Childhood Adversity and Cognition in Marginally Housed Young Adults

by

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Abstract

Young people who are marginally housed have elevated rates of numerous adverse outcomes, including cognitive deficit, psychiatric illness, substance use and premature mortality. Childhood adversity is also elevated in marginally housed youth but its relationship to cognition in this population is understudied. Furthermore, there is a paucity of research on potentially crucial moderators of the impact of childhood adversity on cognition, such as developmental timing of the adversity. Using a sample (*N* = 122) of marginally housed young adults (age 19-29 years), the present study examined associations between childhood adversity (physical abuse, sexual abuse, foster care, residential mobility and adverse home environment) and adulthood cognitive (memory and inhibitory control) and psychosocial functioning. We also examined associations between age at which physical or sexual abuse occurred and cognition and regional brain volumes (hippocampus and dorsolateral prefrontal cortex [DLPFC]) in adulthood. We found significantly elevated rates of childhood physical (48 percent) and sexual abuse (34 percent) and foster care placement (27 percent), as well as high residential mobility (an average of 5 changes in residence throughout childhood) in this sample. While the sample as a whole demonstrated low cognitive and psychosocial functioning compared to normative levels, select adversities were associated with relatively higher cognition and psychosocial functioning. Although participants with these adversities still presented with cognition and psychosocial functioning that was below normative levels, physical abuse was associated with relatively higher memory, sexual abuse with relatively higher psychosocial functioning, and residential mobility with relatively higher inhibitory control and psychosocial functioning. Foster care was associated with lower memory and psychosocial functioning. Physical or sexual abuse that occurred at age 6 was linked with better memory and inhibitory control, while age of abuse was not associated with volumes of the hippocampus or DLPFC. In follow-up analyses, higher residential mobility was associated with fewer neurological soft signs. We tentatively suggest that these results may reflect differential developmental trajectories within the heterogenous population of marginally housed youth. Individuals with higher childhood adversity may represent a more neurodevelopmentally typical group, while those with lower childhood adversity may present with higher rates of neurodevelopmental aberrations which impact cognitive development.

Keywords: marginal housing; youth; cognition; childhood adversity

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Chapter 1. Introduction

1.1. Homelessness and marginal housing in youth

Homelessness and marginal housing represent a major societal problem, with at least 235,000 Canadians experiencing homelessness or marginal housing annually (Gaetz, Dej, et al., 2016). Homelessness typically refers to being unsheltered (i.e., living in spaces not intended for human habitation, such as sidewalks, parks, or vehicles), while marginal housing includes accommodations that are unstable, temporary in nature, or in substandard condition, such as shelters, transitional housing, or motels (Gaetz et al., 2012). In practice, these two categories are not completely discrete as many individuals alternate between absolute homelessness and marginal housing (Hwang et al., 2011). The homeless and marginally housed population represents a particularly vulnerable sector of society, with high rates of numerous mental and physical health conditions and a high mortality rate (Fazel et al., 2014; Hwang et al., 2009; Jones et al., 2015; Vila-Rodriguez et al., 2013). The prevalence of substance dependence is strikingly high, as are the rates of psychiatric illness, with psychotic illness affecting nearly half, followed by mood and anxiety disorders (Vila-Rodriguez et al., 2013). Physical illnesses, particularly viral infections including human immunodeficiency virus (HIV) and hepatitis C (HCV), are also common (Vila-Rodriguez et al., 2013). Many individuals experience multimorbidity of substance dependence, mental illness and physical illness, highlighting the complex treatment needs of this population (Vila-Rodriguez et al., 2013). Premature mortality is another well-established factor associated with homelessness and marginal housing (Hwang et al., 2009; Jones et al., 2015). The mortality rate in marginally housed individuals has been estimated as approximately 8 times higher than expected in age- and sex-matched housed adults (Jones et al., 2015). Significantly, much of this premature mortality is attributed to treatable illnesses, such as HCV infection and psychosis (Jones et al., 2015).

Teens and young adults (hereafter collectively referred to as youth[1]) comprise approximately twenty percent of the homeless and marginally housed population in

[1] The specific age ranges used to define youth vary across the studies summarized in the following paragraphs, but typically include the later teen years and/or young adults in their 20s with varying cut-off ages.

Canada (Gaetz et al., 2014). These individuals represent a unique subgroup of the homeless and marginally housed population. Youth is a key developmental period in which individuals acquire skills necessary for adult functioning (Fry et al., 2017). Homeless and marginally housed youth, however, have often faced adversity from an early age. Many first experienced homelessness before the age of 16, and 9 percent had their first homeless episode before age 13 (Gaetz, O'Grady, et al., 2016). Unstable family environments and high family conflict are often reported (Brakenhoff et al., 2015). Experiences of childhood abuse are also common, with estimated rates of physical and sexual abuse as high as 63 and 52 percent, respectively (Mar et al., 2014). Over half of marginally housed youth report previous involvement with child protection services, and for approximately one-third this involvement began at a very young age, before 6 years old (Gaetz, O'Grady, et al., 2016). School drop-out rates in Canadian marginally housed youth are estimated around 50 percent, compared with the Canadian national average of 9 percent (Gaetz, O'Grady, et al., 2016). In prospective studies, poor family relationships, single-parent homes, parental work limitations and lower educational attainment are predictive of homelessness, highlighting the role of early life adversity in a youth's pathway into homelessness (Brakenhoff et al., 2015; Shelton et al., 2009; van den Bree et al., 2009).

Once youth have become homeless or marginally housed, they are at high risk for inadequate healthcare and premature mortality (Auerswald et al., 2016; Barbic et al., 2018; Gaetz, O'Grady, et al., 2016). The mortality rate for homeless and marginally housed youth is striking. One study of homeless youth in San Francisco estimated the mortality rate as 10 times higher that of the age-matched general population, with most deaths attributed to suicide or substance use (Auerswald et al., 2016). In a Canadian sample, the mortality rate for marginally housed young adults was estimated at 18 times higher than the Canadian mortality rate for this age group (Barbic et al., 2018). Despite the high prevalence of mental health concerns in this population, nearly 30 percent report that their mental health needs are not being met (Barbic et al., 2018). Thus, homeless and marginally housed youth are a particularly disadvantaged group, whose early life adversity is compounded by further adversity once living on the streets.

Homeless and marginally housed youth have been identified as a key priority for several Canadian communities in recent years (Gaetz, Dej, et al., 2016). Effective policy development is hampered, however, by a lack of rigorous research evaluating strategies

for addressing youth homelessness and marginal housing (Morton et al., 2020; Wang et al., 2019). Nevertheless, an emerging body of literature suggests that individual and family therapy leads to improvements in mental health and substance use outcomes in homeless youth, and housing programs, such as the Canadian At Home/Chez Soi program, are associated with increased housing stability (Kozloff et al., 2016; Morton et al., 2020; Wang et al., 2019). Other interventions, such as case management, motivational interviewing and employment programs, have shown inconclusive effects (Morton et al., 2020; Wang et al., 2019). Given the complex presentation of homeless and marginally housed youth, scholars have highlighted the need for interventions that are individually tailored and address the personal needs and circumstances of the individual being treated (Wang et al., 2019). Furthering our understanding of the characteristics of homeless and marginally housed youth will help with this aim. In a recent review examining cognitive deficit, psychopathology and substance use in homeless and marginally housed youth, the authors observed a notable gap in the literature in terms of understanding the cognitive functioning in this population (Burke et al., 2022).

1.2. Cognitive impairment in homeless and marginally housed youth

An emerging research literature indicates that cognitive impairment is a significant challenge faced by homeless and marginally housed youth (Fry et al., 2017; Saperstein et al., 2014; Waclawik et al., 2019), one that has substantial consequences for daily functioning. For example, one study documented the prevalence of cognitive deficits in homeless young adults at 63 percent (Saperstein et al., 2014). Previous work by our group similarly demonstrated mild cognitive impairment in 40 percent of the sample, and moderate-severe impairment in a further 16 percent (see Figure 1; Waclawik et al., 2019). In marginally housed young adults referred for neuropsychological testing for suspected cognitive impairment, cognitive impairment rates were as high as 80 percent (Barone et al., 2019). Across these studies, the most commonly impaired domains comprised verbal memory, executive functions, attention, working memory and processing speed, (Barone et al., 2019; Saperstein et al., 2014; Waclawik et al., 2019). These high rates of cognitive impairment are likely to have significant consequences for psychosocial functioning, which is also impaired in marginally housed young people (Barbic et al., 2018; Barone et al., 2019). In one study, homeless young adults with cognitive impairment were less likely to earn a livable wage than their counterparts without cognitive impairment (Saperstein et al., 2014). In a sample of homeless adolescents, poorer executive functioning was associated with increased risk of remaining homeless over a six-month period, while those with better executive functioning were more likely to obtain housing (Fry et al., 2019).

Despite the high prevalence and functional significance of cognitive impairment in this vulnerable population, there is a notable paucity of studies elucidating risk factors for cognitive impairment in marginally housed youth. Several risk factors have been identified in marginally housed samples that were on average middle-aged, including chronic substance use, traumatic brain injury (TBI) and HIV (e.g., Gicas et al., 2014, 2017, 2020). However, many of these factors are greatly reduced or relatively absent in younger marginally housed populations (Barbic et al., 2018). In contrast, one of the few prior studies utilizing a young adult sample of marginally housed individuals

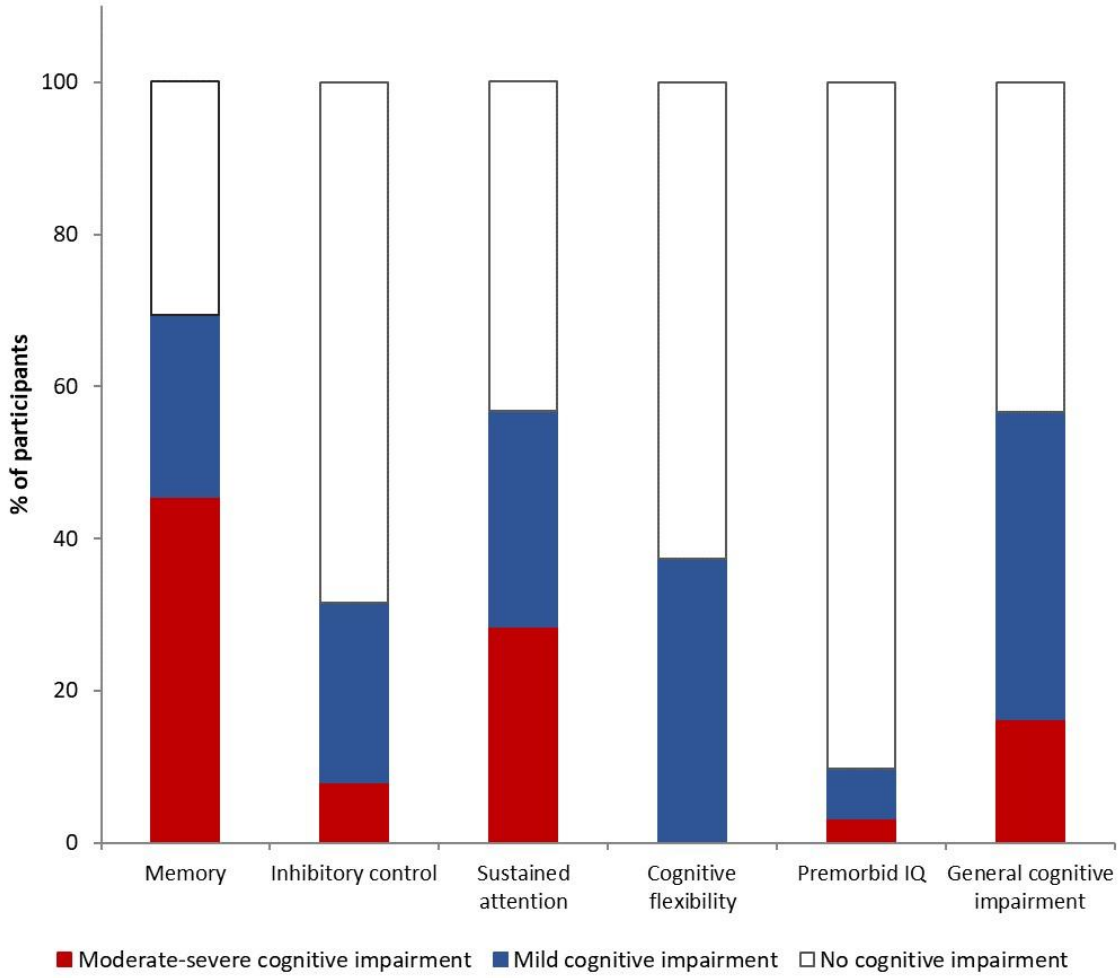


Figure 1. Rates of cognitive impairment in marginally housed youth (from Waclawik et al., 2019).

demonstrated that developmental factors, including neurological soft signs (an indicator of nonspecific neurodevelopmental abnormalities; Breslau et al., 2000), predicted cognitive impairment. In this study, most current health factors, including substance dependence and viral infection, were not associated with cognitive impairment (Waclawik et al., 2019), in contrast to findings in middle-aged samples (Gicas et al., 2014, 2017, 2020). These results suggest that developmental factors may be particularly relevant to an understanding of cognitive functioning in younger marginally housed samples, but to date there has been limited research on this issue and the prior report (Waclawik et al., 2019) explored a limited selection of developmental and

childhood factors. Childhood adversity, for example, has not been examined in relation to cognition in marginally housed youth, despite its high prevalence in this population.

1.3. Childhood adversity and cognition

Childhood adversity is a term which encompasses a range of negative experiences including abuse and neglect (often collectively referred to as maltreatment), caregiving disruptions such as foster care placement, and negative household factors such as witnessing domestic violence, parental substance use or mental illness (Kalmakis & Chandler, 2014). Previous studies have documented that marginally housed young people have high rates of childhood adversity. In a sample of Canadian homeless young people, Mar et al. (2014) found high rates (52-69%) of five types of maltreatment: sexual abuse, physical abuse, emotional abuse, physical neglect and emotional neglect. In a meta-analysis of childhood adversity rates in homeless adults living in Western countries, Sundin and Baguley (2015) documented prevalence of 37 percent for physical abuse and 32 percent for sexual abuse. History of foster care placement has been reported as high as 30 percent in homeless youth (Bender et al., 2015). In contrast, in the general Canadian population, the prevalence of childhood physical and sexual abuse is estimated at 22 and 6 percent, respectively (Cotter, 2019), and foster care placement is approximately 0.6 percent (Ministry of Children and Family Development, 2019). Childhood adversity may be particularly relevant in young marginally housed populations, as it is a risk factor for younger age at entry into homelessness (Mar et al., 2014), and is more frequently cited as a cause of homelessness in young compared to middle-aged populations (Whitbeck & Simons, 1993).

A large body of research has documented that a history of childhood adversity is associated with reduced cognitive functioning. This effect has been found in general as well as psychiatric populations, although the link between childhood trauma and cognition in psychiatric populations has received relatively less research attention (as noted by others, e.g., Begemann et al., 2016; Masson et al., 2016; Velikonja et al., 2020). In children who have been exposed to adversity, impairments of a moderate to large effect size have been documented in memory, executive functioning, processing speed, visuospatial skills, working memory and intelligence (Kavanaugh et al., 2017; Masson et al., 2015; Malarbi et al., 2017; Pechtel & Pizzagalli, 2011). The effects of

childhood adversity on cognition appear to persist into adulthood, indicating that childhood adversity has long-lasting impacts on cognitive development. Several meta-analyses and systematic reviews have consistently documented that a history of childhood adversity is associated with reduced cognitive functioning in adulthood (J. B. Goodman et al., 2018; Hedges & Woon, 2011; Lund et al., 2022; Masson et al., 2015; Pechtel & Pizzagalli, 2011). A meta-analysis of adult survivors of childhood maltreatment without psychiatric diagnosis documented that maltreatment was associated with lower overall cognition, executive functioning, verbal memory, attention, working memory and processing speed, with effect sizes in the small to moderate range (Masson et al., 2015). Recent large-scale, nationally representative studies have provided further evidence for the association between childhood adversity and reduced adulthood cognition. Danese et al. (2017) reported on two large-scale studies in the United Kingdom and New Zealand for a total of approximately 3,000 participants and found that a history of childhood adversity (including physical and sexual abuse, neglect, witnessing of domestic violence, and bullying) was associated with lower intellectual functioning, verbal memory, executive functions, and processing speed in both young and mid-adulthood (Danese et al., 2017). In their nationally representative sample of over 12,000 participants in the United States, Hawkins et al. (2021) documented that a history of childhood neglect was associated with reduced working memory and verbal memory and childhood sexual abuse with poorer verbal memory in adulthood.

Studies that have included or focused exclusively on psychiatric samples have similarly found poorer adulthood cognition in those with a history of childhood adversity. However, there is some evidence to suggest that the effect of childhood adversity on cognition is smaller in psychiatric than general populations. In one meta-analysis including children and adults with psychiatric diagnosis, history of abuse or neglect was associated with impairments of a small to moderate effect size in working memory, verbal memory, intelligence and processing speed (R.-Mercier et al., 2018). These authors noted that, although childhood adversity was associated with lower overall cognition, the effect size in the psychiatric population was smaller than that in a prior meta-analysis utilizing non-psychiatric samples (Masson et al., 2015; R.-Mercier et al., 2018). Vargas et al. (2019), in their meta-analysis, found that childhood abuse and neglect were associated with lower overall cognition, executive functioning, verbal and visual memory, processing speed and attention in both adults with psychotic disorder

and in non-psychiatric controls, although the effect size was stronger in the non-psychiatric controls. The effect of childhood adversity in psychiatric samples may be smaller due to non-adversity related cognitive deficit already present in this population (R-.Mercier et al., 2018; Vargas et al., 2019). Other work, however, has documented similar magnitude of effect for psychiatric and non-psychiatric samples. In their meta-analysis, Goodman et al. (2018) documented that childhood adversity (abuse, neglect, bullying and adverse family environment) was related to lower adulthood working memory, and the effect was of a similar magnitude across both clinical and non-clinical samples.

Despite the ample body of evidence documenting that childhood adversity is associated with reduced cognition in adulthood, a handful of studies have found that those with a history of childhood adversity evidenced relatively higher cognition, compared to those without such a history. In a large, nationally representative sample of young adults, Dunn et al. (2016) found that the direction of the relationship between childhood abuse and cognition depended upon the type of abuse, the age at which abuse occurred, and the cognitive domain. Specifically, they found better verbal memory among those exposed to physical abuse compared to unexposed participants, which appeared to be driven by higher verbal memory among those first exposed to abuse during late childhood (Dunn et al., 2016). They further found that, compared to unexposed participants, those first exposed to sexual abuse in early childhood had better working memory; however, those first exposed to sexual abuse in adolescence had lower working memory (Dunn et al., 2016). In an Irish nationally representative study of older adults, a history of childhood sexual abuse was associated with better global cognition and verbal memory relative to those without childhood sexual abuse (Feeney et al., 2013).

In a small community sample (*N* of 30) of adults with first episode psychosis, those with a history of childhood abuse or neglect had higher premorbid IQ than those without such a history, and a greater decline from premorbid to current IQ (Campbell et al., 2013). However, after accounting for premorbid IQ, childhood maltreatment was associated with lower performance on measures of semantic fluency, visual memory and visuospatial working memory (Campbell et al., 2013). Velikonja et al. (2020) tested a large sample of teens and young adults at clinical high risk for psychosis and found a trend for better overall cognitive performance for those with a history of childhood

psychological abuse and emotional neglect than those without. In a sample of patients with major depression recruited from an outpatient clinic, Dannehl et al. (2017) found that some types of adversity were associated with better cognition while others were associated with lower cognition; emotional abuse predicted better executive functioning, while physical abuse was associated with lower executive functions and physical neglect with lower verbal learning. It is important to note that, with the exception of Campbell et al. (2013), these studies did not describe normative scores of abused and non-abused groups, raising questions about the clinical significance of the differences. Campbell et al. (2013) reported premorbid IQ within the average range for both abused and non-abused participants, despite relatively higher premorbid IQ in the group with a history of abuse.

Various explanations have been proposed for these anomalous results. Some scholars (e.g., Dannehl et al., 2017; Dunn et al., 2016; Feeney et al., 2013) have proposed that childhood adversity leads to enhanced vigilance and arousal, resulting in increased cognitive performance. In their psychiatric samples, however, Campbell et al. (2013) and Velikonja et al. (2020) propose a different explanation. These authors posit that their findings may be explained by divergent pathways into psychosis. In one pathway, childhood adversity acts as a risk factor for the development of psychosis and also impacts cognitive development, while the second pathway is characterized by a greater neurodevelopmental/genetic vulnerability for the development of psychosis which leads to relatively greater cognitive deficit (Campbell et al., 2013; Velikonja et al., 2020). To our knowledge, these various hypotheses have not been directly tested. While the bulk of the evidence indicates that childhood adversity is associated with reduced cognition, the small number of studies finding the opposite effect suggest that the relationship between childhood adversity and cognition may be nuanced, particularly in complex populations such as those with psychiatric illness.

Despite the ample evidence for the association between childhood adversity and reduced cognition, important gaps in the literature remain. Potentially crucial moderators of the effect have received less research attention. Timing of childhood adverse events may be a particularly relevant moderator, as several scholars have theorized that there may be sensitive periods for the effects of childhood adversity on cognition (Lupien et al., 2009; Masson et al., 2015; Teicher & Samson, 2016). This hypothesis is motivated by the literature on brain development, which documents distinct developmental

trajectories for different brain regions closely associated with cognition (Paquola et al., 2016; Pechtel & Pizzagalli, 2011; Teicher et al., 2016). Specifically, the hippocampus, which plays a key role in memory functions (Dickerson & Eichenbaum, 2010), develops primarily during the early years of life and is close to adult volumes by 4 years of age (Gogtay et al., 2006). Thus, the hippocampus and, by extension, memory abilities, may be particularly vulnerable to the effects of adversity early in life (Andersen & Teicher, 2008). In contrast, the prefrontal cortex is known to undergo protracted development, reaching peak volume in late childhood and early adolescence and subsequently undergoing a prolonged period of synaptic pruning and continued myelination (Giedd & Rapoport, 2010; Konrad et al., 2013). In particular, the dorsolateral prefrontal cortex (DLPFC) is among the latest areas to mature (Giedd et al., 2012; Giedd & Rapoport, 2010; Gogtay et al., 2004), and notably is also one of the prefrontal regions most consistently linked to childhood maltreatment history (Teicher & Samson, 2016). Moreover, cognitive components thought to be tightly linked to the DLPFC, including inhibitory control (Breukelaar et al., 2017; Egner & Hirsch, 2005; Gbadeyan et al., 2016) and working memory (Petrides, 2000), are among those affected by childhood adversity (Dunn et al., 2016; Navalta et al., 2006). Thus, given the protracted development of the prefrontal cortex, in particular the DLPFC, adolescence has been posited as a sensitive period for the effects of child adversity on prefrontal cortex and related executive functions (Andersen et al., 2008; Pechtel & Pizzagalli, 2011).

To date, however, there has been limited research testing the hypothesis of sensitive periods for childhood adversity on cognition and brain volume outcomes. Indeed, recent meta-analyses have noted the lack of studies that include age at onset of adversity, highlighting a significant limitation of the existing literature (Masson et al., 2015; Matte-Landry et al., 2022). Nevertheless, the limited existing literature has supported the hypothesis of sensitive periods for cognition and regional brain volumes. In a sample of adolescents, Humphreys et al. (2018) reported that severity of early life adverse events (5 years or earlier) was more strongly linked to reduced hippocampal volume than severity of adverse events in later childhood (6 years or later). Similarly, in adult women, Andersen et al. (2008) found that sexual abuse in early childhood (aged 3-5 years) and, to a lesser degree, middle childhood (11-13 years old) was associated with reduced hippocampal volume, while abuse in adolescence (14-16 years old) was associated with reduced total prefrontal cortex volume. Other work has also

demonstrated reduced hippocampal volume coinciding with abuse in early childhood (Pechtel et al., 2014; Teicher et al., 2018). This work is further supported by animal models demonstrating effects on synaptic density in the hippocampus, but not the prefrontal cortex, in adult rats following early life maternal separation (Andersen & Teicher, 2004; Teicher et al., 2016; Teicher & Samson, 2016).

Only a few studies have examined sensitive periods for childhood adversity using cognitive outcomes, and results have partially supported the hypothesis of sensitive periods for cognition. In a sample of children aged 3-9 years, onset of abuse or neglect in infancy (before 2 years of age) was associated with lower inhibitory control and working memory than those who had onset of maltreatment after infancy (Cowell et al., 2015). In another study, adult participants were categorized according to age period of childhood abuse onset (Dunn et al., 2016). In comparison to unexposed participants, those first exposed to sexual abuse in adolescence (14-17 years) had lower working memory (Dunn et al., 2016). As described above, however, other developmental periods in this study were associated with better cognition compared to participants without abuse: physical abuse in late childhood (ages 9-11 years) with higher verbal memory, and sexual abuse in early childhood (ages 3-5 years) with higher working memory (Dunn et al., 2016). Despite these mixed findings, however, the emergent body of research generally supports the hypothesis of distinct sensitive periods for the effects of childhood adversity on cognition and regional brain volumes.

In summary, the bulk of the evidence documents that a history of childhood adversity is associated with reduced adulthood cognitive functioning (Danese et al., 2017; J. B. Goodman et al., 2018; Hawkins et al., 2021; Hedges & Woon, 2011; Lund et al., 2022; Masson et al., 2015; Pechtel & Pizzagalli, 2011; R.-Mercier et al., 2018; Vargas et al., 2019). A small number of studies have documented relatively better cognition in those with a history of childhood adversity relative to those without such a history (Campbell et al., 2013; Dannehl et al., 2017; Dunn et al., 2016; Feeney et al., 2013; Velikonja et al., 2020), but the reasons for these counterintuitive findings are as yet unclear. An emerging body of research suggests that the age at which adversity occurs may be an important moderator of the effect via its impact on brain development, with preliminary evidence supporting the hypothesis that adversity in early childhood increases risk for memory deficits as well as reduced hippocampal volume while adversity in adolescence is associated with executive function deficits and reduced

prefrontal cortical volume (Andersen et al., 2008; Dunn et al., 2016; Humphreys et al., 2018).

1.4. Study aims and hypotheses

This is the first study to our knowledge to examine the effect of childhood adversity and its developmental timing on cognition, psychosocial functioning and regional brain volumes in marginally housed young adults. The aims of the present study were to 1) document the prevalence of several types of childhood adversity in marginally housed young adults; 2) examine the contribution of diverse aspects of childhood adversity (physical and sexual abuse, adverse home environment, foster care, and residential mobility) to cognitive and psychosocial functioning in a marginally housed young adult sample; and 3) test the hypothesis that there are distinct sensitive periods for abuse on cognition and regional brain volumes.

With regards to the first aim, we anticipated that the rates of childhood adversity would be elevated in this sample, and, consistent with previous work (Mar et al., 2014), higher than in the general population. In terms of the second aim, it was hypothesized that all aspects of adversity would contribute to reduced memory and executive functioning. These cognitive domains were selected as the most appropriate to address our research questions, given their association with brain regions affected by childhood adversity in previous work (Andersen et al., 2008; Humphreys et al., 2018). While numerous facets of adversity have been linked to lower cognition in the literature, including physical and sexual abuse, neglect, parental mental illness or substance use, witnessing domestic violence, emotional abuse, foster care, and residential mobility (Coley & Kull, 2016; Fry et al., 2017; Hedges & Woon, 2011; Pechtel & Pizzagalli, 2011), studies have rarely comprehensively modeled multiple types of adversity. Therefore, while we hypothesized that each adversity would be negatively associated with cognitive functioning, the state of the literature currently does not allow for more specific hypotheses regarding the relative strengths of the impact of different types of adversity. Based on prior research documenting widespread negative outcomes of childhood adversity (e.g. Mar et al., 2014; Roos et al., 2013), it was anticipated that childhood adversity would be associated with reduced psychosocial functioning as well as lower cognition. In the formulation of these hypotheses, it is important to acknowledge that some types of adversities may represent causal factors (Pechtel & Pizzagalli, 2011),

while others (such as residential mobility or foster care) may represent proxy variables for a host of stressful experiences.

For the third aim, it was hypothesized that there would be distinct sensitive periods for the effects of abuse on cognitive domains and regional brain volumes. Based on prior research on the differential developmental trajectories of the hippocampus and prefrontal cortex (Giedd et al., 1996, 2012; Giedd & Rapoport, 2010; Gogtay et al., 2004), and preliminary evidence for differential sensitive periods (Andersen et al., 2008; Humphreys et al., 2018), it was anticipated that early childhood adversity would be associated with reduced memory and smaller hippocampal volume, while adversity in adolescence would be related to lower inhibitory control and reduced DLPFC volume. These two brain regions were selected based on theory and research highlighting their sensitivity to timing-related effects of childhood adversity (Andersen et al., 2008; Humphreys et al., 2018) and their association with cognitive functioning.

Chapter 2. Methods

2.1. Participants

Participants were recruited as part of an ongoing longitudinal study (the Hotel Study; see Vila-Rodriguez et al., 2013) on the health of marginally housed populations living in Vancouver's impoverished Downtown East Side (DTES) neighbourhood. Participants were recruited via staggered enrollment between 2008 and 2017 from three streams: single-room occupancy (SRO) hotels, the local district court, and from the primary general hospital servicing the DTES. The only Hotel Study eligibility criteria were that participants were fluent in English and were over 18 years old. The present study utilized all Hotel study participants who were under 30 years old at the time of recruitment, consistent with the definition of young adults used in prior work by our group (Barbic et al., 2018; Mental Health Commission of Canada, 2017; Waclawik et al., 2019). Of the 521 participants enrolled in the study, 122 met criteria of being under 30 years old at the time of recruitment (*n* = 91 recruited from SRO hotels, *n* = 10 recruited from the local district court, and *n* = 21 from the hospital).

2.2. Procedures

Participants completed neuropsychological, psychiatric, serological and neurological assessment, questionnaires pertaining to childhood adversity, housing history and psychosocial functioning, and magnetic resonance imaging (MRI) scans. The current study utilized baseline data of these measures.

2.2.1. Assessment of cognitive and psychosocial functioning

Neuropsychological assessment was conducted by research assistants who were trained and supervised by a registered psychologist. Neuropsychological assessment consisted of measures of verbal learning and memory, executive functioning, predicted intellectual functioning (as measured by the predicted IQ score on the Weschler Test of Adult Reading [WTAR], which estimates IQ based on demographic characteristics and word-reading ability; Weschler, 2001), decision-making and processing speed. For the present study, cognitive domains strongly associated with

childhood adversity and sensitive periods in past research were selected for analysis (Andersen et al., 2008; Humphreys et al., 2018): verbal memory and inhibitory control. Verbal memory was measured by the total recall score of the Hopkins Verbal Learning Test-Revised (HVLT-R; Brandt & Benedict, 2001), which has demonstrated adequate test-retest reliability and convergent validity with other measures of verbal memory (Strauss, Sherman, & Spreen, 2006). Inhibitory control was measured by the colour-word inhibition trial of the Stroop Colour-Word test (Golden & Freshwater, 2002). This version of the classic Stroop task has demonstrated adequate to high test-retest reliability and convergent validity with other measures of inhibition (Strauss et al., 2006). Psychosocial functioning was assessed using the Role Functioning Scale total score (RFS; Goodman et al., 1993).

2.2.2. Childhood adversity measures

Childhood adversity was measured by three questionnaires completed in interview format by trained research assistants. Critical items were selected from the Trauma History Questionnaire (THQ; Hooper et al., 2011) in order to analyze physical and sexual abuse. While the THQ assesses for a range of adverse events, such as crime-related events, natural disasters, and serious accidents, we chose to use only those items pertaining to physical and sexual abuse for several reasons. Firstly, the use of the summary measure for the scale (i.e., a count of all trauma types endorsed) would not allow for evaluation of the impact of individual adversities, which was a goal of our study. Secondly, physical and sexual abuse have a stronger evidence base in terms of their relationship to cognition than the other types of adversities included on the THQ, which have rarely been studied in relation to cognition. Finally, in our sample, most of the other adversity types were more rarely reported in childhood, limiting our power to examine their effects.

History of physical abuse was obtained from the THQ items 21-23 (“Has anyone, including family members or friends, ever attacked you with a gun, knife, or some other weapon?”; “Has anyone, including family members or friends, ever attacked you without a weapon and seriously injured you?”; “Has anyone in your family ever beaten, spanked, or pushed you hard enough to cause injury?”) , and history of sexual abuse from the THQ items 18-20 (“Has anyone ever made you have intercourse or oral or anal sex against your will?”; “Has anyone ever touched private parts of your body, or made you

touch theirs, under force or threat?"; "Other than incidents mentioned in Questions 18 and 19, have there been any other situations in which another person tried to force you to have an unwanted sexual contact?"). If participants endorsed any of the items described above, they were asked to provide the age(s) at which the incident(s) occurred; incidents occurring up to and including age 18 were counted as childhood abuse for the purposes of this study. Age of abuse data was coded such that for each age (from infancy to 18 years), participants received a binary score based on whether they reported experiencing physical or sexual abuse at that age. Due to low frequency of abuse events reported during ages 1-3, the data for these ages was combined. Thus, 16 age variables were created: abuse reported at ages 1-3, abuse reported at age 4, abuse reported at age 5, etc. up to age 18. This approach has recently been used by others in research on sensitive periods of adversity exposure (Fujisawa et al., 2018; Herzog et al., 2020; Pechtel et al., 2014; Schalinski et al., 2016, 2018; Schalinski & Teicher, 2015; Takiguchi et al., 2015; Teicher et al., 2018; J. Zhu et al., 2019).

History of foster care and residential mobility were obtained from a sociodemographic questionnaire. On this questionnaire, participants provided a list of all places of residences and dates at each residence. History of foster care was coded as positive if participants reported living with a foster family at any time before 18 years of age. Residential mobility was coded as the number of different residences reported up to 18 years of age.

An index of adverse home environment was obtained from the Childhood Abuse and Neglect (CAN) questionnaire (Wilson et al., 2006), which consists of five subscales assessing emotional neglect, family turmoil (e.g. having a household member with a mental illness or substance use problem, or who attempted suicide or went to jail; prolonged separation from mother; parental separation or divorce), parental intimidation (e.g. verbal abuse), parental violence (e.g. witnessing domestic violence), and financial need. A composite scale score combining information from all five subscales was utilized to measure adverse home environment.

2.2.3. Brain imaging

Whole-brain MRI scans were obtained on a 3.0-T scanner (Philips Achieva) at the University of British Columbia MRI Research Centre using an 8-channel SENSE

head coil. High resolution 3D T1-weighted FFE sagittal images were acquired (TE/TR = 3.7/8.1 ms, flip angle = 8°, field of view = 256 mm x 256 mm, acquisition matrix = 256 mm x 250 mm, scan duration = 443 s, 190 1-mm thick slices). Images were visually inspected for significant motion artifact by trained raters. Automatic parcellation was completed using the PICSL Multiatlas segmentation tool from the Advanced Normalization Tools (ANTs) program (http://stnava.github.io/ANTs/). Selected regions of interest include hippocampus and DLPFC, which, consistent with prior literature (Cox et al., 2014; Sanches et al., 2009; Shaked et al., 2018), was defined as the sum of the superior and middle frontal gyri, for both of which the anterior margin was the grey tissue boundary and the posterior boundary the precentral sulcus.

2.2.4. Psychiatric, neurological and serological assessment

Psychiatric diagnoses were determined by a psychiatrist through the Best Estimate Clinical Evaluation and Diagnosis (BECED), according to the Diagnostic and Statistical Manual for Mental Disorders-TR, Fourth Edition (*DSM-IV;* APA, 2013), the edition in print at the time the study commenced. Serology tested for presence of antibodies for hepatitis C. Neurological soft signs were measured by the Cambridge Neurological Inventory (Chen et al., 1995).

2.3. Statistical Analyses

2.3.1. Analyses Set 1

The first set of analyses tested the hypothesis that childhood adversities would be associated with reduced memory, inhibitory control and psychosocial functioning. A summary listing of outcome variables, predictor variables and covariates for the first set of analyses is provided in Table 1. Three separate hierarchical multiple linear regression analyses were implemented for the three outcome variables: memory (HVLT-R total recall), inhibitory control (Stroop colour-word score), and psychosocial functioning (RFS total score). In each model, childhood adversity variables included adverse home environment from the CAN questionnaire, physical abuse and sexual abuse from the THQ, and foster care and residential mobility from the sociodemographic questionnaire.

For each analysis, potential covariates were identified for inclusion in the model via pre-screen, with the criteria that variables demonstrating a minimum of a small correlation (i.e., *r* or *rho* ≥ .10) with the outcome variable were included in the analysis for that variable. Candidate covariates included variables that were not of theoretical interest to the present study but are relevant to cognitive and psychosocial functioning and thus potentially needed to be controlled for, and included age, gender, education, primary psychotic illness (schizophrenia or schizoaffective disorder), bipolar disorder, PTSD, stimulant dependence, opiate dependence, alcohol dependence, cannabis dependence and hepatitis C infection.

Table 1. List of outcome variables, predictor variables and covariates for Analyses Set 1.

Outcome variables	Predictor variables	Covariates*
Memory (HVLT-R)	Adverse home environment	Age
Inhibitory control (Stroop)	Physical abuse	Gender
Psychosocial functioning (RFS)	Sexual abuse	Education
	Foster care	Psychotic illness (schizophrenia or schizoaffective disorder)
	Residential mobility	Bipolar disorder
		PTSD
		Stimulant dependence
		Opiate dependence
		Alcohol dependence
		Cannabis dependence
		Hepatitis C infection

*included in model if demonstrated a minimum of a small correlation (*r* or *rho* ≥ .10) with the outcome variable

Covariates that met pre-screen criteria but did not demonstrate statistically significant coefficients in regression were dropped from the final model. Covariates were entered on the first block of each model and the second block comprised the five childhood adversity variables. Thus, the final regression models for each analysis were: for memory, age as a control variable on Block 1 and the five childhood adversity variables on Block 2; for inhibitory control, there were no control variables, thus the five childhood adversity variables were entered on Block 1; for psychosocial functioning,

gender, education, stimulant dependence and opiate dependence as control variables on Block 1, and the five childhood adversity variables on Block 2. All analyses for Analysis 1 were completed using the Statistical Package for the Social Sciences (SPSS) Version 27 (IBM, 2020).

2.3.2. Analyses Set 2

The second set of analyses were associated with the timing of childhood adversity. These analyses tested the hypotheses that exposure to physical or sexual abuse in early childhood would be associated with reduced memory and smaller hippocampal volume, while abuse in adolescence would be associated with lower inhibitory control and smaller DLPFC volume. Random forest regression with conditional trees was used to test these hypotheses. Random forest regression utilizes statistical learning methods to build models (King & Resick, 2014). This approach is well-suited to high-dimensional data and to multicollinearity of predictors, two features often present in age of exposure data which are not handled well by traditional statistical techniques (King & Resick, 2014; Strobl et al., 2009). Random forest regression involves the creation of multiple decision trees; decision trees are created by recursively partitioning the sample, with splits based on the predictor variable with the smallest *p*-value in an association test (King & Resick, 2014). Utilization of multiple decision trees via random forest regression increases prediction accuracy and overcomes the problem of instability present within single-tree models (King & Resick, 2014). In a random forest, each tree is grown from a randomly selected subsample of cases using a randomly selected subsample of predictors in order to further increase stability of the model (King & Resick, 2014). A pseudo-R^2 is obtained by calculating the discrepancy between predicted scores for the out-of-bag data for each tree and actual scores, and pooled across all trees (King & Resick, 2014). The relative importance of each of the predictor variables is identified by randomly permuting the values of each predictor in turn, and assessing the change in prediction accuracy (King & Resick, 2014). A large decrease in prediction accuracy is indicative of higher variable importance (King & Resick, 2014). Because variable importance only provides a ranking of predictors and not the direction of the effect, variables identified in random forest regression were subsequently entered in linear regression to determine the magnitude and direction of the effect (King & Resick, 2014). Random forest regression includes built-in techniques for dealing with missing

data; for predictor variables with missing data, a surrogate variable is selected from among the other predictors as that which most accurately predicts values on the incomplete variable; this surrogate variable is then used as the predictor for cases with missing data on the original predictor variable (King & Resick, 2014).

A summary listing of outcome variables, predictor variables and covariates for Analysis 2 is provided in Table 2. Separate random forest regressions were completed for each of the four outcome variables: memory, inhibitory control, hippocampal volume, and DLPFC volume. For the hippocampus and DLPFC, left and right volumes were summed. Predictors for each analysis included age, gender, and age at exposure to physical or sexual abuse, as well as total brain volume for the analyses on hippocampal and DLPFC volume. For this analysis, each forest was grown to 500 trees, consistent with recommendations in the literature (King & Resick, 2014; Probst & Boulesteix, 2017). Adversity variables for random forest regression were limited to physical and sexual abuse, given that these were the only variables with age data available. These analyses were completed using R packages “Party” and “More Party” (R Core Team, 2021; Hothorn et al., 2015; Strobl et al., 2007).

Table 2. List of outcome variables, predictor variables and covariates for Analyses Set 2.

Outcome variables	Predictor variables	Covariates
Memory (HVLT-R) Inhibitory control (Stroop) Hippocampal volume Dorsolateral prefrontal cortex (DLPFC) volume	Age of physical or sexual abuse: binary yes/no variable indicating whether either physical or sexual abuse occurred at each of: ages 1-3 years, 4 years, 5 years, 6 years, 7 years, 8 years, 9 years, 10 years, 11 years, 12 years, 13 years, 14 years, 15 years, 16 years, 17 years, 18 years:	Age Gender Total brain volume* *for the models with hippocampal volume and DLPFC volume as outcome variables

Chapter 3. Results

3.1. Descriptive Statistics

Participant characteristics are displayed in Table 3. The sample was approximately 74 percent male, with an average age of 25 years (*SD* = 2.91, range: 19-29 years) and average educational attainment of 10 years (*SD* = 1.45, range: 7-15 years). Prior reports in this sample (Waclawik et al., 2018) documented low cognitive functioning compared to normative levels, particularly in verbal memory, with executive functioning deficits tending to be less prevalent and less severe. Consistent with this previous work, we found the average standardized score for verbal memory (HVLT-R total recall) to be 1.5 standard deviations below the normative mean (*M* = 35.00, *SD* = 12.30, range = 20-66). Standardized scores for inhibitory control (Stroop) were on average at the normative mean (*M* = 49.56, *SD* = 11.26, range = 21-82). Psychosocial functioning was low overall, with mean scores on all four domains of the RFS falling at least in the range of marginal functioning (i.e., at or below 4 on the 7-point scale). For example, within the domain of independent living/self-care, marginal functioning is described as "often uses regular assistance to maintain self-care/independent functioning; minimally participates in running household". Detailed descriptions of other sample characteristics are provided in previous publications (Barbic et al., 2018; Waclawik et al., 2019).

Table 3. Sample characteristics.

	Original data	**Imputed data (N = 122)**	***N* with original data**
	M (SD, range) or %(*n)*	*M* or %(*n)*	
Age	25.09 (2.91, 19-29)	*	122
Male	73.8% (91)	*	122
Education (years)	10.58 (1.45, 7-15)	*	122
HVLT-R total recall			103
Raw	21.63 (6.36, 5-35)	21.75	
T-score	35.00 (12.30, 20-66)	^	
Stroop colour-word interference trial			105
Raw	40.52 (11.78, 11-77)	40.35	
T-score	49.56 (11.27, 21-82)	^	

Role Functioning Scale	12.58 (2.96, 5-21)	12.56	118
Work productivity	1.89 (1.13, 1-5)	^	
Independent living/self care	3.36 (0.88, 2-6)	^	
Immediate social network relationships	3.97 (1.16, 1-6)	^	
Extended social network relationships	3.36 (0.81, 1-6)	^	
Schizophrenia or schizoaffective disorder	31.7%% (38)	32.6% (39.80)	120
Bipolar disorder	19.2% (23)	19.5% (23.80)	120
Major depressive disorder	5.8% (7)	6.6% (8.00)	120
PTSD	15.0% (18)	15.6% (19.00)	120
Stimulant dependence	62.5% (75)	62.2% (75.90)	120
Opiate dependence	37.8% (45)	38.8% (47.30)	120
Alcohol dependence	18.3% (22)	18.5% (22.60)	120
Cannabis dependence	58.3% (70)	58.6% (71.50)	120
Hepatitis C infection	25.3% (23)	24.2% (29.50)	91

* No missing data ^ Not included in imputation model

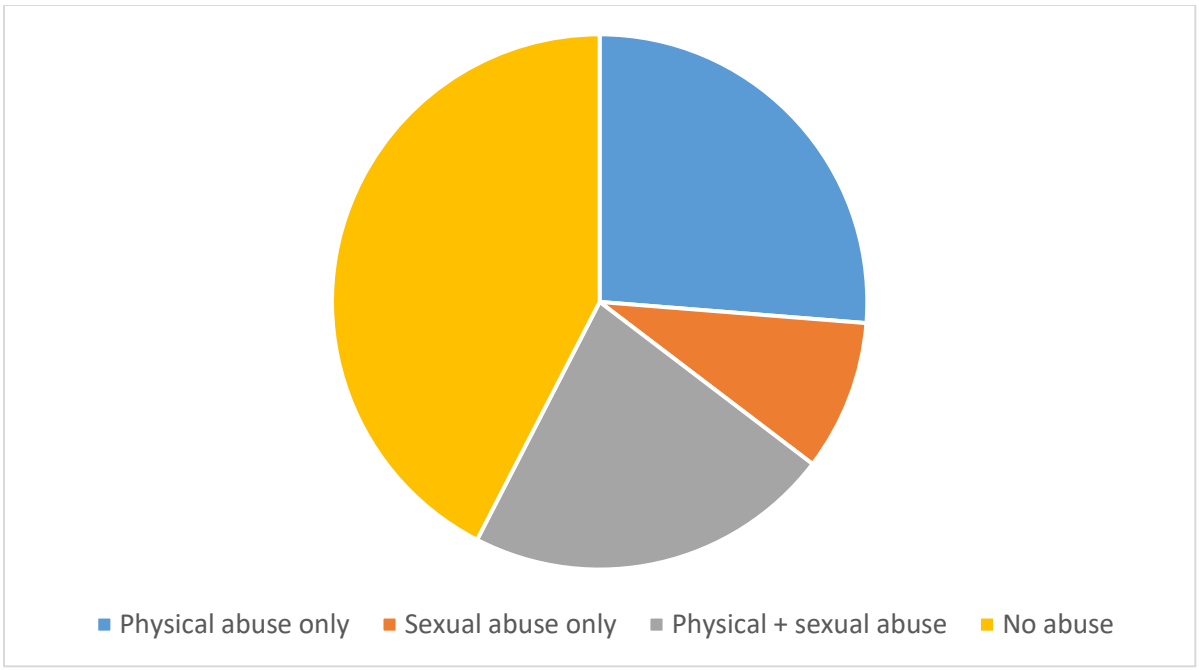
Descriptive statistics of childhood adversity measures are displayed in Table 4 and prevalence and overlap between physical and sexual abuse and foster care are displayed in Figure 2. Participants reported high rates of abuse, with nearly half the sample reporting physical abuse, approximately one-third reporting sexual abuse, and nearly one-third reporting a history of foster care. As shown in Figure 2, it was not uncommon for participants to have experienced more than one type of adversity, such as both physical and sexual abuse, or abuse as well as foster care placement. Prevalence of physical and sexual abuse stratified by age at which the abuse occurred are shown in Figure 3. Relationships between the five childhood adversity variables (physical abuse, sexual abuse, foster care, adverse home environment, and residential mobility) ranged from negligible to moderate effect sizes (r = -.07 to.37 for relationships involving continuous variables, *phi* = -.02 to .30 for categorical variables; see Table A1 in the Appendix). Correlations between regional brain volumes for the hippocampus and dorsolateral prefrontal cortex and demographic and adversity variables are displayed in Table B1 in the Appendix.

Table 4. Descriptive statistics of childhood adversity.

	Original data	*Imputed data* (*N* = 122)	*N* with original data
	%(*n*) or *M* (*SD,* range)	%(*n*) or *M*	
Physical abuse	48.50% (49)	48.11% (58.70)	101
Sexual abuse	33.90% (37)	34.43% (42.00)	109
Adverse home environment [a]	22.33 (12.38, 1-51)	21.95	82
Foster care	27.30% (33)	27.21% (33.20)	121
Residential mobility	5.43 (3.83, 2-20)	*	119

[a] Potential range: 0-59

* Log-transformed variable included in multiple imputation analysis and subsequent analyses to correct for positive skew



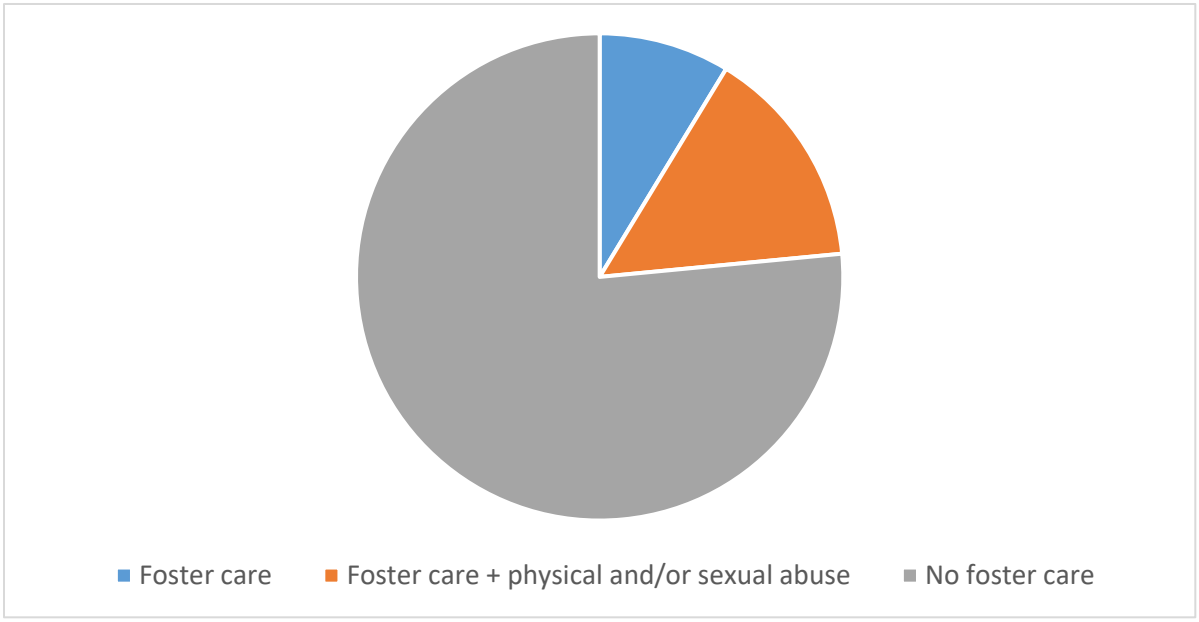


Figure 2. Prevalence rates of physical and sexual abuse and foster care.

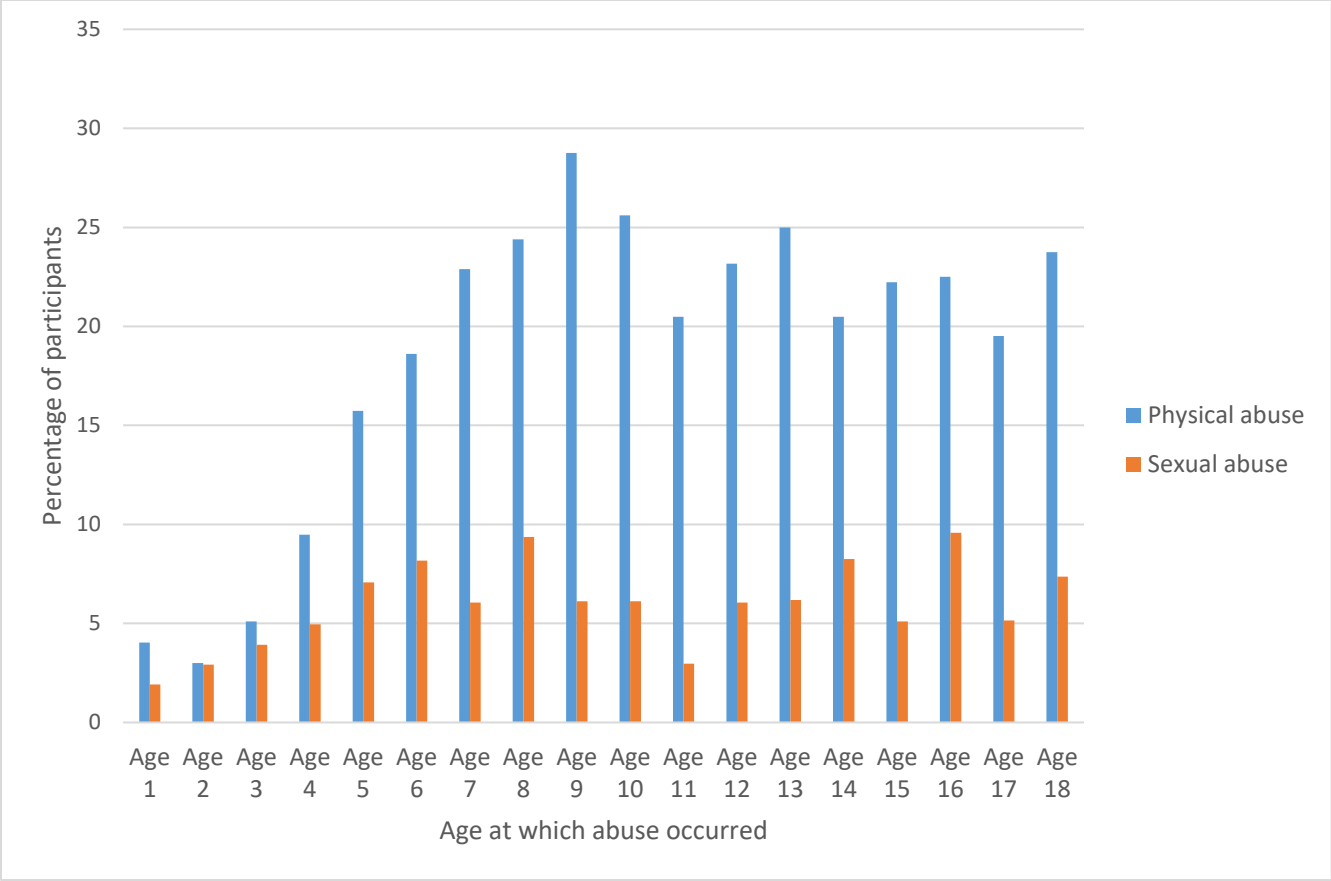


Figure 3. Prevalence rates of physical and sexual abuse stratified by age at which abuse occurred.

3.2. Analyses Set 1

3.2.1. Missing Data

Missing data ranged from 0% (for age, gender and education) to 32.8% (for the CAN questionnaire). Results of Little's MCAR test supported the inference of the mechanism of missing completely at random, $\chi^2(154) = 154.43$, $p = .475$. Based on standards in the literature (Tabachnick & Fidell, 2013; White et al., 2011), multiple imputation by chained equations was used for missing data. Sixty-two imputed datasets were created (Bodner, 2008; Molenberghs et al., 2020; White et al., 2011), and results were compared between analyses using the imputed datasets and complete case analyses to ensure equivalency. In the tables below, the unstandardized regression

coefficients and significance levels are pooled results from imputed data, while the standardized coefficients and model fit statistics are from complete case analyses, given that there is not an established procedure for pooling these statistics in regression (van Ginkel et al., 2020). Results were comparable between pooled analyses using imputed datasets and complete case analysis, with similar direction and magnitude of regression coefficients (see Tables C1-C3 in the Appendix for results of analyses with original data).

3.2.2. Memory

The pattern of results partially supported the hypothesis that childhood adversity would be associated with reduced memory (see Table 5). On Block 1, older age was associated with poorer memory (β =-.13, p < .001). On Block 2, the childhood adversity variables predicted a further 21 percent of the variance in memory scores, over and above the effect of age (ΔR^2 = .23, p = .02). As predicted, a history of foster care was associated with lower memory performance (β = -.26, p < .02). Surprisingly, however, a history of childhood physical abuse was associated with higher memory scores (β = .41, p = .01).

Table 5. Regression of childhood adversity onto memory (HVLT-R).

	B [a]	Standard error [a]	β[b]	*p* [a]
Block 1 R^2 = .02, p = .27				
Age	-0.73	0.21	-.13	<.01
Block 2 R^2 = .23, p = .02				
Adverse home environment	-0.03	.06	-.10	.64
Physical abuse	3.41	1.29	.41	.01
Sexual abuse	-0.06	1.29	-.05	0.97
Foster care	-3.86	1.33	-.26	<.02
Residential mobility	3.73	2.62	.18	.15

[a] Pooled analyses from imputed data. [b] Original data.

3.2.3. Inhibitory Control

The pattern of results also partially supported the hypothesis that childhood adversity would be associated with reduced inhibitory control (see Table 6). The childhood adversity variables as a whole predicted 21 percent of the variance in inhibitory control (R^2 = .21, p = .01). A history of foster care was marginally associated with poorer inhibitory control (β = -.14, p = .08). However, contrary to the hypothesis, higher residential mobility was related to higher inhibitory control (β = .26, p = .03).

Table 6. Regression of childhood adversity onto inhibitory control (Stroop).

R^2 = .21, p = .01 [b]	***B*** [a]	**Standard error** [a]	**β**[b]	***p*** [a]
Adverse home environment	-0.13	0.13	-.21	.30
Physical abuse	3.70	2.52	.23	.14
Sexual abuse	3.51	2.64	.30	.18
Foster care	-4.71	2.66	-.14	.08
Residential mobility	11.08	4.93	.26	.03

[a] Pooled analyses from imputed data. [b] Original data.

3.2.4. Psychosocial Functioning

The hypothesis that childhood adversity would be associated with decreased psychosocial functioning was partially supported (see Table 7). On Block 1, female

gender, stimulant dependence and opiate dependence were associated with lower psychosocial functioning, while higher education was associated with better psychosocial functioning. The childhood adversity variables predicted a further 27 percent of the variability in psychosocial functioning ($\Delta R^2 = .27$, $p < .001$). Consistent with the hypothesis, history of foster care was associated with lower psychosocial functioning ($\beta = -.33$, $p = .01$). However, contrary to what we anticipated, history of sexual abuse ($\beta = .36$, $p < .01$) and greater residential mobility were both associated with better psychosocial functioning ($\beta = .32$, $p < .001$).

Table 7. Regression of childhood adversity onto psychosocial functioning (RFS).

	B [a]	**Standard error** [a]	**β**[b]	***p*** [a]
Block 1 $R^2 = .13$, $p = .07$ [b]				
Female	-1.74	0.65	-.16	.01
Male	*ref*	*ref*	*ref*	*ref*
Education	0.50	0.17	.21	<.01
Stimulant dependence	-1.03	0.52	-.22	.05
Opiate dependence	-1.37	0.52	-.24	.01
Block 2 $R^2 = .40$, $p < .001$ [b]				
Adverse home environment	-0.01	0.03	-.09	.60
Physical abuse	0.03	0.59	-.06	.95
Sexual abuse	1.89	0.66	.36	<.01
Foster care	-1.44	0.55	-.33	.01
Residential mobility	3.55	1.07	.32	<.001

[a] Pooled analyses from imputed data. [b] Original data.

3.2.5. Exploratory Follow-Up Analyses

The finding that some facets of childhood adversity were associated with relatively higher functioning was surprising and contrary to our hypotheses. It is important to note, however, that compared to normative levels, the sample showed generally low functioning, regardless of adversity exposure. Specifically, both those with physical abuse ($M_{\text{T-score}}$ = 37.24, SD = 12.92) and without ($M_{\text{T-score}}$ = 31.67, SD = 10.44) showed memory that was low compared to normative levels. Similarly, those with and without sexual abuse both showed low levels of psychosocial functioning (respectively, M = 12.95, SD = 2.45 and M = 12.55, SD = 3.20), with mean scores on all four domains of the RFS at least in the range of marginal functioning for both groups.

Given the presence of several findings in the opposite direction than predicted, a thorough search for potential confounding factors was conducted. Associations were examined between adversity variables displaying counterintuitive relationships with cognitive and psychosocial functioning (i.e., physical abuse, sexual abuse and residential mobility) and several variables: gender, predicted IQ, neurological soft signs, history of special education classes, and parental education. Although psychiatric diagnosis was already examined in pre-screen of candidate covariates, further examination of psychiatric diagnosis (schizophrenia, bipolar disorder, and PTSD) was conducted in follow-up to determine if it could explain the counterintuitive findings.

While women were more likely than men to report both physical and sexual abuse (physical abuse: χ^2 [1, N = 101] = 9. 64, p < .05, phi = .31; sexual abuse: χ^2 [1, N = 109] = 33.47, p < .001, phi = .55), gender was not associated with either memory (r = .07, p = .49) or psychosocial functioning (r = -.11, p = .24), so it was not feasible that gender differences were driving the relationship between abuse and these outcome variables. Furthermore, when female participants were excluded from analyses, the counterintuitive relationship between physical abuse and verbal memory was still present and of a similar magnitude (β = .33, p = .03), and the relationship between sexual abuse and psychosocial functioning retained marginal significance and was of a similar magnitude (β = .23, p = .09). We were unable to compare women with and without abuse due to the low number of women who did not endorse abuse. However, our results indicate that, despite the correlation between gender and abuse, the counterintuitive findings could not be explained by gender differences on the outcome

variables, as the effects of physical abuse and sexual abuse were retained in male participants. Gender was not associated with residential mobility (r = .06, p = .49).

In terms of psychiatric diagnosis, those with sexual abuse were less likely to have schizophrenia (χ^2 [1, N = 108] = 6.49, p = .01, *phi* = -.25), but more likely to have bipolar disorder and PTSD (bipolar disorder: χ^2 [1, N = 108] = 6.06, p = .01, *phi* = .24; PTSD: χ^2 [1, N = 108] = 18.91, p < .01, *phi* = .42). Schizophrenia was marginally associated with lower psychosocial functioning (r = -.16, p = .08), while bipolar disorder was marginally associated with higher psychosocial functioning (r = .16, p = .08) and PTSD was not associated with psychosocial functioning (r = .04, p = .64). Therefore, exploratory analyses were conducted to determine whether differences in psychiatric diagnosis profile could explain the relationship between sexual abuse and higher psychosocial functioning. Cell sizes were too small to complete a comparison between schizophrenia and non-schizophrenia participants with and without sexual abuse. However, when analyzing only those participants without schizophrenia, sexual abuse was still positively associated with psychosocial functioning with an effect of a similar magnitude (β = .40, p = .02). Therefore, the higher prevalence of participants with schizophrenia in the no-sexual abuse group did not account for the relationship between sexual abuse and higher psychosocial functioning. Similarly, when controlling for bipolar disorder in the regression model for psychosocial functioning, sexual abuse retained its significance and with a similar magnitude (β = .36, p = .02); similar results were obtained when controlling for PTSD (β = .34, p = .04). Physical abuse was not significantly associated with any psychiatric diagnoses.

Those with higher residential mobility were marginally less likely to have schizophrenia (r = -.18, p = .05) and more likely to have PTSD (r = .25, p < .01). When schizophrenia was included in the regression models, residential mobility was still positively associated with psychosocial functioning (β = .31, p = .01) and marginally with inhibitory control (β = .21, p = .08), with effects of a similar magnitude. Similarly, when controlling for PTSD, residential mobility retained its significance and effect size for psychosocial functioning (β = .31, p = .01) and inhibitory control (β = .26, p = .05).

Higher residential mobility was significantly associated with fewer neurological soft signs (r = -.25, p =.03), and fewer soft signs were related to better inhibitory control (r = -.52, p < .001) and psychosocial functioning (r = -.25, p = .03). When soft signs

were entered into the inhibitory control model, soft signs attenuated residential mobility's relationship with inhibitory control and the residential mobility coefficient was no longer significant (β = .12, p = .41; see Table D1 in Appendix D). The addition of soft signs to the model with psychosocial functioning did not attenuate the relationship between soft signs and psychosocial functioning (β = .31, p = .01). Neurological soft signs were not associated with physical (r = -.02, p = 89) or sexual abuse (r = .05, p = .66).

No relationships emerged with the other variables (predicted IQ, history of special education classes and parental education) that could explain the counterintuitive findings.

3.3. Analyses Set 2

3.3.1. Memory

The hypothesis that early age of abuse would be associated with reduced memory was not supported. The random forest regression model overall explained 14.89% of the variance in memory scores. As shown in Figure 4, predictors with highest variable importance included age, physical or sexual abuse at age 6, followed by physical and sexual abuse across several of the teen ages. However, when entered in linear regression, the direction of the relationship between abuse at age 6 and memory was opposite to that predicted: abuse that was reported to have occurred at age 6 portended better current memory (β = .32, p = .002), after controlling for age at assessment (β = -.23 p = .02; overall model significance: R^2 = .17, p < .001).

3.3.2. Inhibitory Control

The hypothesis that abuse in adolescence would predict reduced inhibitory control was not supported. In random forest regression, predictors with the highest variable importance were abuse at ages 6 and 5 (Figure 4). However, when testing the direction of the relationship in linear regression, abuse reported at age 6 was significantly associated with better current inhibitory control (β = .32, R^2 = .10, p = .002).

Notably, these results were consistent with the overall pattern of results in Analysis 1, in which physical and sexual abuse were associated with higher functioning.

In follow-up analyses, we determined that this counterintuitive relationship between age of abuse and cognition was not unique to the ages selected by random forest regression; inspection of a correlation matrix between the cognitive variables and each age at abuse variable revealed consistently positive correlations between cognition and abuse exposure across numerous ages (see Table D1 in Appendix E).

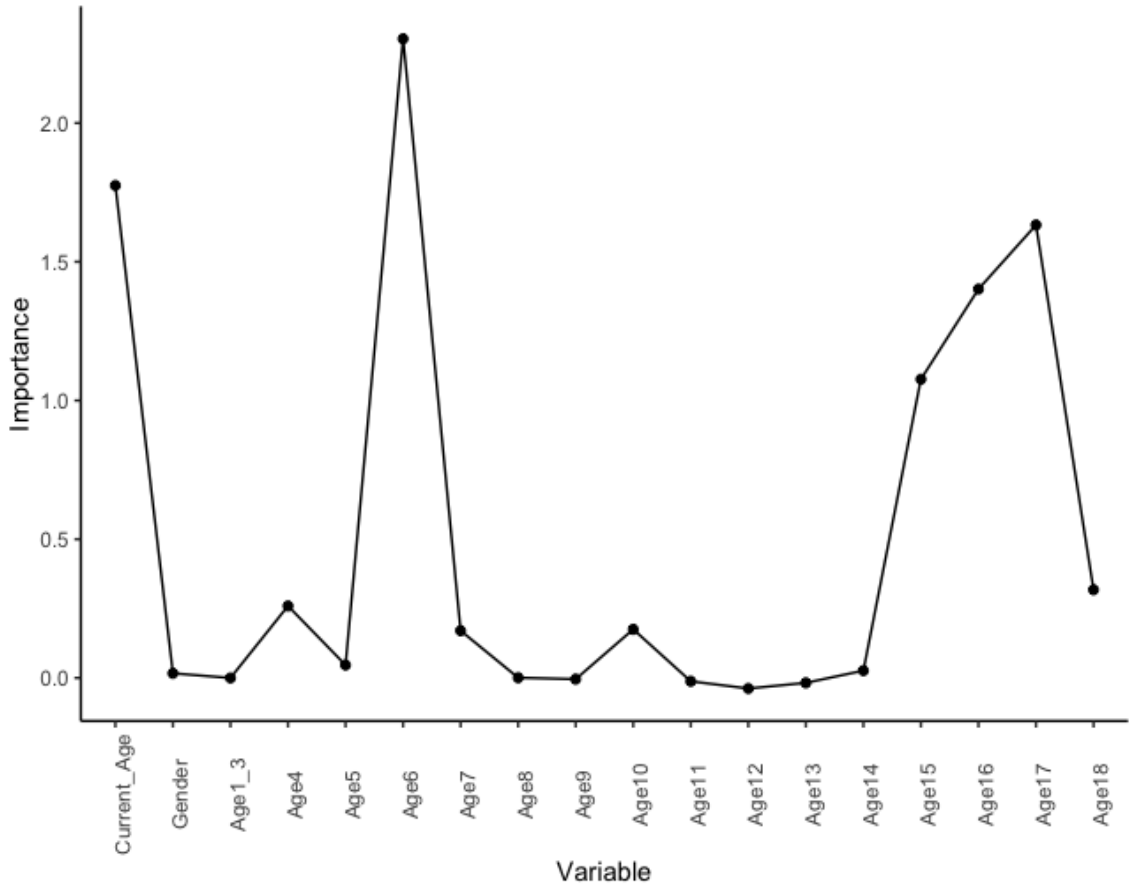
3.3.3. Hippocampus

Contrary to our hypothesis, early childhood abuse did not predict smaller hippocampal volumes. The random forest regression overall explained 28.07% of the variance. Predictors with the highest variable importance were total brain volume, gender, and abuse at age 9 (Figure 4). In linear regression, abuse at age 9 (β = -.04, p = .69) did not contribute significantly to hippocampal volume after controlling for total brain volume (β = .72, p < .001) and gender (β = .08, p = .42; overall model significance: R^2 = .49, p < .001).

3.3.4. Dorsolateral Prefrontal Cortex

The hypothesis that abuse in adolescence would be associated with smaller DLPFC volume was also not supported. The random forest regression altogether explained 49.33% of the variance in DLPFC volume. As shown in Figure 4, predictors with the highest variable importance included total brain volume, gender, current age, and abuse at age 9. After accounting for total brain volume (β = .85, p < .001), gender (β = .12, p = .09), and current age (β = -.17, p = .01), abuse at age 9 did not contribute significant variance to DLPFC volume in linear regression (β = -.03, p = .69; overall model significance: R^2 = .72, p < .001).

A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1.0
0.5
0.0
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Gender
Age1_3
Age4
Age5
Age6
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Age8
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Age11
Age12
Age13
Age14
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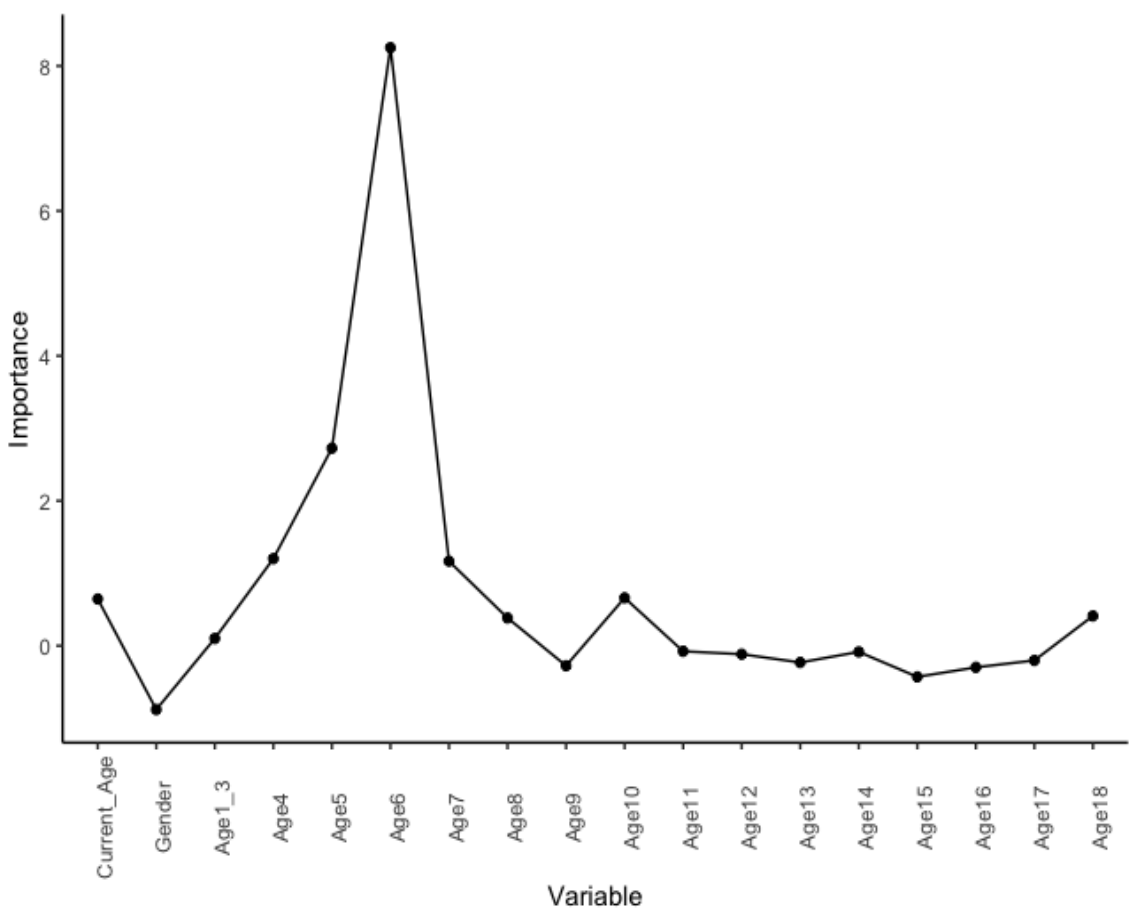
Age16
Age17
Age18
Variable

B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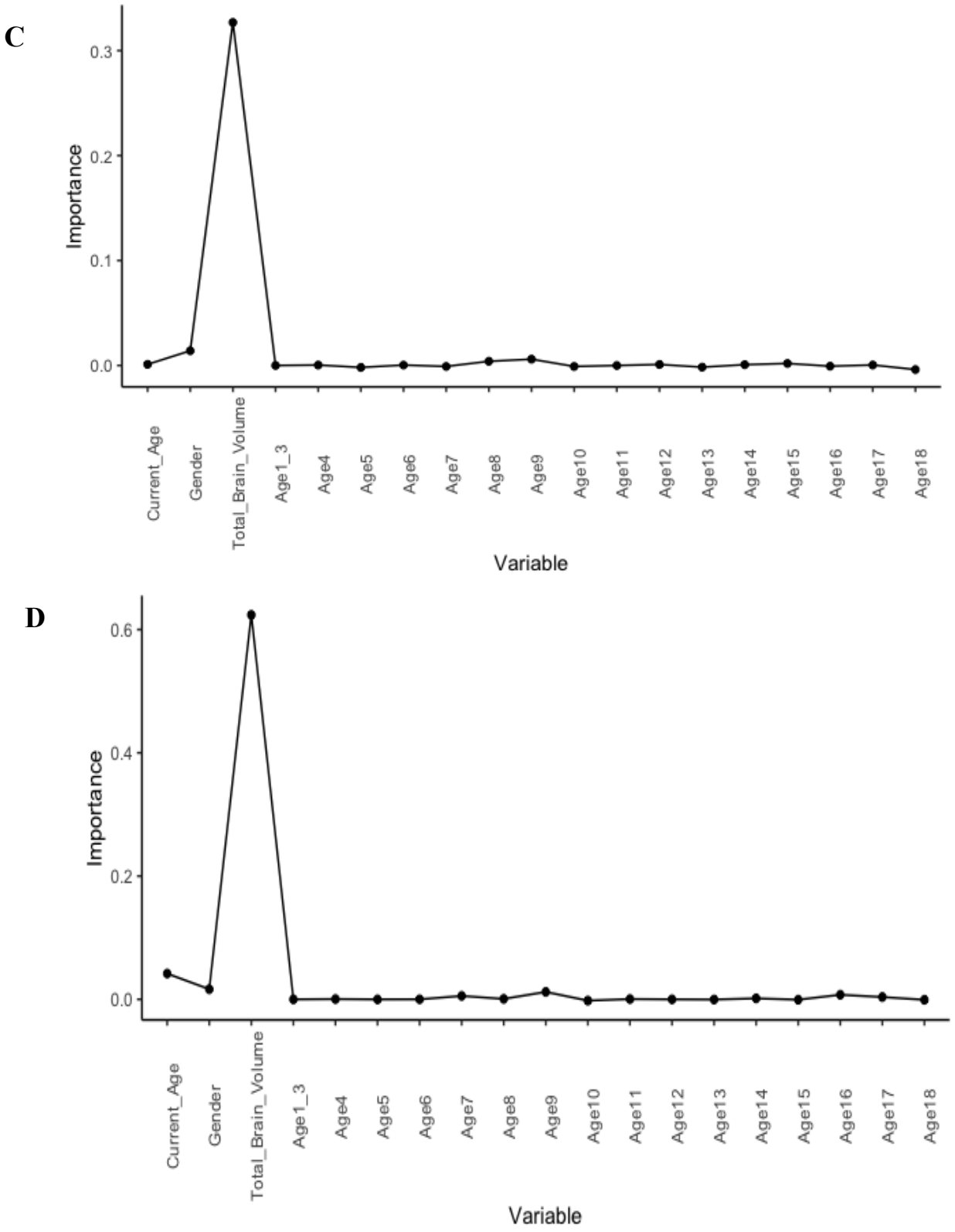

Figure 4. Variable importance of random forest regression for memory (A), inhibitory control (B), hippocampal volume (C) and dorsolateral prefrontal cortex volume (D).

Chapter 4. Discussion

This study documented high rates of childhood adversities in a sample of marginally housed young adults. Nearly half the sample reported experiencing physical abuse in childhood, one-third endorsed childhood sexual abuse, and one-third reported a history of foster care placement. These rates are substantially higher than in the general population, in which physical and sexual abuse are estimated at 22 and 6 percent, respectively (Cotter, 2019), and foster care placement at 0.6 percent (Ministry of Children and Family Development, 2021). Our sample also experienced high rates of residential mobility, reporting an average of 5 changes in residence throughout childhood; in contrast, residential mobility in the general population has been estimated as low as 1-2 moves on average during childhood (Coley & Kull, 2016). The elevated rates of childhood adversities in our sample of marginally housed young adults are consistent with prior studies (Mar et al., 2014; Sundin & Baguley, 2015) and highlight the complex burdens faced by this vulnerable population.

The sample as a whole exhibited low psychosocial functioning and verbal memory, consistent with prior work documenting reduced cognition and functioning in marginally housed youth (Barone et al., 2019; Fry et al., 2019; Saperstein et al., 2014). Interestingly, however, we found that childhood adversity types were differentially related to either lower or relatively higher cognitive and psychosocial functioning, depending upon the particular adversity type. Self-reported history of foster care during childhood was related to reduced memory and psychosocial functioning, and marginally to reduced inhibitory control. In contrast, self-reported history of childhood physical and sexual abuse was linked to relatively higher memory and psychosocial functioning, respectively, although those with abuse still presented with low memory and psychosocial functioning compared to normative levels. Increased residential mobility was associated with higher inhibitory control and psychosocial functioning.

Differences in gender, psychiatric diagnosis, educational history, predicted IQ and parental education did not explain these counterintuitive results. However, higher residential mobility was linked with lower rates of neurological soft signs, an indicator of aberrant neurodevelopment (Chen et al., 1995), and soft signs partially explained the counterintuitive relationship between residential mobility and cognitive functioning.

Examination of potential sensitive periods for abuse exposure were consistent with the overarching finding of better functioning in those with abuse in our study. Physical or sexual abuse reported to have occurred at age 6 was linked with higher current memory and inhibitory control. The age at which physical or sexual abuse occurred was not significantly linked to adulthood volumes of the hippocampus or DLPFC.

Although the bulk of previous research has documented that childhood adversity is associated with reduced adulthood cognition (e.g., Danese et al., 2017; J. B. Goodman et al., 2018; Hawkins et al., 2021; Hedges & Woon, 2011; Lund et al., 2022; Masson et al., 2015; Pechtel & Pizzagalli, 2011; R.-Mercier et al., 2018; Vargas et al., 2019), our results are in line with a handful of prior reports documenting the opposite effect (Campbell et al., 2013; Dannehl et al., 2017; Dunn et al., 2016; Feeney et al., 2013; Velikonja et al., 2020). In large, nationally representative samples in the United States and Ireland, Dunn et al. (2016) and Feeney et al. (2013) documented that physical and sexual abuse were associated with higher scores on general cognition as well as specific domains, including verbal memory, relative to those without such a history. A history of childhood abuse and neglect has been found to be related to higher premorbid IQ in adults with first-episode psychosis (Campbell et al., 2013) and higher overall cognition in youth at clinical high risk for psychosis (Velikonja et al., 2020), in comparison to those without childhood abuse or neglect. One study has documented similar results in patients with major depression (Dannehl et al., 2017).

One possible explanation for our unexpected results is line with the hypothesis proposed by Campbell et al. (2013) and Velikonja et al. (2020). This hypothesis proposes dual pathways into psychosis; one that is triggered by environmental stressors such as childhood adversity, and one that is more strongly linked to neurodevelopmental and genetic factors (Campbell et al., 2013; Velikonja et al., 2020). The latter group may have more inherent neurodevelopmental abnormalities which portend a predisposition to develop psychosis and also impact on cognitive development (Velikonja et al., 2020). In contrast, Velikonja et al. (2020) proposed that the portion of their sample with childhood adversity history may represent an initially typically developing group who were triggered into the development of psychosis by the stress of adversity, but maintained relatively higher levels of functioning than the neurodevelopmental group.

We propose an application and extension of the dual pathways hypothesis and speculate that our sample may comprise subgroups of youth who ended up in marginal housing through diverse trajectories. Those with lower rates of adversity may represent a group with pre-existing subtle neurodevelopmental abnormalities that influenced their pathway into marginal housing. Their poorer cognitive functioning may stem largely from neurodevelopmental factors and represent a risk factor for entry into marginal housing. On the other hand, those with a history of childhood adversity may represent a more neurodevelopmentally typical group whose adverse childhood experiences contributed to their entry into marginal housing (for example, the need to leave their caregiver as a result of abuse or family instability). This conjecture is supported by our finding that individuals with higher rates of one adversity (residential mobility) had lower neurological soft signs.

It is important to note that, despite the relative differences between abused and non-abused groups, both groups demonstrated deficits in cognitive and psychosocial functioning, consistent with prior research in marginally housed young adults (Barone et al., 2019; Saperstein et al., 2014). Thus, although the individuals with greater adversity may potentially represent a more neurodevelopmentally intact group and are relatively less impaired, they still present with cognitive and psychosocial functioning challenges that are likely to pose barriers to rehabilitation (Fry et al., 2019; Saperstein et al., 2014). Most of the previous studies (with the exception of Campbell et al., 2013) that reported better cognition in those with childhood adversity (Dannehl et al., 2017; Dunn et al., 2016; Feeney et al., 2013; Velikonja et al., 2020) did not report on the normative scores of the abused and non-abused groups, so it is not clear whether groups had meaningful differences in terms of normative levels in these studies. Campbell et al. (2013) reported premorbid IQ within the average range for both abused and non-abused participants, despite relatively higher premorbid IQ in the group with a history of abuse, raising the question of the clinical significance of these findings.

Future research should seek to clarify the clinical significance of differences between groups with and without childhood adversity. Despite normatively low functioning across groups with and without childhood adversity in our sample, differences in cognitive functioning may nevertheless predict differential trajectories of outcome for these two groups. In a sample of homeless adolescents, even among those with low cognitive functioning normatively, relatively higher performance predicted

increased likelihood of obtaining housing over a six-month period (Fry et al., 2019). Thus, even subtle differences in cognition may be associated with meaningful differences in outcomes such as attainment of housing. For clinicians working with marginally housed young people, an understanding of the diverse subgroups within the population of marginally housed individuals may help inform differential treatment targets and goals. For example, those with relatively higher cognition may be particularly likely to benefit from cognitive and vocational rehabilitation. Indeed, previous research on homeless young adults in a vocational support program documented that participants with greater cognitive skills were more likely to earn a livable wage (Saperstein et al., 2014). Thus, those with relatively higher cognition may be more likely to derive substantial benefit from vocational support programs. A recent pilot study demonstrated effectiveness of a cognitive rehabilitation program in homeless young adults, but highlighted the feasibility issues of intervention in such a transient population, with many participants lost to follow-up or regularly missing treatment sessions (Medalia et al., 2017). Identification of candidates who are particularly likely to benefit from cognitive and vocational rehabilitation would help focus resources.

On the other hand, those with reduced cognition and potentially greater neurodevelopmental factors may particularly benefit from programs with more of a focus on structured assistance for activities of daily living. While some programs that provide coaching and support for activities of daily living have demonstrated effectiveness in elderly homeless populations (e.g., Henwood et al., 2023), there is limited research examining such programs in younger marginally housed populations. However, interventions with multiple components, such as mental health support, peer support and case management to provide assistance with navigating relevant systems (such as housing, health and education systems), have shown promise in homeless youth (Kidd et al., 2020). In general, interventions that involve multiple levels of support and can be individually tailored to meet a person's level of functioning and need are thought to be necessary for homeless and marginally housed youth, but to date there has been a paucity of research examining interventions in this population (Kidd et al., 2020).

Other scholars have proposed an alternative explanation for a positive association between childhood adversity and cognition, positing that childhood adversity enhances vigilance and arousal which is adaptive when completing cognitive tasks (Dunn et al., 2016; Feeney et al., 2013). However, it does not appear plausible that

participants with adversity in our sample had enhanced vigilance and arousal, given that cognitive and psychosocial functioning was not enhanced relative to normative levels. Our results do suggest that type of adversity is important in differential prediction of either lower or relatively higher cognition, and future studies should continue to measure a range of types of childhood adversity to fully elucidate these differential effects. It is possible that in some cases certain types of childhood adversity (such as abuse) lead to coping strategies that are adaptive for cognition, while other adversities (such as frequently changing caregivers through foster care) impede the learning of such coping strategies.

An alternative explanation for our findings, which has been proposed by others (e.g., Velikonja et al., 2020), is that participants with better cognition were better able to recall and report childhood adverse events. However, the self-report questionnaires (Trauma History Questionnaire and Childhood Abuse and Neglect Questionnaire) used in our study have demonstrated good reliability and validity (Hooper et al., 2011; Wilson et al., 2006), including in samples with severe mental illness (Mueser et al., 2001). Additionally, the test-retest reliability of the individual items from the THQ assessing physical and sexual abuse has been tested in one study and found to be adequate (Mueser et al., 2001). Furthermore, prior research has demonstrated that source of abuse history (i.e. self-report versus cases confirmed via child protection agencies) does not influence findings on the relationship between abuse and cognition (Masson et al., 2015). Nevertheless, it is still conceivable that individuals with better cognition were more likely to accurately report abuse in our study, and the use of retrospective self-report measures of childhood adversity is a limitation of our study, as discussed below. Future research that directly compares self-reported rates of abuse with rates confirmed by other sources (e.g., child protection agencies) in cognitively intact versus compromised participants would help to further clarify this issue.

Our analysis of sensitive periods for the effects of physical or sexual abuse on cognition was consistent with the overall pattern of relatively higher functioning in those with abuse. A history of physical or sexual abuse at age 6 was associated with better memory and inhibitory control. Indeed, follow-up analyses revealed that abuse exposure at multiple ages from infancy to 18 years demonstrated significant positive correlations with cognition. Thus, although abuse at age 6 was the most predictive of cognitive functioning in our study, abuse at other ages followed the same general pattern of

relatively higher cognition. Although abuse at age 9 was identified in random forest regression as the age most predictive of hippocampal and DLPFC volume, the relationship was not statistically significant once total brain volume and current age were accounted for. Although prior research has documented distinct sensitive periods for abuse exposure for cognition and regional brain volumes (Andersen et al., 2008; Dunn et al., 2016; Humphreys et al., 2018; Pechtel et al., 2014; Teicher et al., 2018), this is the first study to test the hypothesis of sensitive periods in a complex, multimorbid, marginally housed sample. Our findings suggest that the presence of sensitive periods for the effects of adversity on cognition and brain volume may depend on the nature of the sample.

In contrast to the other adversity types, a history of placement into foster care was associated with reduced memory and psychosocial functioning, and marginally with reduced inhibitory control. These results are consistent with prior research documenting lower cognition in those with history of foster care (Vinnerljung & Hjern, 2011). While physical and sexual abuse were associated with relatively less impairment in our study, it is possible that foster care served as a proxy for very severe abuse or neglect, or the trauma of parental abandonment, adversities that may have crossed the threshold into causing more serious developmental damage. Indeed, not all participants who reported abuse were placed into foster care, as indicated by lower rates of foster care than of abuse in our sample, and it is possible that only those experiencing severe levels were placed into care.

4.1. Limitations

The current research should be interpreted in light of certain limitations. Firstly, childhood adversity was captured via retrospective self-report measures. Although this is not an ideal method for measuring childhood adversity, in adult samples it is often the only method available, as prospective measures or corroboration from other sources (e.g., caregivers, child protection agencies) are often not possible. The questionnaires used in this study (Trauma History Questionnaire and Childhood Abuse and Neglect Questionnaire) have generally demonstrated good test-retest and interrater reliability and construct validity (Hooper et al., 2011; Wilson et al., 2006). Additionally, there is research evidence to indicate more generally that retrospective reports of childhood adversity accurately capture childhood events. For example, a recent prospective cohort

study demonstrated that retrospective recall of childhood adversity in adulthood was associated with measures of adversity prospectively collected in childhood, and both demonstrated relationships with adulthood outcomes including cognition (Reuben et al., 2016). Other research has demonstrated that agreement between retrospective and prospective reports is higher when the retrospective reports were collected via interview format (Baldwin et al., 2019), as was the case in our study. Nevertheless, an important limitation of our work is that we did not have corroborating documentation of childhood adversity through other sources such as child protection agency records, which would be particularly relevant for recall of adversity in very early developmental periods that individuals are unlikely to remember first-hand. Our results should be interpreted with this limitation in mind. The use of multiple-informant sources of childhood adversity (e.g., caregiver reports, child protection documentation and self-report) in future studies would help overcome the limitations of our work.

Secondly, it is important to note that an analysis of discrete ages of abuse occurrence does not take into consideration the cascading effects of childhood traumas (Masten & Cicchetti, 2010; Toth & Cicchetti, 2013). The effect of childhood adversity on development is likely to involve complex interactions with numerous factors such as genetics (Handley et al., 2019; Y. Zhu et al., 2022), as well as both negative and positive experiences occurring later in development (Toth & Cicchetti, 2013). These complex interactions may make it difficult to link distinctive childhood ages of abuse exposure to distal outcomes in adulthood. Prospective studies are ideally suited to the study of sensitive periods and would allow for more comprehensive examination of moderating factors , but to date there is limited prospective research examining childhood adversity and cognitive outcomes (Schaefer et al., 2022). Nevertheless, previous cross-sectional work has supported the concept of sensitive periods, successfully linking ages of childhood abuse to numerous adulthood outcomes including cognition, regional brain volumes, functional brain imaging metrics and psychiatric symptoms (Andersen et al., 2008; Dunn et al., 2016; Humphreys et al., 2018; Pechtel et al., 2014; Teicher et al., 2018; J. Zhu et al., 2019). Prospective research utilizing psychiatric outcomes has provided further support for the concept of sensitive periods, demonstrating that developmental periods in which abuse occurs can differentially predict distinct psychiatric symptoms. For example, a recent prospective study demonstrated that abuse occurring in middle but not early childhood predicted externalizing symptoms in

childhood, which in turn predicted adulthood substance use disorder and antisocial personality disorder, while abuse occurring across multiple developmental periods including early and middle childhood predicted a broader range of psychiatric symptoms in childhood and adulthood psychiatric diagnoses (Russotti et al., 2021). Thus, despite the potential for complex interaction effects, sensitive periods do appear to have predictive value for numerous outcomes in prior research. However, as noted above, there are likely to be numerous moderating factors for the effects of adversity at specific ages, and prospective studies are the best method for studying these complex relationships. Our finding of a sensitive period for abuse associated with relatively higher cognition and our failure to find sensitive periods for regional brain volumes is at odds with prior research, and may reflect unique relationships in our complex sample. Future studies utilizing prospective designs to study cognitive development in relation to sensitive periods of childhood adversity would be of significant benefit.

As a third limitation, we did not have a measure of the developmental timing of adversities besides physical and sexual abuse. Future research on sensitive periods could expand on the present work by examining the impact of development timing of other adversities.

Fourth, a few limitations in our statistical analysis should be noted. Although most participants had completed the questionnaires measuring physical abuse, sexual abuse, foster care and residential mobility, there was a higher proportion of missing data for the measure of adverse home environment (the Childhood Abuse and Neglect Questionnaire). However, it is important to note that results of analyses where missing data was imputed and analyses including original data only were comparable.

The exploratory analyses should be interpreted with some caution given that they were not part of the initial analysis plan and may have been underpowered due to the number of variables tested. These analyses were intended to be exploratory in order to establish potential explanations for our counterintuitive findings, which can serve as a basis for future research.

Finally, it is important to recognize that the current study employed observational examination of the relationships between childhood adversity and cognitive, functional and brain outcomes. This design does not allow for definitive causal conclusions.

Convergence of evidence from multiple lines of research, including animal studies, will contribute to increased confidence in the direction of the relationship between childhood adversity and relevant outcomes.

4.2. Conclusion

In summary, in our sample of marginally housed young adults, we found that foster care was associated with poorer cognition and psychosocial functioning, while history of childhood physical and sexual abuse and higher residential mobility were associated with relatively higher cognition and psychosocial functioning, and neurodevelopmental differences partially explained the latter finding. We suggest that young adults enter into marginal housing through diverse trajectories, including one primarily driven by external stressors such as abuse, and one in which neurodevelopmental factors play a relatively greater role. Future research should seek to further delineate the multiple pathways by which young adults may become marginally housed, and how these pathways relate to cognitive functioning. Importantly, in our study, even the relatively higher-functioning group with childhood adversity still presented with cognitive and psychosocial deficits compared to normative levels, highlighting the ubiquitous need for interventions and rehabilitation efforts that address the burden of cognitive deficits in this vulnerable population.

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Appendix A. Relationships between childhood adversity variables

Table A1. Relationships between childhood adversity variables.

		Residential mobility	Physical abuse	Sexual abuse	Foster care
	r				
Adverse home environment		.25*	.37**	.34**	.01
Residential mobility			-.07	.05	.19*
	χ^2 (phi)				
Physical abuse				9.13 (.30)**	0.48 (.07)
Sexual abuse					0.02 (-.02)
Foster care					

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

Appendix B. Correlations between hippocampal and dorsolateral prefrontal cortical volumes and demographic and adversity variables

Table B1. Correlations between hippocampal and dorsolateral prefrontal cortical volumes and demographic and adversity variables

	Hippocampus [a]	Dorsolateral prefrontal cortex [a]
Age	-.06	-.27*
Gender [b]	-.30**	-.34**
Education	-.13	-.02
Adverse home environment	.06	.07
Physical abuse	-.18	-.08
Sexual abuse	-.14	-.20
Foster care	-.18	-.08
Residential mobility	.10	.01
[a] Average of left and right volumes [b] Male = 0, Female = 1 * $p < .05$ ** $p < .01$		

Appendix C. Results of Analysis 1 with original data

Table C1. Regression of childhood adversity onto memory (HVLT-R) with original data.

	B	Standard error	β	*p*
Block 1 R^2 = .02, *p* = .27				
Age	-0.28	0.28	-.13	.30
Block 2 R^2 = .23, *p* = .02				
Adverse home environment	-.05	.07	-.10	.47
Physical abuse	4.91	1.56	.41	.03
Sexual abuse	-.68	1.72	-.05	.70
Foster care	-3.71	1.69	-.26	.03
Residential mobility	4.18	2.93	.18	.16

Table C2. Regression of childhood adversity onto inhibitory control (Stroop) with original data

	B	Standard error	β	*p*
R^2 = .21, *p* = .01				
Adverse home environment	-0.19	0.13	-.21	.13
Physical abuse	5.22	2.93	.23	.08
Sexual abuse	7.35	3.13	.30	.02
Foster care	-3.62	3.06	-.14	.24

Residential mobility	11.33	5.40	.26	.04

Table C3. Regression of childhood adversity onto psychosocial functioning (RFS) with original data.

	B	Standard error	β	p
Block 1 R^2 = .13, p = .07				
Female	-1.12	1.00	-.16	.27
Male	*ref*	*ref*	*ref*	*ref*
Education	0.41	0.23	.21	.07
Stimulant dependence	-1.33	0.70	-.22	.06
Opiate dependence	-1.39	0.69	-.24	.05
Block 2 R^2 = .40, p < .001				
Adverse home environment	-0.02	0.03	-.09	.46
Physical abuse	-0.35	0.74	-.06	.64
Sexual abuse	2.28	0.93	.36	.02
Foster care	-2.21	0.73	-.33	<.01
Residential mobility	3.65	1.29	.32	.01

Appendix D. Regression model of inhibitory control including neurological soft signs

Table D1. Regression of childhood adveristy and neurological soft signs onto inhibitory control (Stroop)

	B	Standard error	β	*p*
R^2 = .30, *p* = .02				
Adverse home environment	-.011	0.18	-.11	.46
Physical abuse	6.08	3.25	.27	.07
Sexual abuse	5.67	3.48	.23	.11
Foster care	-4.97	3.77	-.17	.20
Residential mobility	5.23	6.22	.12	.41
Neurological soft signs	-0.64	0.31	-.30	.04

Appendix E. Correlations between age of abuse and cognition

Table E1. Correlations between age of physical or sexual abuse and memory and inhibitory control

		Verbal memory (HVLT-R)	Inhibitory control (Stroop)
Age of physical or sexual abuse	*N* with abuse occurring at each age		
Ages 1-3	9	.14	.25*
Age 4	12	.32**	.26*
Age 5	18	.25*	.29*
Age 6	21	.35**	.32**
Age 7	23	.27*	.24*
Age 8	27	.23*	.22*
Age 9	28	.11	.20
Age 10	26	.29**	.24*
Age 11	19	.16	.13
Age 12	24	.15	.09
Age 13	24	.21	.13
Age 14	25	.06	.09
Age 15	21	.37**	.22*
Age 16	26	.35**	.11
Age 17	21	.38**	.18
Age 18	25	.32**	.24*

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