		Working Memory (SBMD)				
Parameter	Estimate (Est; b)	Standardized Estimate (β)	Std. Error (SE)	Est/SE	*p*	FDR-corrected *p*
Factor Loadings						
SBMD Slope → Time 1	0 =	0 =				
SBMD Slope → Time 2	0.123	0.123	.097	1.263	.270	.450
SBMD Slope → Time 3	0.432	0.432	.094	4.601	< .001	< .001
SBMD Slope → Time 4	0.855	0.855	.099	8.621	< .001	< .001
SBMD Slope → Time 5	1.179	1.179	.107	11.049	< .001	< .001
SBMD Slope → Time 6	1 =	1 =				
Regression effects on slope						
Abuse→ SBMD Slope	0.057	.047	.182	0.314	.753	.904
Neglect → SBMD Slope	−0.316	−.326	.131	−2.410	.016	.027
Race → SBMD Slope	−0.736	−.351	.238	−3.094	.002	.005
Regression effects on intercept						
Abuse → SBMD Intercept	−0.008	−.004	.180	−0.047	.963	.980
Neglect → SBMD Intercept	−0.004	−.002	.145	−0.025	.980	.980
Race → SBMD Intercept	−0.320	−.095	.342	−0.935	.350	.467
Factor covariances						
SBMD Intercept ↔ SBMD Slope	0.536	.563	.207	2.595	.009	.018
Abuse ↔ Neglect	0.199	.333	.057	3.462	.001	.003

Note. SBMD = Stanford Binet Memory for Digits. *p* values correspond with the unstandardized estimates. For scaling purposes, we fixed the first and last time points to 0 and 1, respectively, for unstandardized estimates only; thus, the factor loadings are presented in unstandardized estimates.

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Table 4. Results of conditional growth curve models of abuse and neglect effects on inhibitory control, as measured by the multi-source interference task

	Inhibitory Control (MSIT)					
Parameter	Estimate (Est; b)	Standardized Estimate (β)	Std. Error (SE)	Est/SE	*p*	FDR-corrected *p*
Factor Loadings						
MSIT Slope → Time 1	0 =	0 =				
MSIT Slope → Time 2	0.408	0.408	.025	16.500	< .001	< .001
MSIT Slope → Time 3	0.617	0.617	.025	24.501	< .001	< .001
MSIT Slope → Time 4	0.790	0.790	.024	32.690	< .001	< .001
MSIT Slope → Time 5	0.909	0.909	.026	34.438	< .001	< .001
MSIT Slope → Time 6	1 =	1 =				
Regression effects on slope						
Abuse → MSIT Slope	−0.010	−.100	.013	−0.767	.443	.554
Neglect → MSIT Slope	0.012	.139	.011	1.030	.303	.433
Regression effects on intercept						
Abuse → MSIT Intercept	−0.001	−.010	.011	−0.098	.922	.922
Neglect → MSIT Intercept	−0.001	−.016	.009	−0.158	.874	.922
Factor covariances						
MSIT Intercept ↔ MSIT Slope	−0.004	−.746	.001	−4.481	< .001	< .001
Abuse ↔ Neglect	0.198	.330	.057	3.445	.001	.002

Note. MSIT = Multi-Source Interference Task. *p* values correspond with the unstandardized estimates. For scaling purposes, we fixed the first and last time points to 0 and 1, respectively, for unstandardized estimates only; thus, the factor loadings are presented in unstandardized estimates.

Cognitive flexibility (WCST)

Unconditional growth curve model

For WCST, a latent basis growth model provided the best fit for the data (χ^2 = 11.102, *df* = 11, *p* = .435, RMSEA = 0.007, CFI = .998) (see Table S2; see Figure S3 for the shape of the growth curve of the estimated means). WCST showed rapid growth between Times 1 and 2, and steady increases between Times 2 and 6. In this model, the residuals of manifest variables were freed to vary across time, the time 1 residual was set to 0 (to prevent negative variance), and residuals between Times 3 and 5 and Times 4 and 6 were allowed to covary. There was significant variance for the intercept (σ = 16.953, *SE* = 4.751, *p* < .001) and the slope (σ = 15.247, *SE* = 3.916, *p* < .001), indicating significant individual differences in initial levels and growth in cognitive flexibility. The means of the intercept (*M* = -7.361, *SE* = 0.326, *p* < .001) and slope (*M* = 2.576, *SE* = 0.307, *p* < .001) were significantly different from zero, indicating that cognitive flexibility abilities increased over time.

Conditional growth curve model

The model examining the effects of neglect and abuse on WCST demonstrated acceptable fit (χ^2 = 26.679, *df* = 23, *p* = .270, RMSEA = 0.031, CFI = .954). However, none of the regression paths estimating the effects of neglect and abuse on the growth factors of WCST were statistically significant (see Table 5 for unstandardized estimates). The intercept and slope factors were negatively correlated with each other, indicating that those whose intercepts were higher at Time 1 showed slower increases over time. Additionally, neglect and abuse were significantly correlated with each other.

As such the results indicate that childhood neglect, but not abuse, was significantly associated with developmental changes in working memory, such higher levels of neglect predicted slower increases in working memory abilities throughout adolescence and into young adulthood. The effects of neglect and abuse were not significant for the developmental changes of inhibitory control and cognitive flexibility. The expectation of the R^2 revealed that neglect explained 27% of the variance of the slope of SBMD (for working memory), whereas it explained 2% of the variance of MSIT (for inhibitory control), 1% of the variance of WCST (for cognitive flexibility), and 4% of the variance of the overall executive function.

Discussion

Sufficient self-regulation skills encompassing executive function are crucial for the healthy development of individuals, and lower self-regulation has been tied to a host of issues, such as psychopathology, substance use, and greater levels of risk-taking behaviors (Crockett et al., 2006; Eisenberg et al., 2009; Zucker et al., 2011). Thus, it is critical to examine how neglect and abuse experiences may affect the development of self-regulation skills. Particularly, given the important role of executive function in the development of psychopathology in childhood and adolescence (Kim-Spoon et al., 2019), understanding how neglect and abuse may differentially affect the development of executive function would allow more precise targets for prevention of and intervention for myriad psychopathology problems among individuals who experienced child maltreatment. The Dimensional Model of Adversity and Psychopathology, which is one of the prevailing theories regarding adversity effects, posits the differential impacts of deprivation (e.g., neglect) and threat (e.g., abuse) on the development of cognitive functioning such as executive function (Sheridan & McLaughlin, 2014). The current study aimed to examine the differential effects that neglect and

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Table 5. Results of conditional growth curve models of abuse and neglect effects on the cognitive flexibility, as measured by the wisconsin card sorting task

	Cognitive Flexibility (WCST)					
Parameter	Estimate (Est; b)	Standardized Estimate (β)	Std. Error (SE)	Est/SE	*p*	FDR-corrected *p*
Factor Loadings						
WCST Slope → Time 1	0 =	0 =				
WCST Slope → Time 2	0.706	0.706	.094	7.524	< .001	< .001
WCST Slope → Time 3	0.985	0.985	.044	22.401	< .001	< .001
WCST Slope → Time 4	0.903	0.903	.077	11.717	< .001	< .001
WCST Slope → Time 5	0.985	0.985	.041	23.887	< .001	< .001
WCST Slope → Time 6	1 =	1 =				
Regression effects on slope						
Abuse → WCST Slope	−0.485	−.086	.422	−1.149	.251	.377
Neglect → WCST Slope	−0.130	−.029	.338	0.338	.700	.726
Race → WCST Slope	0.660	.067	1.017	0.649	.517	.620
Regression effects on intercept						
Abuse → WCST Intercept	0.413	.072	.419	1.027	.304	.405
Neglect → WCST Intercept	0.110	.023	.314	0.350	.726	.726
Race → WCST Intercept	−1.260	−.122	1.049	−1.201	.230	.377
Factor covariances						
WCST Intercept ↔ WCST Slope	−15.724	−.993	4.062	−3.871	< .001	< .001
Abuse ↔ Neglect	0.199	.333	.057	3.466	.001	.002

Note. WCST = Wisconsin Card Sorting Task. p values correspond with the unstandardized estimates. For scaling purposes, we fixed the first and last time points to 0 and 1, respectively, for unstandardized estimates only; thus, the factor loadings are presented in unstandardized estimates.

abuse have on the developmental trajectories of executive function throughout adolescence and into young adulthood. Specifically, we used growth curve modeling based on prospective data of six time points to examine how neglect and abuse are associated with the development of executive function as a whole, as well as the individual components of executive function including working memory, inhibitory control, and cognitive flexibility.

Existing literature has shown conflicting evidence regarding developmental trajectories of executive function development throughout adolescence and into young adulthood. We examined within-person changes of task-based executive functions and found that executive function abilities as a whole increased from ages 14 to 20. Additionally, we found that performance on each individual component of executive functions (working memory, inhibitory control, and cognitive flexibility) improved over time. Our findings offer insight into the development of executive function across adolescence and early young adulthood, showing that these abilities continue to develop from ages 14–20.

Our first hypothesis was that neglect, not abuse, would predict low initial levels of overall executive function abilities (i.e., combined levels of working memory, inhibitory control, and cognitive flexibility). Further, while we expected to see positive growth in executive function, we expected that individuals who experienced neglect would experience slower growth compared to individuals who did not experience neglect (including compared to individuals who experienced abuse), as is consistent with the Dimensional Model of Adversity and Psychopathology. The results partially supported our hypothesis. Specifically, while executive function abilities increased over the six years, neglect and abuse were not associated with individual differences in the initial levels and growth rates of executive function development.

The findings from the current study are inconsistent with prior research indicating a significant association between child neglect and the parent-reported overall executive function composite that combined working memory, inhibitory control, monitoring, and organization among adolescents (Sheridan et al., 2017). Additionally, our findings are inconsistent with previous findings showing that deprivation is associated with worse performance on the overall executive function composite that combined non-verbal reasoning and cognitive flexibility tasks among middle-aged adults (Nikulina & Widom, 2013). The discrepancy in the findings may be attributed to the different ways that each study constructed the executive function composite and the ways in which the executive function components were assessed. Our study used repeatedly measured (from ages 14 through 20) behavioral performance of three theoretical components of executive function, whereas the prior studies used parent-reported or behavioral performance of one or two theoretical components of executive function measured only at one time point.

Our second aim was to explore the differential effects of neglect and abuse on the initial levels and growth trajectories of each individual component of executive function: working memory, inhibitory control, and cognitive flexibility. Given inconsistent prior research on individual components of executive function and their associations with maltreatment, our goal was to explore these components to uncover any differences in potential effects of neglect and abuse. As expected, there was significant growth in each of the individual components. We found that greater levels of

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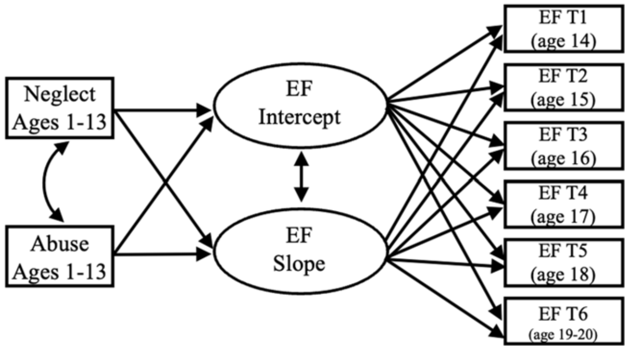

Figure 2. Conceptual model for the conditional growth curve model of executive function predicted by abuse and neglect. EF = executive function; T = time.

neglect were significantly associated with the growth of working memory, such that individuals who experienced greater amounts of neglect had slower increases in working memory abilities over the six-year timespan. This finding is consistent with the Dimensional Model of Adversity and Psychopathology and with previous literature showing that experiences of deprivation (e.g., neglect) are significantly associated with worse working memory (see Johnson et al., 2021 for a review). There are several possible mechanisms through which neglect may affect working memory. Early neglect may involve resource scarcity, such as in poverty, and thus may lead to a lack of enrichment activities that have been tied to better working memory (Sarsour et al., 2011). Further, in the current study, the construct of neglect included *emotional* neglect, which contains items such as not having a parent around to help with homework. Such a lack of parental involvement could lead to worsened working memory development. As proposed by McLaughlin et al. (2017), deprivation (e.g., neglect) may produce long-lasting alterations in different domains of cognitive development, and in the case of working memory, by way of accelerated neurodevelopmental processes of synaptic pruning and limited myelination in the regions that serve working memory development including dorsolateral prefrontal cortex (D'Esposito & Postle, 1999; Goldman-Rakic, 2011; Smith & Jonides, 1995).

Our findings have potential implications for possible interventions to prevent cascading effects. There is evidence that reduced working memory abilities are a mediator between child maltreatment and later substance use (Edalati & Krank, 2016). Additionally, some research has suggested that working memory can be trained, and it is a significant predictor of delay discounting (i.e., the decrease in value of a reward as a function of the delay to its receipt) which is a transdiagnostic mechanism that explains many forms of addiction including substance misuse (Bickel et al., 2011). Indeed, lower working memory abilities have been tied to greater levels of substance use as well as reduced delay discounting (Khurana et al., 2017; Mitchell et al., 2005). A recent review has suggested that mindfulness practices have promising results for improvements in executive function, including working memory (Diamond & Ling, 2020). For example, mindfulness meditation has been shown to give rise to significant improvements in working memory abilities among adolescents (Quach et al., 2016). Further, there are interventions designed to improve working memory by having individuals complete blocks of working memory tasks several times per week (Klingberg, 2010) or through computerized training programs (Bickel et al., 2014). However, some literature has suggested that the effects of working memory training are not sustained and may not transfer to real-world examples (Gobert & Sala, 2023; Melby-Lervåg & Hulme, 2013; Melby-Lervåg et al., 2016). Further research is needed to determine if interventions targeting working memory abilities (e.g., such as mindfulness practices involving movement) may have cascading effects that result in substance use disorders among individuals who experienced neglect in childhood.

We did not find significant effects of neglect on the initial levels of working memory. This finding may be in part due to working memory still developing throughout adolescence and young adulthood. That is, although levels of neglect were not significantly associated with working memory at the first time point (i.e., around age 14), the change rate of working memory abilities from age 14 through 20 was associated with childhood neglect. Further, the finding suggests that the developmental period of adolescence is a critical period during which the effects of childhood neglect culminate, manifested as impaired development of working memory in part due to the fact that the prefrontal regions involved in working memory mature faster during adolescence than in earlier years (Goldman-Rakic, 2011; van den Bosch et al., 2014).

Next, experiences of neglect or abuse were not significantly associated with the initial levels or the growth of inhibitory control. A systematic review indicated that between the ages of 6 and 17, inhibitory control is particularly impaired by trauma including maltreatment (i.e., neglect, abuse, institutionalization, witnessing death), as compared to early in the life or in young adulthood (i.e., between the ages 2 and 5 or between the ages of 18 and 25) (see van der Bij et al., 2020 for a review). It is possible that in young adulthood (i.e., after age 17 as noted by van der Bij et al., 2020), the effects of maltreatment on inhibitory control may start waning, although this possibility could not be directly concluded from the systematic review that was based on comparisons across different age groups rather than longitudinal studies of within-person changes. In the current study, we did not find evidence that maltreatment experienced between the ages of 1 and 13 hindered inhibitory control abilities between the ages of 14 and 20. There could be dose-response at play, such that greater levels of overall are related to worse inhibitory control. In our study, we examined two separate composites of neglect and abuse as competing predictors rather than a single cumulative amount of adversity. A fruitful direction of future work is to utilize prospective longitudinal data over a longer lifespan to examine whether the effects of abuse and neglect on inhibitory control development diminish from childhood through adulthood.

Finally, with respect to cognitive flexibility, abuse or neglect did not have significant effects on the initial levels or the growth rates. The nonsignificant effects of abuse and neglect on cognitive flexibility are partially inconsistent with a previous study that identified a significant association between neglect (but not abuse) and deficits in cognitive flexibility by comparing between a sample of middle-aged adults with court-substantiated maltreatment and a control group (Nikulina & Widom, 2013). It is plausible that the effects of neglect may be more readily detectable when extreme groups (i.e., court-substantiated severe neglect vs. control) are compared. More importantly, our finding of non-significant effects of abuse and neglect on cognitive flexibility development is consistent with the systematic review by Johnson et al. (2021) who reported no significant deprivation or abuse effects on cognitive flexibility. Further, there is emerging literature indicating that cognitive flexibility may be enhanced by early adversity. It has been

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proposed that cognitive flexibility abilities facilitate how well people can adapt to adverse experiences such that the ability to successfully shift attentional resources can modulate the mismatch between expected and real-world scenarios (Yao & Hsieh, 2019). Indeed, Mittal et al. (2015) reported that individuals growing up in unpredictable environments with regard to socioeconomic status were better at cognitive flexibility. Similarly, Fields et al. (2021) found that exposure to unstable caregiving in childhood (i.e., number of caregiving switches) promotes better cognitive flexibility. The current study did not examine the construct of unpredictability per se, and we recommend that future work should examine if there are differential effects between deprivation and unpredictability.

While the previous literature is inconsistent regarding the individual components of executive function, the Dimensional Model of Adversity and Psychopathology suggests that neglect should influence these executive function abilities given the altered brain structure and function due to exposure to deprivation. Altogether, our data indicated that each of the individual components of executive function showed growth throughout adolescence and into young adulthood, but only neglect (not abuse) was associated with slower growth in working memory abilities.

There were limitations in the current study that should be addressed in future work. First, although our analysis was a longitudinal design across six time points, the correlational data do not allow us to infer causality. Second, child maltreatment was assessed using retrospective self-reports on the MACE which was administered at 18–19 years that were close enough to childhood to capture as reliable recall as possible. Given the poor agreement between prospective and retrospective measures of maltreatment has been reported (Baldwin et al., 2019; Danese & Widom, 2020), we acknowledge the limitation that retrospective reports of neglect and abuse might have produced different results than if prospective reports were used. Prospective reports can help recall biases, but they can suffer from underreporting biases based on an unwillingness to disclose what is currently occurring or has recently occurred (Hardt & Rutter, 2004). In contrast, research has shown that retrospective reports of child maltreatment can identify underreporting maltreatment cases (Kobulsky et al., 2018; White et al., 2016). Concerning predictive validity, converging evidence suggests that retrospective self-reports have stronger associations with psychopathology outcomes than prospective records (Danese & Widom, 2020, 2021, 2023; Francis et al., 2023; Negriff et al., 2017; Newbury et al., 2018; Shaffer et al., 2008). Considering the different strengths and limitations of the two approaches, future research should use multi-method approaches to examine child maltreatment. Researchers should keep in mind that prospective and retrospective measures may capture largely different groups of individuals (e.g., Baldwin et al., 2019) and may vary predictive validity dependent upon the report types of outcomes (e.g., Reuben et al., 2016).

Third, there have been recent criticisms of Miyake et al. (2000) model stating that executive function does not always split into the three-factor model (Doebel, 2020; Karr et al., 2018). Future research should examine the factor structure of executive function in different populations and should replicate the findings with larger samples to confirm the robustness of the current study's findings, as well as examine multiple executive function tasks for each component to provide a more comprehensive picture of the latent constructs (e.g., Camerota et al., 2020). Additionally, we attempted to measure the working memory component of Miyake et al. (2000) model using the Backward Digit Span task. We acknowledge that this task does not directly capture the updating component in the original model. Future work should examine these findings with tasks that capture updating, such as the *n*-back task (e.g., Miyake & Friedman, 2012). Fourth, our sample had a wide range of SES with substantial representation of adolescents from poor, working-class families, equal representation of sexes, and regionally representative racial diversity. However, the current sample was a convenience sample, and future work should examine other populations to see if the results generalize. Finally, individual differences in executive function can be significantly impacted by genetics (Miyake & Friedman, 2012). Given that the current study examined the effects of abuse and neglect by the caregiver (i.e., largely biological parental maltreatment), future research should examine the potential influences of the genetic contributions to executive function abilities on adolescents' executive function development. That is, an adolescent may show worse executive function abilities due to a combination of both genetic predisposition and having experienced neglect.

Notwithstanding the limitations noted, there were significant strengths of the present study that overcome limitations of past research. Most past research measured adverse childhood experiences and used broad definitions of deprivation (e.g., physical and emotional neglect, institutionalization, and food insecurity) and threat (e.g., emotional, physical, and sexual abuse, but also any exposure to violence in or outside the home) and thus fell short of distinguishing potentially differential effects between abuse and neglect regarding executive function development (e.g., Johnson et al., 2021). Yet, it is crucial to focus on neglect and abuse experiences for two reasons: First, they may exert qualitatively distinctive influences on development, compared to the early life adverse experiences that are relatively within the normal range (e.g., non-traumatic exposure to violence, intermittent food insecurity). Second, literature is clear about neglect and abuse being transdiagnostic predictors of psychopathology, which is not necessarily the case for adverse childhood experiences. Thus, the results of using neglect and abuse constructs can be more directly translated. Additionally, most prior research failed to compare the three theoretical facets of executive function. In the current study, multiple behavioral measures of executive function were utilized, allowing not only the examination of executive function as a construct as a whole, but also the ability to detangle specific effects of the individual components of theoretical importance. The latter approach is crucial, considering the three-factor structure of executive function during adolescence and young adulthood (Lee et al., 2013; Miyake et al., 2000), as well as the recent evidence revealing notably different effects of adversity on cognitive flexibility compared to working memory and inhibitory control (Fields et al., 2021; Mittal et al., 2015). Further, we were able to examine trajectories of executive function abilities across six time points throughout adolescence and into young adulthood, which allowed us to examine the developmental trajectories and the effects of earlier neglect and abuse experiences on them.

Conclusion

Overall, the current findings from longitudinal prospective analyses provide some support for the existing Dimensional Model of Adversity and Psychopathology (Sheridan & McLaughlin, 2014) by demonstrating that neglect specifically was associated with slower growth of working memory abilities. We did not find that earlier neglect nor abuse were associated with executive function abilities as a whole as well as inhibitory control or cognitive flexibility abilities, suggesting that neglect was particularly influential on working memory development. These findings highlight that working memory is a facet of adolescent executive function and its development is more vulnerable to the detrimental effects of childhood neglect experiences that can potentially be targeted by preventive intervention efforts.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0954579424001457.

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Competing interests. None.

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