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# Childhood maltreatment predicts poorer executive functioning in adulthood beyond symptoms of internalizing psychopathology☆

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ABSTRACT

*Background:* A history of childhood maltreatment predicts poorer functioning in several domains during childhood, including executive function (EF). While there is also evidence of poorer EF in adults with a history of childhood trauma, results are mixed. Notable limitations of previous research are (a) the use of single indicators of EF, and/or (b) not consistently assessing whether childhood maltreatment predicts poorer EF beyond internalizing psychopathology.
*Objective:* We sought to overcome limitations of prior work by examining relationships between childhood maltreatment and EF in adulthood by using a latent factor of EF derived from multiple indicators and including psychopathology covariates in our analyses.
*Participants and setting:* The present study included a large sample of community adults ($n = 489$) who were oversampled for internalizing psychopathology symptoms.
*Methods:* Primary analyses examined whether childhood maltreatment (cumulative and subtypes) predicted EF using a latent factor approach and linear mixed effects models. Follow-up analyses assessed the impact of childhood maltreatment on EF beyond internalizing psychopathology symptoms and assessed whether gender moderated relationships between EF and childhood maltreatment.
*Results:* Greater cumulative maltreatment predicted poorer EF ($B = -0.15$), and emotional neglect emerged as a unique predictor of EF ($B = -0.18$). These results remained after controlling for psychopathology symptoms. Gender moderated the relationship between physical abuse and EF, with physical abuse predicting poorer EF among males ($B = 0.30$), but not females ($B = -0.04$).
*Conclusions:* Overall, results indicate that general EF deficits are related to a history of childhood maltreatment, which is not accounted for by internalizing psychopathology symptoms. Potential implications and future directions are discussed.

## 1. Introduction

Childhood maltreatment is an underreported and relatively common occurrence that predicts negative outcomes in multiple domains of functioning throughout the lifespan, including emotional well-being and physical health (Arnow, 2004; MacMillan et al., 2001; Springer et al., 2007; Wegman & Stetler, 2009). Identifying specific factors that are adversely affected by childhood

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maltreatment is a critical endeavor, as these factors may uncover key processes that contribute to poorer long-term outcomes. One factor that may be an important consequence of childhood maltreatment is poor executive function (EF) – a critical risk factor for psychopathology that also plays a role in treatment responsivity (McLennan & Mathias, 2010; Mohlman & Gorman, 2005). Broadly, EF encompasses several related cognitive processes that help to effortfully guide behavior toward goals (Banich, 2009) and is strongly linked to the prefrontal cortex (Miller & Cohen, 2001). While the general structure of the prefrontal cortex is reached by early adolescence, maturational changes continue into young adulthood (early to mid-twenties; Romine & Reynolds, 2005), creating a prolonged window of vulnerability during which early stressors, such as childhood maltreatment, can adversely impact normative neurodevelopment processes that support EF.

Available evidence indicates that several EF processes are impaired among children and adolescents with a history of maltreatment (Biedermann et al., 2018; De Bellis et al., 2013; Fergusson et al., 2013; Lund et al., 2020). Results of studies examining EF impairment in adults with a history of childhood trauma history are less consistent than those with children, with some showing impaired EF and others showing no association (Feeney et al., 2013; Gould et al., 2012; Majer et al., 2010; Nikulina & Widom, 2013). A notable limitation of prior work that may contribute to inconsistencies in the literature is the use of single indicators of EF (e.g., Feeney et al., 2013; Majer et al., 2010). This is problematic because most neurocognitive tasks require several cognitive processes to perform (both EF and non-EF related), commonly referred to as the "task impurity problem" (Miyake et al., 2000). As a result, relationships between childhood maltreatment and EF may be obscured. One approach to addressing the task impurity problem is to create an EF variable(s) from multiple measures of EF processes, via methods such as latent factor modeling that capture variance that is common across multiple EF measures (Miyake et al., 2000; Snyder et al., 2015).

Although EF processes are separable, there is strong evidence of shared variance, or a common process across EF tasks (Friedman & Miyake, 2017; Madian et al., 2019; Miyake & Friedman, 2012). For example, Miyake and Friedman (2012) identified a "common EF" factor that subsumes inhibition, shifting and updating working memory. Madian et al. (2019) found that a single-factor model provided the best fit across nine EF measures. These and other studies proposed that common EF reflects proactive control of behavior, top-down biasing of attention, and active goal maintenance, which strongly depend on the activation of regions of the frontoparietal ("central executive") network. In contrast, processes that are not shared across EF tasks do not activate the frontoparietal network as strongly (Yarkoni & Braver, 2010). Given the relationship between "common EF" and frontoparietal network activity, it is plausible that childhood maltreatment may be detrimental for the development of cognitive control functions that are utilized across EF tasks.

Though not always considered in studies that assess the relationship between EF and childhood maltreatment, EF deficits are common in internalizing psychopathology, including mood (Snyder, 2013) and anxiety-related disorders (Aupperle et al., 2012; Leskin & White, 2007). Because a history of childhood maltreatment is a robust risk factor for internalizing psychopathology in adulthood (MacMillan et al., 2001; McLaughlin et al., 2010), it is important to identify whether EF deficits remain after accounting for psychopathology symptoms. If EF deficits are the result of current psychopathology, then the alleviation of psychopathology symptoms should improve EF in those with a history of childhood abuse. However, if deficits are not accounted for by psychopathology symptoms, then EF deficits themselves may be important targets of intervention.

The primary goal of the present study was to identify relationships between childhood maltreatment and EF among adults using a latent factor approach, which captures variance in behavioral performance that is shared across multiple EF tasks. It was hypothesized that a single-factor model would provide a good fit for the data (Madian et al., 2019), and that cumulative childhood maltreatment would predict poorer EF. Follow-up tests examined whether maltreatment subtypes (e.g., emotional neglect, physical abuse) uniquely predicted EF impairment. Additionally, the present study sought to identify whether relationships between cumulative childhood maltreatment, maltreatment subtypes, and EF would hold after controlling for current symptoms of depression, anxiety, or post-traumatic symptoms. A dimensional approach to measuring psychopathology was used based on evidence indicating that (a) psychopathology is well-captured by a dimensional approach (Hankin et al., 2005; Shankman et al., 2009), and (b) subthreshold symptoms that are not captured by a Diagnostic and Statistical Manual of Mental Disorders (DSM) diagnosis nonetheless impact functioning (Shankman et al., 2009). A measure of personality was also included to capture more persistent tendencies to experience mood and anxiety symptoms, as personality dimensions account for a significant portion of variance in psychopathology and related impairment (Conway et al., 2019).

The study also had two secondary aims. First, because females report higher rates of certain types of childhood maltreatment (specifically, sexual abuse; Briere & Elliott, 2003; Pereda et al., 2009) and some studies have identified gender differences in the impact of childhood maltreatment on outcomes (MacMillan et al., 2001), the present study explored whether gender moderated relationships between childhood maltreatment and EF. It was hypothesized that if gender differences emerged, they would be characterized by a greater impact of maltreatment on EF for females than males. Second, although there is evidence that individuals can accurately report on past experiences of abuse (Brewin et al., 1993; Goodman et al., 2003), there are concerns about the validity of retrospective reports of childhood maltreatment (Baldwin et al., 2019). To this end, the present study sought to assess the extent to which siblings' childhood maltreatment experiences were shared. Although this approach does not assess agreement regarding a given sibling's experience, it is a proxy measure of the validity of reported maltreatment, as maltreatment tends to "run in families" (e.g., as a result of family dynamics such as family culture, intergenerational transmission of abuse, and economic circumstances; Belsky, 1993; Straus, 1979).

## 2. Methods

### 2.1. Participants

Individuals were recruited as part of a larger family study of transdiagnostic mechanisms of internalizing psychopathology.

Participants were recruited from mental health clinics and the local community in a large midwestern city, and primary eligibility criteria included (1) age between 18 and 30 years old, and (2) having a biological sibling within the same age range who was interested in participating. Individuals were excluded if they were left-handed, could not read or write English, had a history of a head trauma with loss of consciousness, or had a personal or first-degree family member with a history of manic, hypomanic, or psychotic symptoms (for full method details, see Gorka et al., 2016; Kaiser et al., 2020; Weinberg et al., 2015). Although participants were not specifically recruited for the presence of DSM disorders, participants were oversampled for severe internalizing psychopathology using the Depression, Anxiety, and Stress Scale (DASS; Lovibond & Lovibond, 1995) during the initial phone screen. Overall, the sample had normally distributed DASS scores, but also had a higher average number of symptoms than the general population ($M = 23.6$, SD = 20.5 versus $M = 8.3$, SD = 9.8; Crawford et al., 2011).

### 2.2. Assessments and measures

#### 2.2.1. Childhood maltreatment

Childhood maltreatment was assessed using the self-report short-form version of the Childhood Trauma Questionnaire (CTQ), which has excellent psychometric properties in nonclinical and clinical samples (Bernstein et al., 2003; Bernstein & Fink, 1998). The CTQ assesses childhood and adolescent (i.e., before the age of 18) experiences of maltreatment in five domains: sexual abuse, physical abuse, emotional abuse, physical neglect, and emotional neglect (reverse scored). The CTQ domains are each assessed via five items on a five-point Likert scale from 1 (never true) to 5 (very often true), with higher scores reflecting more frequent and severe experiences of childhood maltreatment. The CTQ domain scores can be used as dimensional measures of childhood maltreatment and/or to classify maltreatment experiences categorically (e.g., "severe-to-moderate sexual abuse"). Additionally, CTQ domain scores can be summed together for a total maltreatment score.

Cronbach's alphas for the CTQ subscales ranged from 0.60 to 0.93 and was 0.89 for the full scale (see Supplemental Table S2 for all Cronbach's alphas). The observed internal consistencies for the physical neglect and physical abuse subscales (0.60 and 0.69, respectively) fell below the commonly accepted cutoff of 0.70 (Nunnally, 1978), which is in line with a previous large study of community participants (Scher et al., 2001). Relationships between items and the subscale total scores were examined to identify whether any items were driving the less than ideal internal consistency. For physical neglect, one item exhibited a small correlation with the total physical neglect score ($r = 0.22$; "My parents were too drunk or high to take care of the family"), whereas all other correlations were in the moderate-to-large range ($rs = 0.41$–$0.64$). For physical abuse, all items exhibited strong correlations with the total physical abuse score ($rs = 0.56$–$0.79$); thus, no single physical abuse item appeared to account for internal consistency less than 0.70.

#### 2.2.2. Inventory of depression and anxiety symptoms, expanded form (IDAS-II)

The IDAS-II (Watson et al., 2012) is a 99-item questionnaire that measures current symptoms of depression and anxiety-related disorders that includes ten subscales representing homogeneous symptom dimensions. Each item is rated on a 5-point Likert scale ranging from 0 (not at all) to 5 (extremely). In the present study, General Depression (with Well-Being items removed), Well-Being (reverse scored; referred to from here on as "Anhedonia"), and Panic, Social-Anxiety were included as internalizing psychopathology covariates. Additionally, Traumatic Intrusions and Traumatic Avoidance were included as a separate set of covariates. The observed internal consistencies were all in the acceptable range (General Depression: $\alpha = 0.91$, Well-Being: $\alpha = 0.86$, Panic: $\alpha = 0.80$, Social-Anxiety: $\alpha = 0.86$, Traumatic Intrusions: $\alpha = 0.75$, Traumatic Avoidance: $\alpha = 0.85$).

#### 2.2.3. Personality inventory for the DSM-5 (PID-5-Adults)

The PID-5 (Krueger et al., 2012) is an empirically derived measure that follows a dimensional model of personality and has high convergent validity with other well-established personality measures (Thomas et al., 2013; Wright & Simms, 2015). It includes 220 items that assess pathological personality traits across five domains and 25 facets. Each item is rated on a four-point Likert scale ranging from 0 (very false or often false) to 3 (very true or often true). In the present study, the Depressivity and Anxiousness facets were included as personality covariates, reflecting more persistent tendencies to experience internalizing symptoms. The observed internal consistencies were all in the acceptable range (Depressivity: $\alpha = 0.93$ and Anxiousness: $\alpha = 0.84$).

#### 2.2.4. Intelligence and motor speed

The Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) was used to estimate participants' full-scale IQ (FSIQ) and included as a covariate in the present study. During the WTAR assessment, participants are asked to pronounce 50 irregularly spelled words and scores reflect the number of words pronounced correctly. To estimate FSIQ from the WTAR scores, participants' raw scores were converted to a standard score (normed by age group), which were converted to predicted FSIQ scores that are co-normed with the Wechsler Adult Intelligence Scale, 3rd Edition. Scores on the WTAR are highly correlated with FSIQ ($r = 0.73$; Strauss et al., 2006). Motor speed was assessed using the motor speed condition of the Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001) Trail Making Test and was also included as a covariate to account for the potential impact of slowed reaction time on EF performance.

#### 2.2.5. Executive function

Performance on the following tasks from the D-KEFS were used to assess EF: Design Fluency, Verbal Fluency, Trail Making, and Color-Word Interference. Tasks were selected to (1) capture EF processes that are implemented across multiple EF domains (namely, shifting and inhibition), and (2) vary sufficiently in non-EF processes (e.g., verbal processing, visual spatial processing), thereby

enhancing our ability to statistically capture a "purer" latent EF factor (Snyder et al., 2015).

*2.2.5.1. D-KEFS design fluency.* There are three conditions in this task, the third of which assesses participants' ability to switch between two response sets. During the category switching condition, participants switch between connecting empty and filled dots with four straight lines as quickly as they can within 60 s. Participants are instructed not to repeat any designs. The dependent measure computed from this task was the total number of successful designs made during the category switching condition.

*2.2.5.2. D-KEFS verbal fluency.* There are three conditions in this task, the third of which assesses participants' ability to switch between two verbal response sets. During the category switching condition, participants switch between naming types of fruit and types of furniture as quickly as they can within 60 s. Participants are instructed not to repeat any items and to change to the other response category after each response. The dependent measure was the total number of successful switches made during the category switching condition.

*2.2.5.3. D-KEFS trail making.* There are five conditions in this task, the fourth of which assesses participants' ability to shift between two different response sets. During the number-letter switching condition, participants must switch between connecting numbers and letters in order. This condition is printed on two pages with numbers (1 through 16) and letters (A through P) that are contained within circles, and individuals are instructed to draw lines between the numbers and letters as quickly as they can starting at 1 and ending at P (e.g., 1-A-2-B, etc.). The dependent measure was the completion time for the number-letter sequencing condition multiplied by −1 for reverse-scoring, with more negative scores represent poorer shifting ability.

*2.2.5.4. D-KEFS color-word interference.* This task consists of four conditions, the third and fourth of which measure inhibition and inhibition/switching, respectively. During the inhibition condition, participants name the ink color of 50 consecutive words that are printed in an ink color that is incongruent with the word (e.g., the word "blue" is printed in red ink). Participants are instructed to say the ink color aloud as quickly as they can "without making mistakes," which requires overriding (i.e., inhibiting) the prepotent word-reading response. During the inhibition/switching condition, participants alternate between naming the ink color of the word and reading the word when cued. Participants must override the more automatic word-reading response during the color-naming trials, and, when prompted, inhibit an old rule and shift to a new rule (e.g., changing from word reading to color naming). The dependent measures were (1) time to complete the inhibition condition and (2) time to complete the inhibition/switching condition. These measures were multiplied by −1 for reverse-scoring, with more negative scores representing poorer EF.

## 2.3. Data analysis

### 2.3.1. Intraclass correlation coefficients (ICCs)

Intraclass Correlation Coefficients (ICCs) were computed for CTQ scores among sibling pairs ($n = 222$). Agreement between the sibling pairs was assessed with a one-way random effects model (ICCs [1,1]).

### 2.3.2. Confirmatory factor analysis (CFA)

A CFA was implemented using the lavaan R package (Rosseel, 2012) to identify whether a single-factor model provided a good fit for the EF data. Dependent variables from all the EF tests (Design Fluency, Verbal Fluency, Trails, Color-Word Inhibition, and Color-Word Inhibition/Switching) were included in the single-factor model. To account for sibling relationships in the model, siblings were randomly assigned to either be sibling 1 or 2 and a latent EF factor model was fit for each sibling group (EF 1 and EF 2) with manifest means, residual manifest variances, and cross-sibling manifest covariances constrained to be equivalent across sibling pairs. Participants without sibling data were also included by randomly assigning them to be sibling 1 or 2, with data for the missing sibling accounted for using full-information maximum likelihood (FIML) estimation.

The Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA) Index, and Standardized Root Mean Square Residual (SRMR) Index were used to assess model fit. Comparative Fit Index values closer to 1 indicate better fit, with values $\geq$0.95 considered to reflect a "good fit" (Hu & Bentler, 1999; West et al., 2012). Root Mean Square Error of Approximation values $\leq$0.06 are considered acceptable (Hu & Bentler, 1999), whereas values $\geq$0.10 reflect a poor fit (Browne & Cudeck, 1993). Standardized Root Mean Square Residual values $<$0.10 are indicative of acceptable fit and values $<$0.05 are indicative of good model fit (Hu & Bentler, 1999; Iacobucci, 2010; Kline, 2011; Schermelleh-Engel et al., 2003). Because each participant was randomly assigned to sibling groups to estimate the latent EF factor, which can suppress model fit estimates, model fit values were adjusted following Olsen and Kenny (2006).

### 2.3.3. Regression analyses

Factors weights from the best-fitting model were carried forward to linear mixed effects (LME) models using Matlab's fitlme function (The MathWorks, Inc., Natick, MA) to assess relationships between childhood maltreatment and EF. Separate regression models were implemented for (1) the childhood maltreatment total score, and (2) the five CTQ subtypes included in a single model to identify potential unique relationships between childhood maltreatment type and EF. In the first model, CTQ scores were summed together across all maltreatment domains (i.e., CTQ total), and in the latter model sexual abuse was dichotomized (coded as no sexual abuse history: CTQ sexual abuse score $< 6 = -1$ and sexual abuse history: CTQ sexual abuse score $\geq 6 = 1$) due to low dimensional

score variance, whereas physical abuse, emotional abuse, physical neglect, and emotional neglect were included as dimensional variables. To account for familial relation among sibling pairs, family was included as a random effects factor. All models covaried for predicted FSIQ and motor speed. Follow-up LMEs separately tested the incremental validity of relationships over and above (1) current internalizing symptoms as measured by the IDAS, (2) current traumatic intrusions and avoidance symptoms as measured by the IDAS, or (3) persistent tendencies to experience symptoms of depression and anxiety as measured by the PID-5. Symptoms of depression and anxiety, symptoms of trauma, and personality dimensions were examined separately to clarify whether the impact of childhood maltreatment on EF holds above symptoms that are related to internalizing symptoms versus trauma more specifically or personality features more broadly (the latter of which confer risk for multiple forms of psychopathology). Lastly, gender was included as a moderator to identify whether the impact of childhood maltreatment on EF differed for females and males.

## 3. Results

### 3.1. Sample demographics

Three-hundred and seven participants self-identified as female (63%), the average age of participants was 22.3 years (SD = 3.1), and the sample was racially/ethnically heterogeneous (42% self-identified as White (see Table 1). Means and standard deviations for the neuropsychological assessment (e.g., IQ, motor speed, shifting, inhibition) and psychopathology measures are reported in Table 1 (see Supplemental Table S1 for zero-order correlations between the psychopathology measures). Over half of participants had a lifetime history of an internalizing disorder (see Table 1). For a majority of the internalizing disorders, participants exhibited lifetime rates that were twice as high as national lifetime rates (Kessler et al., 1994), providing further evidence that participants were oversampled on internalizing psychopathology.

Participants' CTQ scores are provided in Table 2 (see Supplemental Table S2 for zero-order correlations between the CTQ subscales). Notably, CTQ scores were slightly higher than those of previous studies that assessed maltreatment within community samples (e.g., the CTQ Total scores for males and females were in the 75th percentile range of community norms; Scher et al., 2001). Based on established CTQ cutoff scores (see Bernstein et al., 2003), mild-to-severe childhood maltreatment was endorsed by 13%, 25%, 35%, 24%, and 30% of participants for sexual abuse (score $\geq$ 6), physical abuse (score $\geq$ 8), emotional abuse (score $\geq$ 9), physical neglect (score $\geq$ 8), and emotional neglect (score $\geq$ 10), respectively.

### 3.2. Childhood maltreatment questionnaire validity

As reported in Table 3, the ICCs for sibling agreement for total childhood maltreatment and the childhood maltreatment subscales were all significant. The ICCs ranged between 0.16 and 0.50, with all except sexual abuse falling between 0.30 and 0.50. Physical abuse yielded the highest degree of agreement between siblings (0.50).

### 3.3. Confirmatory factor analysis

The CFI, RMSEA, and SRMR values for the single-factor model were all in the good-to-acceptable range for the single-factor model (0.97, 0.08, and 0.04, respectively; correction applied)[1]. The association between the latent EF factor for sibling 1 and sibling 2 was significant ($r = 0.39$, $p < .001$), indicating moderate familiality of the latent EF factor. Factor weights from the single-factor model were carried forward to the regression analyses (see Fig. 1).

### 3.4. Linear mixed effects regression analyses

#### 3.4.1. Childhood maltreatment and executive function

Controlling for motor speed and IQ, greater cumulative childhood maltreatment predicted poorer EF in adulthood, $t(451) = -3.27$, $B = -0.15$, $p = .001$. Including the CTQ subscales as simultaneous predictors of EF in a multiple regression model revealed that only emotional neglect predicted a unique portion of variance in EF, $t(434) = -3.23$, $B = -0.18$, $p = .001$, while physical abuse was marginally significant, $t(434) = -1.95$, $B = -0.10$, $p = .052$ (see Table 4 for full results).

#### 3.4.2. Childhood maltreatment and executive function controlling for internalizing psychopathology

Controlling for motor speed, IQ, and current symptoms of depression and anxiety reported on the IDAS (general depression with well-being items removed, anhedonia, panic, and social anxiety), greater cumulative childhood maltreatment predicted poorer EF, $t(434) = -2.44$, $B = -0.11$, $p = .015$. Overall childhood maltreatment also remained a significant predictor of EF after controlling for current traumatic intrusions and avoidance symptoms, $t(436) = -2.30$, $B = -0.10$, $p = .022$, or more persistent tendencies to experience symptoms of depression and anxiety as measured by the PID-5, $t(434) = -2.20$, $B = -0.10$, $p = .028$. When the CTQ subscales

[1] An alternative two-factor model was tested, with the shifting-related dependent variables (Design Fluency, Verbal Fluency, Trails, and Color-Word Inhibition/Switching) included as indicators of factor 1 and the inhibition-related dependent variables included as indicators of factor 2 (Color-Word Inhibition and Color-Word Inhibition/Switching). Fit indices (CFI, RMSEA, and SRMR) for this two-factor model were below the good-to-acceptable range (0.94, 0.11, and 0.13; correction applied).

**Table 1**
Demographic, cognitive, and clinical characteristics.

| $N = 489$ | Mean (SD) |
|---|---|
| Age | 22.3 (3.1) |
| Gender | 63% female, 1% other |
| Ethnicity | White: 42%<br>Black/African American: 15%<br>Hispanic: 21%<br>Asian: 12%<br>Middle Eastern: 3%<br>Mixed: 6%<br>Other: 0.4%<br>No response: 0.6% |
| Predicted IQ (SS) | 105.6 (8.9) |
| Motor speed (RT) | 23.0 (8.7) |
| DKEFS DF (# of completed figures) | 9.7 (2.8) |
| DKEFS VF (# of successful switches) | 13.9 (2.9) |
| DKEFS trails (RT) | 63.6 (21.4) |
| DKEFS inhibition (RT) | 45.6 (10.3) |
| DKEFS inhibition switch (RT) | 52.8 (11.3) |
| IDAS subscales | |
| Depression (well-being items removed) | 31.7 (120) |
| Well-being (reverse-scored) | 25.3 (6.7) |
| Social anxiety | 9.5 (4.4) |
| Panic | 10.4 (3.5) |
| Traumatic intrusions | 5.7 (2.6) |
| Traumatic avoidance | 7.1 (3.6) |
| PID-5 Facets | |
| Depressivity | 0.36 (0.51) |
| Anxiousness | 1.10 (0.73) |
| Lifetime diagnosis of internalizing disorder (DSM-5) | |
| Major depressive disorder | 35.0% ($n = 171$) |
| Panic disorder | 8.2% ($n = 40$) |
| Social anxiety disorder | 20.4% ($n = 100$) |
| Specific phobia | 20.4% (n = 100) |
| Generalized anxiety disorder | 10.2% ($n = 50$) |
| Posttraumatic stress disorder | 6.7% ($n = 33$) |
| Obsessive compulsive disorder | 6.5% ($n = 32$) |
| Lifetime diagnosis of any internalizing disorder (DSM-5) | 55.2% ($n = 270$) |

*Note.* IQ = Intelligence Quotient; SS=Standard Scores; DKEFS=Delis-Kaplan Executive Function System; DF=Design Fluency; VF = Verbal Fluency; IDAS=Inventory of Depression and Anxiety Symptoms; PID-5 = Personality Inventory for DSM-5.

were included as simultaneous predictors, only emotional neglect accounted for a unique portion of variance in EF when controlling for motor speed, IQ, and either (1) current internalizing psychopathology symptoms, $B = -0.18$, (2) current trauma symptoms, $B = -0.19$, or (3) more persistent internalizing psychopathology symptoms, $B = -0.17$ (see Table 4 for full results)[2].

### 3.4.3. Childhood maltreatment, executive function, and gender

The inclusion of gender as a potential moderator of the relationship between the CTQ total score and EF did not reveal a significant CTQ total score × Gender interaction, $t(449) = -1.43$, $B = -0.08$, $p = .153$. To identify whether gender moderated the effect of any of the CTQ subscales on EF, each CTQ subscale was simultaneously entered into a multiple regression LME model with gender as a moderator. The main effect of emotional neglect remained, $t(432) = -3.27$, $B = -0.18$, $p = .001$, with no main effects of gender or other CTQ subscales. There was, however, a significant Physical Abuse × Gender interaction, $t(432) = -2.50$, $p = .013$. As shown in Fig. 2, higher levels of childhood physical abuse predicted poorer EF among males, $t(149) = -3.19$, $B = -0.30$, $p = .002$, but not females, $t(277) = -0.54$, $B = -0.04$, $p = .587$.

Finally, we examined whether the interaction between physical abuse and gender held after controlling for motor speed, IQ, and either current internalizing symptoms, current trauma symptoms, or more persistent internalizing symptoms. For all three tests, the Physical Abuse × Gender interaction remained significant, $t(428) = 2.51$, $p = .012$, $t(430) = 2.62$, $p < .001$, and $t(428) = 2.48$, $p = .013$, respectively – for the models controlling for (1) internalizing symptoms, males: $B = -0.30$, females: $B = -0.03$; (2) trauma

[2] Exploratory analyses were implemented to assess whether childhood maltreatment or maltreatment subtypes uniquely predict EF impairment after controlling for the tendency to exhibit externalizing-related symptoms. Controlling for motor speed, IQ, and more persistent tendencies to exhibit externalizing-related behaviors (as measured by Impulsivity, Risk-taking, and Hostility on the PID-5), greater cumulative childhood maltreatment predicted poorer EF, $t(433) = -2.77$, $B = -0.13$, $p = .006$. When the CTQ subscales were included as simultaneous predictors, emotional neglect accounted for a unique portion of variance in EF, $t(429) = -3.01$, $B = -0.17$, $p = .003$.

**Table 2**
Childhood maltreatment characteristics.

| N = 489 | Mean (SD) | Range | % Mild | % Moderate-to-severe |
|---|---|---|---|---|
| CTQ Total (full sample) | 35.8 (11.0) | 25–102 | – | – |
| Males | 35.1 (9.1) | | – | – |
| Females | 36.2 (11.9) | | – | – |
| CTQ SA(full sample) | 5.8 (2.9) | 5–25 | 5 | 8 |
| Males | 5.3 (1.5) | | 5 | 3 |
| Females | 6.1 (3.4) | | 5 | 11 |
| CTQ PA (full sample) | 6.6 (2.4) | 5–25 | 17 | 8 |
| Males | 6.6 (2.0) | | 15 | 8 |
| Females | 6.7 (2.6) | | 18 | 9 |
| CTQ EA (full sample) | 8.3 (3.8) | 5–25 | 22 | 13 |
| Males | 8.3 (3.3) | | 22 | 9 |
| Females | 8.5 (4.1) | | 22 | 15 |
| CTQ PN (full sample) | 6.6 (2.4) | 5–17 | 13 | 11 |
| Males | 6.7 (2.3) | | 14 | 12 |
| Females | 6.5 (2.4) | | 13 | 11 |
| CTQ EN (full sample) | 8.5 (4.0) | 5–25 | 21 | 9 |
| Males | 8.6 (4.0) | | 19 | 10 |
| Females | 8.5 (4.0) | | 22 | 9 |

Note. CTQ = Childhood Trauma Questionnaire, SA = Sexual abuse; PA = Physical abuse, EA = Emotional abuse, PN=Physical neglect, EN = Emotional neglect.

**Table 3**
Intraclass correlation coefficients for agreement of siblings' reported childhood maltreatment.

| | CTQ total | CTQ SA | CTQ PA | CTQ EA | CTQ PN | CTQ EN |
|---|---|---|---|---|---|---|
| ICC(1) | 0.40 | 0.16 | 0.50 | 0.34 | 0.31 | 0.30 |
| F-test [222,222] | $F = 2.35$, $p < .001$ | $F = 1.38$, $p = .009$ | $F = 3.03$, $p < .001$ | $F = 2.01$, $p < .001$ | $F = 1.89$, $p < .001$ | $F = 1.85$, $p < .001$ |
| 95% CI | 0.286 < ICC < 0.507 | 0.028 < ICC < 0.284 | 0.399 < ICC < 0.596 | 0.213 < ICC < 0.446 | 0.185 < ICC < 0.423 | 0.173 < ICC < 0.413 |

*Note.* CTQ = Childhood Trauma Questionnaire, SA = Sexual abuse, PA = Physical abuse, EA = Emotional abuse, PN=Physical neglect, EN = Emotional neglect.

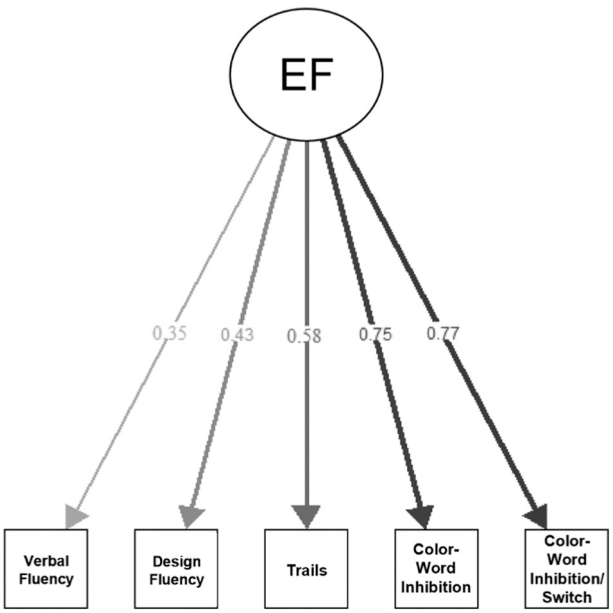


**Fig. 1.** Latent factor model of executive function (EF).

**Table 4**
Linear regression results for childhood maltreatment predicting executive function.

| DV: | CTQ total |
|---|---|
| EF (model 1) | $B$ = -0.11, $p$ = .015 |
| EF (model 2) | $B$ = -0.10, $p$ = .022 |
| EF (model 3) | $B$ = -0.10, $p$ = .028 |

| DV[a] | CTQ SA | CTQ PA | CTQ EA | CTQ PN | CTQ EN |
|---|---|---|---|---|---|
| EF (model 1) | $B$ = 0.00, $p$ = .914 | $B$ = -0.10, $p$ = .051 | $B$ = 0.09, $p$ = .123 | $B$ = 0.03, $p$ = .530 | $B$ = -0.18, $p$ = .003 |
| EF (model 2) | $B$ = 0.00, $p$ = .983 | $B$ = -0.10, $p$ = .058 | $B$ = 0.10, $p$ = .068 | $B$ = 0.04, $p$ = .428 | $B$ = -0.19, $p$ < .001 |
| EF (model 3) | $B$ = 0.01, $p$ = .891 | $B$ = -0.10, $p$ = .051 | $B$ = 0.10, $p$ = .099 | $B$ = 0.04, $p$ = .447 | $B$ = -0.17, $p$ = .002 |

Covariates
Model 1: IQ, motor speed, IDAS General Depression, Well-being (reverse-scored), Social Anxiety, and Panic
Model 2: IQ, motor speed, IDAS Trauma Intrusions, and Trauma Avoidance
Model 3: IQ, motor speed, PID-5 Depressivity and Anxiousness

Note. CTQ = Childhood Trauma Questionnaire, SA = Sexual abuse, PA = Physical abuse, EA = Emotional abuse, PN=Physical neglect, EN = Emotional neglect.
[a] CTQ subscales were entered as simultaneous predictors at predicting EF.

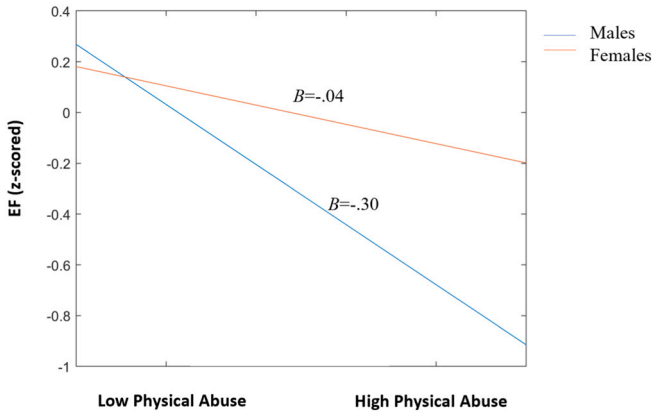


**Fig. 2.** Depiction of the childhood physical abuse × gender interaction predicting executive function

symptoms, males: $B$ = -0.30, females: $B$ = -0.04; and (3) more persistent internalizing psychopathology symptoms, males: $B$ = -0.30, females: $B$ = -0.03.

## 4. Discussion

As hypothesized, EF was well-captured by a single-factor model and greater cumulative childhood maltreatment predicted poorer EF in adulthood. Furthermore, the significant impact of childhood maltreatment on EF in adulthood remained after controlling for IQ, motor speed, dimensions of internalizing psychopathology (including trauma), or persistent tendencies to experience general depression and anxiety (i.e., personality features). Thus, the effects of childhood maltreatment on EF do not appear to be the result of as association between current internalizing psychopathology and EF. Taken together, results indicate that there is a unique impact of cumulative childhood maltreatment on EF in adulthood, at least among adults unselected for the presence of childhood maltreatment.

The finding that childhood maltreatment predicted poorer EF in adulthood has several implications. First, EF has been identified as a risk factor for future psychopathology symptoms (Dickson et al., 2017; Letkiewicz et al., 2014; Rudolph et al., 2018; Snyder & Hankin, 2016). For example, poorer observer-reported EF predicted greater depressive symptoms among adolescent girls over two years (Rudolph et al., 2018). In a study of adults, EF deficits were found to predict higher levels of rumination, which, in turn, predicted increases in depressive symptoms across two weeks (Dickson et al., 2017). Thus, poorer EF in adulthood that related to childhood maltreatment could contribute to the emergence of psychopathology. Second, EF has been identified as a factor that affects treatment response (Dunkin et al., 2000; Mohlman & Gorman, 2005), and individuals with a history of childhood maltreatment and concomitant EF impairment may respond more poorly to treatments. Strategies that target or aim to rehabilitate or compensate for disrupted EF processes among individuals with a history of childhood maltreatment may be needed to help to normalize, or at least enhance, EF.

The present study also examined which specific aspect of childhood maltreatment may connote unique risk for EF deficits – an important, albeit difficult question to test given the high degree of covariation between the different aspects of childhood maltreatment (see Table S2 and Scher et al., 2004). Results revealed that only emotional neglect was uniquely related to poorer EF. Typically

examined in combination with physical neglect, previous work has found that neglect negatively affects adolescent and adult EF processes, including inhibition (Gould et al., 2012) and global self-reported EF (Sheridan et al., 2017), separately from the effects of abuse. Neuroanatomical correlates of this effect have also been explored. For example, greater emotional neglect has been found to predict reduced gray matter volume of the left dorsolateral prefrontal cortex (dlPFC), a key region within the frontoparietal/central executive network (Chen et al., 2013; Sherman et al., 2014), and this effect remained after controlling for depression. Notably, left dlPFC activity in particular supports "common" EF processes, such as imposing a task set and goal maintenance (Banich et al., 2000) and anodal neurostimulation of this region via transcranial direct current stimulation improves EF performance (Dubreuil-Vall et al., 2019).

Although previous and present results highlight an important relationship between childhood emotional neglect and EF, relative to other forms of maltreatment, the impact of emotional neglect has been understudied (Glaser, 2002; Stoltenborgh et al., 2013). Future work should further assess the impact of this form of maltreatment on EF and identify mechanism(s) through which childhood emotional maltreatment contributes to poorer EF in adulthood. One route through which emotional maltreatment affects EF is via dysregulated emotional reactivity. Caregiver responsivity to children's needs and emotions is critical in helping children learn to identify and regulate their emotions (McLaughlin et al., 2017), and emotional deprivation may result in aberrant reactivity and stress responses that negatively impact neurocognitive development (Carrion & Wong, 2012; Teicher et al., 2003). In line with this possibility, childhood emotional neglect predicts greater amygdala reactivity to threating stimuli (Maheu et al., 2010) and atypical cortisol secretion in adulthood (van der Vegt et al., 2009).

In contrast to emotional neglect, the impact of physical abuse on EF was moderated by gender. Specifically, greater physical abuse predicted poorer EF among males, but not females. This finding may be attributable to characteristics of physical abuse that differ for males and females, such as earlier age of physical abuse/assault (Dansky et al., 1996; though see Briere & Elliott, 2003). Given that the reliability (internal consistency) of the physical abuse subscale was just below the acceptable level, this result should be interpreted somewhat cautiously and assessed further in future studies.

A limitation of the present study is the use of retrospective self-reported childhood maltreatment. Concerns have been raised about individuals' ability to accurately report on events, especially more distal events that occurred during childhood. Importantly, the present study examined the validity of these retrospective assessments by testing whether CTQ reports "ran in families." While the reported significant familial effects do not confirm the accuracy of childhood maltreatment, it does support the validity of the maltreatment assessment as familial associations has long been used as a "validator" in psychopathology research (Kaiser et al., 2020; Kendler et al., 2000). Nevertheless, in future studies, multiple forms of assessment should be used to provide further support for the present findings.

Despite the limitation of self-report, the study also had several strengths, including (a) the use of several EF tasks per EF process (rather than single measures), (b) a large sample size that allowed for the application of latent factor modeling, (c) the inclusion of sibling pairs that allowed for the assessment of sibling agreement in childhood maltreatment experiences, (d) the recruitment of a sample that was overrepresented on internalizing psychopathology symptoms, and (e) covarying for important confounds such as current internalizing psychopathology and psychomotor speed. Overall, results suggest that early maltreatment has a negative impact on EF in adulthood that is not accounted for by current internalizing psychopathology symptoms, which is similar to previous results with undergraduates (Letkiewicz et al., 2020). Future work should further assess the relationship between childhood maltreatment and EF in adulthood, examine whether relationships between childhood maltreatment and EF hold above externalizing psychopathology, and identify the impact of EF deficits related to maltreatment on psychopathology risk and treatment outcomes.

## Declaration of competing interest

None.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chiabu.2021.105140.

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