Examining the Role of Childhood Maltreatment, Family History, and Adolescent Cannabis Use in Young Adult Cognition

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Abstract

Childhood maltreatment may have lasting impacts on cognitive performance in young adulthood, but the role of adolescent cannabis use in this association remains unclear. This thesis examined adolescent cannabis use as a mechanism of the association between childhood maltreatment and cognitive performance in young adulthood. Young adults (N=156; 19–25-year-olds) with a history of regular cannabis use completed questionnaires assessing childhood maltreatment and family history of addiction, a cannabis use history interview, and tasks assessing working memory updating, inhibition, set-shifting, and decision-making. Lifetime cannabis use was examined as a mediator between childhood maltreatment and cognitive outcomes, with family history of addiction included as a moderator. Lifetime alcohol use history was included as a parallel mediator to isolate the role of cannabis from co-occurring alcohol use. Sensitivity analyses were run with recent cannabis use as a mediator. In the lifetime use models, history of childhood maltreatment had a significant association with decision-making but not with the remaining cognitive outcomes. Lifetime cannabis and alcohol use were not significantly associated with childhood maltreatment or any cognitive outcomes. Family addiction history did not moderate any associations. The sensitivity analyses revealed unique relationships of childhood maltreatment with recent alcohol use. Finally, recent cannabis use was associated with poorer set-shifting performance. The findings add support to the literature suggesting childhood maltreatment can have long-term impacts on decision-making and suggest that recent rather than distal cannabis use may be a more relevant predictor of cognitive performance. The findings point to potential targets for prevention of cognitive impairments among young adults.

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Cannabis is a widely used substance globally. In 2020, 30.2% of adolescents in the U.S. reported using cannabis at least once in their life, with 14.6% reporting having used in the past month (Johnston et al., 2021). Similarly, in Canada, where recreational cannabis use has been legal since 2018, 44% of 16–19-year-olds reported using cannabis in 2020 (Government of Canada, 2021). Furthermore, the impact of recreational cannabis legalization on rates of use in youth has been a common concern that has been widely discussed with increased recreational cannabis legalization being enacted around the world (McGinty et al., 2016). Cannabis use during adolescence is important to understand as there are potential consequences from heavy use, including psychosis, increased depression, poorer educational outcomes, and cognitive dysfunction (Lorenzetti et al., 2020; Mustonen et al., 2018; Pacheco-Colón et al., 2019).

An important and widely studied consequence of adolescent cannabis use is the potential for lasting impacts on cognition. This is a notable concern as cognitive impairments can have significant behavioural consequences such as increased substance use, worse vocational and academic functioning, and difficulties in completing daily tasks (i.e., taking medication, using electronics, keeping appointments; Jekel et al., 2015; Kuin et al., 2015; Tan, 2009). Executive functioning has received considerable research attention in studies of the cognitive outcomes associated with adolescent cannabis use. Executive functioning is of relevance as it involves higher-order cognitive processes that can help predict a variety of behavioural and psychosocial consequences. Examining the role of childhood or adolescent experiences on executive functioning is crucial as it is a period with continued neural and executive functioning changes (Zelazo & Müller, 2011). Three important facets of executive functioning are working memory updating (i.e., reviewing and updating to the most relevant information presented), set-shifting (i.e., switching between mental tasks), and inhibition (i.e., preventing or interrupting dominant responses; Miyake et al., 2000). Identifying developmental predictors of executive functioning are important as deficits appear to be related to a variety of abnormalities in the posterior, frontal, and parietal regions in the brain (e.g., occipital regions prefrontal cortex, and precuneus; Collette et al., 2006). Deficiencies in executive functioning are also of interest as they are associated with higher rates of substance use in adolescence and young adulthood, poorer adolescent academic achievement, greater frequency and severity of violent offending, and differences in stress-regulation (i.e., risk of greater stress reactivity and slower recovery; Gustavson et al., 2017; Hancock et al., 2010; Samuels et al., 2016; Williams et al., 2009).

While the above executive functioning domains are important to consider, another cognitive construct that is related to executive functioning but has garnered less research attention in studies of the effects of cannabis is decision-making. Decision-making refers to the cognitive process behind an individual making a choice to obtain or avoid certain outcomes and can be influenced by punishments, rewards, perceptions, and values (Miyapuram & Pammi, 2013). Impairments in decision-making, such as making risky choices, are associated with neural activations involving cognitive-emotional processes (e.g., anterior cingulate cortex, dorsolateral prefrontal cortex, and bilateral orbitofrontal cortex; Rodrigo et al., 2014) as well as potential impairments in the ventromedial prefrontal cortex (Bechara et al., 2001). Decision-making impairments are also related to substance and behavioural addictions, as well as increased aggressive behaviour (Bechara et al., 2001; Ko et al., 2017; Kuin et al., 2015).

Looking at these cognitive processes from a developmental perspective, there is evidence that executive functioning develops into two categories: “cool” and “hot” executive functioning.

Cool executive functioning involves more abstract, basic cognitive processes, and emotionally neutral processes (i.e., working memory updating, inhibition, set-shifting), whereas hot executive functioning processes involve higher affect involvement and incentive value (i.e., decision-making in risk/reward-related contexts; Zelazo & Carlson, 2020; Zelazo & Müller, 2011). Further, there are important neural differences between the two cognitive processes; cool executive functions involve activation of the dorsolateral pre-frontal cortex and superior medial areas while hot executive functions typically involve the ventral prefrontal cortex and polar frontal cortex (Stuss & Levine, 2002). With key developmental and neural differences, it is important to evaluate how adolescent cannabis use may have unique impacts on cool executive functioning performance domains like working memory updating, inhibition and set-shifting compared to hot processes like decision-making in reward-related contexts.

Importantly, there is a breadth of evidence linking cannabis use to poorer executive functioning and decision-making. Notably, cannabis use in adolescence is associated with worse executive functioning particularly in inhibition and working memory and other cognitive domains (e.g., processing speed and memory; Lisdahl et al., 2014). Furthermore, starting cannabis use at an early age (i.e., use before age 15), which theoretically would lead to greater cumulative use across adolescence, is associated with poorer executive function compared to later use (Fontes et al., 2011; Pope et al., 2003). This impact of adolescent cannabis use is significant as it suggests that the developing brain may be more sensitive to the effects of cannabis. In regard to decision-making, cannabis use is associated with poorer decision-making on multiple gambling tasks (Casey & Cservenka, 2020; Lisdahl et al., 2014; Whitlow et al., 2004). Additionally, adolescent cannabis use disorder (CUD) is associated with greater neural activity while making risky or uncertain decisions compared to controls, indicating the role of cannabis use in decision-making (De Bellis et al., 2013). Potential explanations for poorer decision-making in cannabis users involve heightened sensitivity to rewards and lower aversion to punishment (Fridberg et al., 2010). However, there are some mixed findings in this literature, with some studies reporting null associations between adolescent cannabis use and cognitive performance (Schaefer et al., 2021; Takagi et al., 2011). Further, it is still unclear whether greater cannabis use in adolescence has a lasting impact on cognition into young adulthood (Pacheco-Colón et al., 2021). There also remains a need to understand how risk factors for adolescent cannabis use may factor into the relationship between cannabis and cognition to get a clearer picture of those at a greater risk of cognitive impairments.

Childhood experiences, particularly childhood maltreatment such as experiences of abuse or neglect, may be linked with adolescent cannabis use and may therefore play a role in young adult cognition. Indeed, adverse childhood experiences have been associated with a variety of cognitive outcomes in adulthood, including lower Intelligence Quotient (IQ) scores and differences in cognitive task performance compared to non-exposed individuals (Lewis et al., 2021; Navalta et al., 2006). More specifically, childhood maltreatment and exposure to a broad range of traumatic experiences as defined by the Diagnostic and Statistical Manual of Mental Disorders have been associated with poorer executive function performance (e.g., working memory) and riskier decision-making in a gambling task (Lewis et al., 2021; Majer et al., 2010; Stoltenberg et al., 2001). Furthermore, there is evidence that childhood maltreatment is associated with weakened attention and inhibitory control (Marshall et al., 2016; Navalta et al., 2006). Childhood maltreatment and trauma are also associated with decreased frontal theta activity during inhibition tasks and can even strengthen the relationship between inhibition and decreased neural activity (Burri et al., 2013; Zhai et al., 2019). Despite this evidence, there is still a need to better understand the mechanisms that could explain the relationship between childhood maltreatment and lasting cognitive consequences in young adulthood.

One possible mechanism could be cannabis use given higher rates of use within trauma-exposed individuals. Lifetime trauma exposure is associated with cannabis use and risk of CUD (Kevorkian et al., 2015). Looking at adverse childhood experiences specifically, there are associations between exposure and greater adult cannabis use in the past month (Rogers et al., 2021). Childhood maltreatment has also been found as a predictor for greater cannabis use during early adolescence, which is associated with worsened cognition (Banducci et al., 2018; Fontes et al., 2011; Pope et al., 2003). Given the evidence showcasing childhood maltreatment and cannabis use overlap, it is possible that adolescent cannabis use may be one factor that partially explains the variance between childhood maltreatment and young adult cognitive outcomes. However, the associations between cannabis use, childhood maltreatment, and cognition require further exploration as there have been no studies evaluating all these relationships together. There remains a need to examine if adolescent cannabis use is a mechanism that can help to explain the relationship of childhood maltreatment with young adult cognition. A better understanding of the role of adolescent cannabis use in this link can provide insight into the potential need for cannabis intervention strategies to help mitigate cognitive consequences among those at risk due to childhood maltreatment.

To understand the relationship between childhood maltreatment and cannabis use, it is also important to examine potential variables that may strengthen or weaken the associations. Family history of substance use disorder may play a role in adolescent cannabis use as it can lead to increased substance use exposure in youth and result in lower parental monitoring towards their substance use (Hill et al., 2018; Kerr et al., 2015). Family history is also relevant as there is evidence that genetic factors and heritability contribute to substance use in adolescence (Young et al., 2006). Intergenerational substance use is consistently supported across a variety of studies, suggesting that parental substance use can predict prevalence of their child's substance use (Knight et al., 2014; Madras et al., 2019; O'Loughlin et al., 2019). Thus, it is possible that individuals who are exposed to childhood maltreatment may be more likely to use cannabis in adolescence if they also have a family history of alcohol/substance use problems. Specifically, individuals with a family history of substances may learn to use substances as a coping mechanism due to increased exposure to substance use from their parents, lower parental monitoring surrounding their use, or they may have a genetic predisposition toward substance use. Theoretically, these factors may create a home environment more conducive to substance use, increasing the likelihood that individuals who have experienced childhood maltreatment may turn to cannabis as a coping mechanism rather than more adaptive coping strategies. However, no studies have yet examined the role of family substance use disorder history in the link between childhood maltreatment and adolescent cannabis use. Thus, it is important to further examine how family history of substance use disorder may influence the strength of the relationship between childhood maltreatment and adolescent cannabis use, which could then lead to worsened cognitive performance in young adulthood.

The Present Study

Currently there is a gap in the literature in understanding the pathways that connect childhood experiences and adolescent cannabis use with young adult cognitive outcomes. This study aimed to help elucidate possible mechanisms underlying the relationship between childhood maltreatment and young adult cognitive performance. Specifically, this study examined adolescent cannabis use history (i.e., cumulative use from age of onset to present) as an explanation for worse executive function performance and impaired decision-making in young adults who were exposed to childhood maltreatment. Additionally, family substance use disorder history was examined as a variable that may impact the strength of the relationship between childhood maltreatment and adolescent cannabis use which would eventually lead to worsened cognitive performance.

This study also considered potentially important confounds in this association. For example, during adolescence and young adulthood, the use of alcohol with cannabis is common (Patrick et al., 2019). Given that alcohol use is also known to have negative effects on cognitive performance (Bernardin et al., 2014), it is important to isolate the potential impacts of cannabis use on young adult cognitive performance from the impacts of alcohol use. Age of cannabis use onset was also considered as a covariate, as there is evidence that earlier cannabis use initiation can predict later cannabis use problems, and thus one would expect earlier age of onset to be associated with greater rates of use during adolescence (Winters & Lee, 2008). Further, as young adults with greater use of cannabis during adolescence are also more likely to be current heavy cannabis users (Homel et al., 2014), it is also important to elucidate if any cognitive impacts of lifetime cannabis use can be explained primarily by recent cannabis use. Thus, the present study includes a sensitivity analysis to compare the role of total lifetime cannabis use with recent cannabis use. Demographic variables were also considered. Both sex and age were included as they can be associated with cannabis use differences (Cuttler et al., 2016; Mauro et al., 2018). Family income during childhood was also considered to account for potential effects of socioeconomic status on cognitive performance (Duncan & Magnuson, 2012). Further, an estimate of premorbid intelligence was included to control for variance in cognitive performance attributable to lower IQ, to help ensure observed associations are specific to decision-making and executive functioning and are not just an artifact of differences in general intelligence.

I hypothesized that total lifetime cannabis use would partially explain the association between childhood maltreatment and young adult cognitive outcomes, such that exposure to childhood maltreatment will lead to higher overall levels of cannabis use, which in turn will lead to worsened cognitive performance (i.e., lower executive functioning task scores and worse decision-making quality). Further, I predicted that a family history of substance use disorder would strengthen the relationship between childhood maltreatment and lifetime cannabis consumption.

Method

Participants

This study involved data from a larger study of cognitive outcomes among young adults who use cannabis. Participants were 160 young adults aged 19 to 25 from the Toronto area who reported at least one period of regular cannabis use throughout their lifetime (i.e., using at least twice a month over a six-month period). Data were collected between late 2018 (after legalization of recreational cannabis in Canada) and early 2020 (prior to the COVID-19 pandemic). Participants were recruited through online advertisements (e.g., Facebook, Google ads, Kijiji), postering around the community (e.g., university and college campuses), and postings on the Centre for Addiction and Mental Health (CAMH) Research Registry/Research Connect. Exclusion criteria involved a history of severe head injury, current or past treatment for alcohol or substance use, monthly use of recreational drugs other than cannabis, a history of mania, psychosis, neurological or neurodevelopmental disorders, or cannabis use for exclusively medical reasons. Participants also had to be fluent in English.

Out of the 160 participants recruited, four were missing data surrounding childhood maltreatment, leaving a final sample of 156 young adults for the current analysis. Mean age of participants was 22.22 (*SD* = 2.06, range = 19-26), with 59% of participants reporting birth sex as female, and 51% reporting their race as White. The majority of participants were currently enrolled as a student (66.7%), with a mean annual household income of $50,000 - $59,999 (CAD). Regarding family income while growing up, participants reported a mean income of $80,000-$99,999. Additional demographic information can be found in Table 1.

Procedure

Interested individuals were first sent a link to complete an online eligibility survey. Eligible participants were asked for an email address and were contacted to schedule a 6-hour in-person appointment. All sessions were scheduled to begin between 10am and 12pm. Eligible participants were also told they would be required to abstain from cannabis and alcohol use for 48 hours prior to their assessment.

The in-person sessions were conducted by trained research assistants with Master's degrees. Participants first completed informed consent, followed by a urine drug screen and breathalyzer to confirm absence of recent illicit drug use as well as a blood alcohol concentration of zero at the time of testing. Participants with a positive urine drug screen for a drug other than cannabis were still included if they had a prescription for a medication that would account for the positive result or they reported a pattern of occasional use of the drug that would still make them eligible (i.e., using less than once per month). Participants were also asked to confirm abstaining from alcohol and cannabis use over the past 48 hours. Participants who reported using cannabis (N= 11; 7.1%) and/or alcohol (N = 6; 4%) within the past 48 hours were also included, as long as they reported no use on the day of the session, were free of observable signs of intoxication, and produced a breathalyzer reading of 0.00. Additional screening was also conducted at the beginning of the session to confirm other eligibility criteria related to head injury, mental health, and substance use history.

Eligible participants then underwent an extensive cognitive battery, and completed interviews for substance use history, and a variety of self-report questionnaires. The relevant cognitive tests and questionnaires pertinent to the current study are described below. Order of administration for cognitive tasks was randomized across participants using a Latin Square design. Participants were encouraged to take breaks every 90 minutes and were given a 30-minute lunch break after the cognitive testing before completing interviews and questionnaire assessments. Participants were compensated a total of $100 for completing the assessment and were offered a $15 allowance for lunch.

Measures

Demographics

Participants completed a demographics questionnaire assessing age, sex, income, and various other factors.

Estimated Premorbid Intellectual Functioning

Participants completed the Test of Premorbid Functioning, a brief assessment that estimates premorbid IQ (Wechsler, 2011). Participants viewed a series of irregularly spelled words and were asked to verbally pronounce each word to the best of their ability. Estimated premorbid intelligence was derived from total number of words pronounced correctly, which was converted to an age-normed standard score.

Childhood Maltreatment

Childhood maltreatment was measured with the Childhood Trauma Questionnaire-Short Form (CTQ-SF), a 25-item retrospective self-report questionnaire that assesses adverse childhood experiences (Bernstein et al., 2003; see Appendix A). The CTQ-SF measures childhood experiences of physical, emotional, and sexual abuse, and emotional and physical neglect. Answers are coded on a 5-point likert scale from 0 "*Never*" to 4 "*Very Often*" (Bernstein et al., 2003). Scores can range from 0 to 100. The CTQ-SF has shown to be a valid and reliable measure for clinical and community samples (Bernstein et al., 2003). Internal consistency for the present sample was acceptable (Cronbach's $\alpha = .75$).

Family History of Substance Use Disorder

Family substance use disorder history was assessed with items adapted from the National Epidemiologic Survey on Alcohol and Related Conditions (National Institute on Alcohol Abuse and Alcoholism, n.d). Participants were asked to report on each family member - both biological parents, siblings, aunts and uncles, and grandparents – if they had a history of alcohol and/or drug use disorder. For each family member, response options included *"Alcohol Abuse", "Drug Abuse", "No Abuse"* and *"Not Applicable".* For this study family history of substance disorder focused on parental use. Family substance use disorder history was dichotomized and coded as "1" for any history of alcohol and/or drug use disorder among either parent and "0" for neither parent has a history of substance/alcohol use disorder.

Cannabis and Alcohol Use History

Lifetime cannabis use history was assessed with an interview adapted from a validated interview for lifetime alcohol use history (i.e., The Cognitive Lifetime Drinking History; Russell et al., 1997; see Appendix B for script procedures). Questions surround age of first cannabis use and monthly patterns of cannabis use (e.g., quantity and frequency of use) throughout the participant's entire lifetime. The interview utilized individualized events and milestones to aid in participant recall (e.g., significant birthdays, entering a new school, high school graduation, entering university, etc.).

For the current study, we focused on cumulative cannabis exposure from use onset to present. For the study, cumulative cannabis exposure was measured in terms of total number of cannabis grams consumed in the lifetime, and so these analyses excluded other non-flower forms of cannabis. This was done as quantifying use of other forms of cannabis (e.g., vape oils) can be difficult and different forms of cannabis vary in potency and so it is not viable to aggregate quantity across multiple forms of cannabis used. Further, cannabis flower was overwhelmingly the most common form of cannabis used in the current sample. In a similar fashion to cumulative cannabis exposure, total exposure to alcohol was captured through lifetime alcohol quantity, measured through total number of standard drinks consumed in the lifetime. To aid participants with cannabis and alcohol quantity recall they were provided with a chart depicting sizes for cannabis flower grams in different forms (i.e., flower nugget, joint, or ground flower; see Appendix C) and a standard drink chart across different forms of alcohol (i.e., beer, wine, or liquor; see Appendix D). Finally, age of onset of regular cannabis use (onset of regular use defined as once a month for six months) was included as a covariate. All measures included were used as continuous variables.

Recent Cannabis and Alcohol Use

The timeline follow back (TLFB) is a well-validated interview to capture substance use over the past 90 days (Sobell & Sobell, 1992). The TLFB was used to capture recent cannabis and alcohol use which were examined in additional sensitivity analyses (see Appendix E for script procedures). The TLFB utilizes a calendar method where the interviewer asks for each day over the past 90 days whether cannabis was used, the route of cannabis administration, the number of grams of cannabis flower used, and the number of standard alcohol drinks consumed. To aid in participant recall, a cannabis substitute (oregano) was shown to participants to give a visual aid for different cannabis flower quantities. Participants were also provided with the same quantity charts for cannabis and alcohol used in the lifetime history interview. Recent cannabis use was measured with total grams of cannabis flower consumed in the past 90 days. Similarly, recent alcohol use was captured through total number of standard drinks consumed in the past 90-days.

Decision Making

Decision making was measured with a version of the Cambridge Gambling Task (CGT; Rogers et al., 1999) that has been programmed for administration via Inquisit (Millisecond software, Seattle, WA). The CGT asks participants to decide if a yellow token is hidden inside a red or blue box. A correct score adds the “bet” amount to their total points, while an incorrect score subtracts from their score. The CGT consists of an ascending order condition, where bets increase in value, and a descending order condition, where bets become smaller over time (Rogers et al., 1999). Each condition was made up of three bet sequences. The participants started with 100 points at each sequence and were encouraged to increase the number of points. The bets available were a fixed percentage of the participant’s total score; either 5%, 25%, 50%, 75%, or 95% (Rogers et al., 1999). The CGT’s shifting probability of correct responses provides insight into decision-making quality with the best choice index, which measures the percent of trials where the best choice was made. Higher scores suggest higher quality decision-making (Rogers et al., 1999).

Executive Functioning

Inhibition. The Stop-Signal Task (administered via Inquisit software) was used to assess inhibition (Logan & Cowan, 1984; Verbruggen et al., 2008). Participants first viewed a fixation point, followed by the presentation of a stimulus. Participants were instructed to respond to the stimulus - by hitting the corresponding key - as quickly as possible, but to inhibit responding when they hear an auditory tone. The delay between the presented stimulus and the auditory tone for subsequent trials was adaptive, with difficulty increasing or decreasing in order to achieve a target inhibition rate of 50% for each participant. For every successful stop trial, the delay increased, and for incorrect trials the delay between stimuli and tone decreased. Inhibition was measured through Stop Signal Reaction Time (SSRT; Verbruggen et al., 2008), which provides an overall measure of inhibition through average latency of the stop process in relation to presentation of the stop trial. Higher SSRT indicates greater time to stop response suggesting poorer inhibition. SSRT data was cleaned and seven outliers were dropped according to criteria developed in Congdon et al. (2012). SSRT data was dropped if i) there was less than 25% or greater than 75% inhibition on stop trials, as the target inhibition rate for the adaptive task was 50%; ii) there was less than 60% Go-Response hits; iii) there was greater than 10% Go-Response misses; and iv) there was a negative SSRT estimate or one that was less than 50 milliseconds (Congdon et al., 2012).

Working Memory Updating. Working memory updating was measured through the N-Back Task (Jaeggi et al., 2003), administered on the computer with Inquisit software. During the task participants viewed a sequence of abstract shapes for two conditions: 2-back and 3-back. In the 2-back condition, participants were instructed to press the A key if a shape matched the image presented two images prior. The 3-back followed the same procedure but participants were identifying if an image matched the one three items prior (Jaeggi et al., 2003). Participants' proportion of correct responses for number of experimental blocks for both conditions were combined to create an overall mean score for working memory updating performance, with higher scores indicating better working memory updating.

Set-Shifting. Finally, the Category Switch Task (CST) was used to examine set-shifting, which is the ability to shift between different types of mental demands (Friedman et al., 2008; Mayr & Kliegl, 2000). The CST was administered on the computer using Inquisit software. Participants were presented with 16 words and were instructed to judge the word based on whether it is larger or smaller than a basketball, or if it is living or non-living. Half the test trials were switch trials, where the participant was instructed to change what category they were responding to from the previous trial, and half were non-switch trials. The presentation of the cues was randomized. For example, participants could have been required to classify living or non-living for four rounds, followed by size for four rounds. Participants were given a prompt on the computer screen to indicate which condition the word was being judged on. Overall set-shifting performance was measured through mean latency for correct responses, with greater latency suggesting poorer set-shifting performance (Friedman et al., 2008).

Data Analysis

A moderated mediation model is used to test whether a proposed indirect (i.e., mediated) association is influenced by another (i.e., moderated) variable (Edwards & Konold, 2020). A moderated mediation model was used to examine the hypothesized indirect associations between childhood maltreatment and poorer cognitive performance mediated through cannabis use history, as well as the moderating effect of family history of substance use disorder on the relationships between childhood maltreatment and adolescent cannabis use. Analyses were run in

MPlus software using a path analysis. The main models of interest examined the indirect path from childhood maltreatment (total CTQ-SF scores) to cognitive performance outcomes through the main mediator of total cumulative lifetime cannabis consumption. Additionally, lifetime alcohol consumption was included as a parallel mediator to isolate the role of cannabis use in the model from the potential overlapping role of alcohol use. Age of cannabis use onset was also included to control for potential confounding effects of earlier cannabis use onset. Substance use variables were allowed to freely covary with one another in all models. This resulted in four total models, one for each of the cognitive performance outcomes: decision-making (CGT best choice), working memory updating (mean N-back scores), inhibition (SSRT), and set-shifting (mean latency scores from the CST). Within each path analysis, family history of alcohol and drug problems was examined as a moderator of the association between total CTQ-SF score and lifetime use of cannabis and alcohol. To so do, an interaction variable was created by multiplying the dichotomous variable of family history with total CTQ-SF scores after mean-centering the CTQ-SF variable. The interaction of family history and childhood maltreatment was dropped in models if not significant in order to facilitate interpretation of the main effects.

Sex, age, childhood family income, and estimated premorbid intelligence were included in all models as covariates, with all outcomes and mediators regressed on these covariates. Regarding childhood family income, 4.5% of participants were missing responses. To prevent dropping these participants from analyses as a result of missing covariates, missing values on the childhood family income variable were dealt with using mean imputation. Further, hours since last cannabis use was included as a covariate predicting cognitive outcomes to control for potential acute or residual effects of recent cannabis use on cognition. This variable was calculated by subtracting the date and start time of the cognitive testing session from the date and time of last cannabis use reported by the participant when they arrived at the session. The mean number of hours since last cannabis use was 367.79 (*SD* = 1323.42) and ranged from 14.42 hours to 14,592 hours. Extreme outliers reflecting last use of cannabis greater than three weeks ago were winsorized to 505 hours (one hour above three weeks since last use) in order to reduce their influence in the models.

For the sensitivity analysis looking at the role of recent cannabis use, four additional models were run, swapping in past 90-day cannabis and alcohol use for the lifetime use variables. To be consistent with the operationalization of lifetime use, recent use was measured with total number of cannabis grams and total standard drinks consumed over the past 90 days. Recent use was run in separate models rather than including recent use variables as covariates or parallel mediators with lifetime use variables as there were high correlations between recent and lifetime cannabis use (r = .62), which could result in multicollinearity by including them in the same models.

To evaluate the significance of direct and indirect associations 95% bias-corrected bootstrapped confidence intervals were obtained (Hayes, 2015). Estimates were deemed to be statistically significant if the 95% confidence interval did not include zero. Standardized estimates were obtained for all path coefficients as the units were not the same across all variables making direct comparisons of unstandardized coefficients difficult. For both lifetime and recent cannabis and alcohol quantity variables, extreme outliers were winsorized (i.e., recoded to one unit above the next highest non-outlying value) prior to analyses (Tabachnick & Fidell, 2007). Due to the complexity of the models for the given sample size, control variables (i.e., age of cannabis use onset, time since last cannabis use, sex, age, estimated premorbid intelligence, and childhood family income) that did not have significant associations across any of the models were removed from the models to improve parsimony. Models were first run with all interactions and main effects across all cognitive outcomes. Participants with missing data for cognitive outcomes were excluded from the respective models, resulting in a total sample size of 155 for decision-making, 154 for working memory updating, 149 for inhibition, and 155 for set-shifting.

Results

Descriptive Statistics

Means, standard deviations, ranges and bivariate correlations for variables of interest are shown in Table 2. The highest correlation was seen between lifetime cannabis use and recent cannabis use (r = .62) followed by lifetime cannabis and lifetime alcohol use (r = .50). Total CTQ scores were significantly correlated with decision-making, lifetime cannabis use, recent cannabis use, lifetime alcohol use, recent alcohol use, and family history of addiction (Table 2). The only significant correlations among cognition and substance use variables was greater working memory updating with greater recent alcohol use and poorer set-shifting with greater recent cannabis use. Examination of scatterplots did not indicate any extreme multivariate outliers that may be driving the associations of interest in the models.

The mean age of onset for cannabis use was 18.05 years old (*SD* = 2.83) and ranged from 11.58 to 24.83 years old. The average number of cannabis flower grams consumed over the lifetime was 574.69 (*SD* = 1142.97) and ranged from 0.00[1] to 5685.00 grams consumed, indicating a wide range of lifetime cannabis exposure. Regarding family history, 17.9% of participants endorsed parental history of drug and/or alcohol use problems. Mean estimated

[1] All participants reported a history of regular cannabis use, but 1.3% (N=2) of participants reported only using non-flower cannabis, thus reported zero grams of cannabis flower.

premorbid intelligence was 120.08 (*SD* = 7.70), which did represent a higher estimate of functioning as the sample mean was over one standard deviation above the population mean (*M* = 100, *SD* = 15).

Model Trimming

The interaction between family history of substance use disorder and childhood maltreatment was not a statistically significant predictor of cannabis variables or cognitive outcomes in any of the models (all 95% CIs contained zero). As a result, the interaction was removed from all models and only a main effect of family history was examined. Further, there were no significant paths from childhood maltreatment to age of cannabis use onset nor from age of onset to any cognitive outcome across the initial models. Thus, age of cannabis use onset was removed from the models to reduce complexity. Hours since last cannabis use also did not reveal any significant associations with any cognitive outcome and was thus removed from the models. All other covariates showed a significant association in at least one model, so they were retained in all models. Thus, each of the final models included paths from childhood maltreatment to parallel cannabis and alcohol mediators (lifetime or recent exposure) to the respective cognitive outcome while controlling for sex, age, childhood family income, estimated premorbid intelligence, and family substance use disorder history.

Lifetime Use Models

All estimates and confidence intervals for the lifetime use model predicting decision making can be seen in Table 3. The direct association of childhood maltreatment on decision-making (*c*' path) was significant (see Figure 1a) such that higher childhood maltreatment scores were associated with poorer decision-making quality on the CGT. However, the indirect association through lifetime cannabis use was not significant. Both the path from childhood maltreatment to lifetime cannabis use (*a1* path) and the path from lifetime cannabis use to decision-making quality (*b1* path) were non-significant (see Figure 1a). For total number of standard drinks consumed, there was no significant path from childhood maltreatment to alcohol use (*a2* path) or from alcohol use to CGT performance (*b2* path), nor was the indirect association of childhood maltreatment to CGT through lifetime drinks consumed significant (see Figure 1a). However, there was a significant main pathway from family history of substance use disorder to lifetime drinks consumed, such that endorsing parental history of alcohol or substance use problems was associated with greater lifetime number of drinks consumed (see Table 3).

In the models examining executive function domains, the paths from childhood maltreatment and family history of substance use disorder to lifetime cannabis and alcohol use were consistent with those observed in the decision-making model (see Tables 4,5,6). In the working memory updating model, no variables significantly predicted N-back performance, other than estimated premorbid intelligence (see Table 4). Also, there were no significant associations between lifetime cannabis or alcohol use and N-back score, nor were there any significant indirect associations from childhood maltreatment to working memory performance through either lifetime cannabis or alcohol use (See Figure 2a). The inhibition models revealed similar findings (see Table 5). The only significant association to SSRT score was age, and there were no significant indirect associations from childhood maltreatment to SSRT score (see Figure 3a). Finally, in the set-shifting model, there were no significant associations to CST latency (see Table 6) or significant indirect relationships through either lifetime cannabis or alcohol quantity consumed (see Figure 4a).

Recent Use Models

In the model examining the paths from childhood maltreatment to decision-making, the direct path (*c'*) from childhood maltreatment to decision-making quality was significant at the 90% CI: [-.452, -.038] but not the 95% CI, with greater childhood maltreatment scores associated with poorer decision-making quality (see Figure 1b). There was also a significant path from childhood maltreatment to recent (past 90-day) alcohol use (*a2* path: see Figure 1b), whereby greater childhood maltreatment was associated with fewer standard drinks consumed. The 95% CI for the path from childhood maltreatment to recent cannabis use contained zero; however, the 90% CI: [.015, .300] did not contain zero, suggesting that greater childhood maltreatment was marginally associated with greater recent cannabis grams consumed (i.e., $p < .10$). Further, there were no significant indirect paths through either recent use variable and neither the path from recent cannabis nor recent alcohol use to CGT scores was significant. Finally, the main effect of family history of drug and alcohol problems to recent standard drinks consumed, similar to the relationship in the lifetime exposure model, was significant (see Table 7).

Interestingly, there was a significant pathway of recent cannabis use to set-shifting performance (*b1* path; see Figure 4b). That is, greater grams of cannabis used in the past 90 days was associated with greater CST latency scores, indicating a slower set-shifting response. However, in this model, the path from childhood maltreatment to recent cannabis use was non-significant. Still, there was a marginally significant indirect association of higher childhood maltreatment to poorer set-shifting through greater recent cannabis use, as the 90% CI: [.004, .110] was significant but not the 95% CI, whereas the direct association of childhood maltreatment to set-shifting was not significant (see Figure 4b). Additional pathways in the set-shifting outcome model can be found in Table 8.

Looking at working memory outcomes, only estimated premorbid intelligence was associated with N-back performance (see Table 9). There was no significant direct association of childhood maltreatment to N-back performance nor indirect paths through either recent use variable (see Figure 2b). Similar findings were revealed in the inhibition models, as no path, other than age was significantly associated with SSRT performance (see Table 10). Further there was no significant direct or indirect paths found for childhood maltreatment in this model (see Figure 3b). However, the indirect path of childhood maltreatment to inhibition through recent alcohol use was marginally significant: although the 95% CI contained zero, the 90% CI: [-.092, -.005] did not contain zero, suggesting a trend level association (i.e., $p < .10$).

Discussion

Given continued liberalization of cannabis use policies and widespread use among youth, understanding the long-term consequences of adolescent cannabis use on cognition is of increasing importance. The goal of the present study was to examine the role of lifetime and recent cannabis use in risk pathways between childhood maltreatment and young adult cognitive performance. Further the study explored the potential for family history of addiction to strengthen relationships between childhood maltreatment and cannabis use. Overall, contrary to my first hypothesis, there was no support for the mechanistic role of greater lifetime cannabis use in the relationship between childhood maltreatment and young adult cognitive performance in the domains of executive functioning and decision-making. Additionally, in opposition to my second hypothesis, family history of substance use disorder did not significantly interact with childhood maltreatment, nor did it influence adolescent cannabis use. However, a few select associations were revealed: a direct path from childhood maltreatment to decision-making, a path between recent cannabis use and set-shifting, and associations of family history of substance use disorder with lifetime and recent alcohol use. These findings are discussed in greater detail below.

The Role of Childhood Maltreatment

An important finding was that greater childhood maltreatment was directly associated with poorer decision-making quality, in the lifetime use model, and near threshold for significance in the recent cannabis use model (i.e., although 95% CI contained zero, the 90% CI did not), with 18% of the variance in decision-making quality explained by the predictors in the lifetime cannabis use model and 17% in the recent use model. This finding is relevant as it adds support to the literature showing that childhood maltreatment can have lasting impacts on decision-making (Lisdahl et al., 2014; Stoltenberg et al., 2001). As many previous studies have focused on risky choices as an index of decision-making impairment, this study extends the current literature to the impact of childhood maltreatment on overall quality of decision-making. Yet, the findings actually conflict with a recent study that found no significant impacts of childhood maltreatment on decision-making quality (Warmingham et al., 2021). However, the Warmingham et al (2021) study targeted a more ethnically diverse young adult sample, which may suggest differences in childhood maltreatment impacts across different backgrounds. As the study did find only a low proportion of variance of decision-making explained by the model, this may add support to other factors not included in this study that should be explored. As our study focused on a cannabis using population, which was not examined in the Warmingham et al. (2021) paper, it may also reveal unique impacts of childhood maltreatment in a cannabis using sample. Further, there was a key methodological difference between the current study and Warmingham et al. (2021) in how childhood maltreatment was measured. While the current study utilized retrospective self-reports the Warmingham et al. (2021) study utilized childhood protective services records to identify cases with recorded maltreatment which may also contribute to differences in the relationship between maltreatment and decision-making quality.

In contrast with the decision-making model, the direct influence of childhood maltreatment was not observed for the three executive functioning outcomes. This lack of an association contradicts the majority of previous research, which has found support for associations between childhood maltreatment experiences and poorer executive functioning, such as working memory and inhibitory control (Hawkins et al., 2021; Lewis et al., 2021; Majer et al., 2010; Marshall et al., 2016; Navalta et al., 2006). The contradicting findings between decision-making and executive functioning may suggest unique impacts of childhood maltreatment on different domains of executive functioning (e.g., hot vs. cool processes). As working memory updating, inhibition, and set-shifting involve different neural mechanisms compared to decision-making (Stuss & Levine, 2002), the findings may reveal specific long-term neurological consequences of childhood maltreatment.

However, it should be noted that the current study did not specifically target a sample with childhood maltreatment, thus it may be that the study represented a lower-level severity than previous research where any long-term executive functioning consequences may have been more subtle and difficult to detect. Further, the sample does represent individuals with high cognitive functioning as it was largely comprised of young adults enrolled in university or who had completed a Bachelors degree. Additionally, the sample had a higher estimate of premorbid intelligence (M = 120.08), greater than one standard deviation (SD = 15) above the population mean (M =100). With this higher level of intellectual functioning, individuals with greater cognitive impairments were not well represented in this sample, thus any effect of childhood maltreatment would be minor or difficult to detect. Future research with a more representative IQ sample may provide deeper insight into long-term cognitive consequences of childhood maltreatment and unique impacts on different cognitive processes. Finally, as the mean family income of the sample was also higher it is possible that even when reporting an early trauma experience, higher socioeconomic status of participants may have buffered against the risks associated with trauma (Amso et al., 2019; Nazri et al., 2021).

Associations with Lifetime Cannabis and Alcohol Use

My results revealed no relationship between childhood maltreatment and lifetime cannabis use (or lifetime alcohol use for that matter), nor did lifetime use history relate to any cognitive outcome. This finding contrasts with some of the extant literature suggesting that childhood maltreatment does predict adolescent cannabis use and related problems (De la Peña-Arteaga et al., 2021; Rogosch et al., 2010). The lack of an association between childhood maltreatment and lifetime cannabis use was surprising and may suggest other variables better account for the relationship between the two. For example, as sex was associated with lifetime and recent cannabis use in the models, controlling for sex may have attenuated the relationship. Also, a confound that may have played a role was alcohol use, as lifetime alcohol use was significantly correlated with both lifetime cannabis use and childhood maltreatment, and thus may have accounted for relationships between childhood maltreatment and cannabis use. Further, there were significant associations between estimated premorbid intelligence and both lifetime and recent cannabis use that were controlled for in the models. These potential confounds may not have been accounted for across all studies of the link between childhood maltreatment and cannabis use, which might help to explain discrepancies in the findings. Motives for cannabis use may also represent an important moderating factor in the link between maltreatment and cannabis use. Coping motives specifically have shown to be an important explanatory factor between childhood maltreatment and young adult cannabis use (Brammer et al., 2022). Thus, it could be the case that cannabis use motives, such as coping, may modify the relationship between childhood maltreatment and lifetime cannabis use such that the relationship would only be present for individuals with higher cannabis coping motives. As the current study did not examine the role of cannabis use motives, future research should examine coping motives in the relationship between childhood maltreatment and cannabis use.

The findings that lifetime cannabis use was not associated with any cognitive outcome contributes to the mixed findings for this relationship. Indeed, while some studies have found adolescent cannabis use can negatively impact cognitive performance (Castellanos-Ryan et al., 2017; Lisdahl et al., 2014), others have found weaker or null associations. For example, Schaefer et al. (2021) found that while adolescent cannabis use did have some associations with young adult educational outcomes and socioeconomic status in young adulthood, the effects of cannabis on a variety of cognitive domains were weak. The Schaefer et al. (2021) study suggests that adolescent cannabis use may not have long-lasting consequences on cognitive performance, but instead is more relevant for consequences in functional domains. My findings support this lack of a long-term effect of lifetime cannabis use on cognitive performance. It should also be noted that lifetime substance use was collected retrospectively in this study. It is possible that the long timeframe considered in retrospective recall led to the reports being less reliable and thus may have weakened relationships. The relationship between adolescent cannabis use and cognitive performance in adulthood has been supported in previous cohort and longitudinal studies (Castellanos-Ryan et al., 2017; Scott et al., 2017), suggesting longitudinal methods may be better at detecting relationships between adolescent cannabis use and cognitive performance.

Another finding of note was that while family history of substance use disorder did not interact with childhood maltreatment, it was associated with greater lifetime and recent alcohol use, suggesting the importance of early life exposure to substance use for future drinking levels. The validity of parental alcohol use problems to predict offspring alcohol use has been supported in a variety of previous studies (e.g., Alati et al., 2014; Lieb et al., 2002). However, the lack of a relationship between family history of substance use disorder and cannabis use was inconsistent with previous research (Knight et al., 2014; Madras et al., 2019; O'Loughlin et al., 2019). This lack of a relationship may have been a result of family history questions asking about alcohol and drugs more broadly, without specifically focusing on cannabis use. Further, as the study relied on self-reports of parent's substance use problems, knowledge of parental substance use may be limited as parents may have been more likely to hide cannabis use from children (which would have been an illicit substance at the time) compared to alcohol use.

Associations with Recent Cannabis and Alcohol Use

In contrast to lifetime use, childhood maltreatment revealed a trend level association (i.e., 95% CI contained zero, but 90% CI did not contain zero) with greater recent cannabis use in the decision-making model. This association may suggest that experiencing abuse or neglect in childhood could have more consequential impacts on cannabis use into young adulthood rather than adolescence. For young adults, cannabis use may be serving as a coping strategy for distress associated with prior childhood maltreatment (Brammer et al., 2022). As young adults tend to have higher rates of cannabis use than adolescents (Government of Canada, 2021), as well as easier access to cannabis in the current legal environment young adults may be more likely to use cannabis as a coping strategy than adolescents. Thus, it makes sense the relationship between childhood maltreatment and cannabis use in young adulthood would be stronger than use during adolescence. However, this finding should be interpreted with caution as the relationship between childhood maltreatment and recent cannabis use was small in magnitude and only present in the decision-making model. Finally, there may be a methodological explanation for the differential association of childhood maltreatment with lifetime vs. recent cannabis use, as the TLFB assessment of recent use required less recall than the retrospective lifetime history interview and thus may be a more reliable measure of cannabis use.

The finding that greater childhood maltreatment was marginally associated with greater recent cannabis use was in the expected direction (e.g., Rogers et al., 2021), but the negative association with recent alcohol use was opposite to what I expected. One possible explanation for the finding may be the selection of the sample; as participants were required to be regular cannabis users, but were not required to be regular drinkers, the study may have targeted heavier cannabis users that do not regularly consume alcohol. Further, the negative, albeit non-significant, bivariate correlation between recent cannabis and alcohol use suggests that those with greater cannabis use consume less alcohol. Thus, there may a substitution effect of cannabis for alcohol (Lucas et al., 2013; Subbaraman, 2016), whereby increased use of cannabis to cope with distress is associated with less use of alcohol hence a negative association between childhood maltreatment and alcohol use.

Looking at the executive functioning associations with recent use, recent cannabis use did not relate significantly with working memory updating or inhibition, but greater recent cannabis use was associated with poorer set-shifting performance. While previous research has shown links between cannabis use and overall executive functioning, memory, and processing speed (Bourque & Potvin, 2021; Crean et al., 2011; Zhornitsky et al., 2021), to my knowledge no study has shown an association between recent cannabis use and the specific set-shifting domain. Thus, this study provides a novel finding of the relationship between cannabis use and impaired set-shifting performance. These findings reveal the importance of recent cannabis use, compared to lifetime use history, on certain executive functioning outcomes, namely set-shifting. However, given that only 11% of the variance in set-shifting was explained by the model predictors, the effect size was modest and should be taken into consideration while considering the relationship of recent cannabis use and young adult set-shifting performance.

Implications

The overall findings add empirical support to the current literature that suggests adverse childhood experiences can impact decision-making into young adulthood (Larsen et al., 2019; Stoltenberg et al., 2001). This relationship is notable as it reveals the importance of prevention of childhood maltreatment for healthy cognitive functioning later in life, specifically decision-making quality. As decision-making impairments can have a variety of social and behavioural consequences (Bechara et al., 2001; Ko et al., 2017; Kuin et al., 2015), improving preventative measures for childhood maltreatment could have implications across a wide array of young adult outcomes. Further the study found an association between recent cannabis use and set-shifting performance. Thus, this study suggests targeting heavier cannabis users may be important for preventing set-shifting impairments among young adults. This is of particular interest as set-shifting impairments can have consequences for mental health (e.g., obsessive compulsive disorder and anorexia nervosa; Lawrence at al., 2006; Steegers et al., 2021) and behavioural outcomes (e.g., intimate partner violence; Romero-Martínez et al., 2019). The lack of a relationship for lifetime cannabis use on cognition is important as it suggests that adolescent cannabis use may not have long-lasting consequences for cognitive functioning, at least not at the cannabis levels observed in the current study and for the specific cognitive tasks used.

Limitations and Future Directions

The results of this study should be considered within the following limitations. The study had a relatively small sample size (N = 156) for the complex nature of the moderated mediation paths. It is possible that there were important smaller magnitude effects that the study was unable to detect due to power limitations. Another limitation of the current study is that it did not specifically target participants who used cannabis during adolescence. The age of onset of cannabis use was relatively high, with the average participant cannabis use onset in young adulthood rather than adolescence, which may have reduced this study's accuracy to examine the mechanistic associations of cannabis use among adolescence. Future research would benefit from targeting early onset cannabis users (i.e. 15 or younger) specifically to better understand the role of early onset and greater adolescent exposure to cannabis use on young adult decision-making and executive functioning. Additionally, the study did not target treatment seekers and thus findings may not generalize to more severe cannabis users. Finally, the study was cross-sectional in nature. Longitudinal designs should be considered to examine long-term causal impacts of childhood maltreatment on cannabis use and cognition. Future ecological momentary assessment studies would also help elucidate immediate consequences of cannabis use on decision-making and executive functioning compared to long-term use consequences.

Additional considerations for future research may be to explore the impacts of different types of childhood maltreatment. As the current study was limited to a smaller sample, childhood maltreatment was represented by a singular index, rather than separating into different subtypes of maltreatment to avoid path models that were overly complex. However, there is evidence that different forms of adverse childhood experiences (e.g., abuse vs. neglect) or even subcategories of abuse (e.g., physical vs. emotional vs. sexual) can have differential impacts on young adult and adolescent consequences (Brammer et al., 2022; De la Peña-Arteaga et al., 2021). Research into various types of maltreatment effects would provide richer evidence for the role of adverse childhood experiences on cannabis use and cognition. Finally, as this study did see differences in the roles of lifetime and recent substance use it may also be interesting to compare potential differences in the role of childhood maltreatment or trauma experiences versus more recent trauma exposure. Future exploration could help better understand how adolescent vs. adult experience can have differential impacts on cannabis use and cognitive performance.

Conclusion

The present study sought to examine adolescent cannabis use history as a mechanism explaining the link between childhood maltreatment and young adult cognitive performance and to examine if family history of substance use disorder impacted these relationships. While results did not support my hypotheses, they did reveal important relationships between childhood maltreatment, recent cannabis use, decision-making, and set-shifting. The study findings contribute to the extant knowledge of how childhood or adolescent experiences (e.g., maltreatment and cannabis use) may or may not have long-term impacts on cognitive performance. In a time of liberalizing cannabis use policies, a better understanding of potential consequences of adolescent cannabis use can have important ramifications for policy implementation and can also inform targeted prevention and intervention strategies.

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Table 1

Demographic Characteristics of the Sample

Variable	%
Sex	
Male	41.0
Female	59.0
Race/Ethnicity[a]	
White	50.6
Black	17.9
Asian	16.7
Pacific Islander	2.6
Indigenous	0.6
East Indian	10.3
Hispanic/Latino	5.1
Other	9.0
Family Income Growing Up[b]	
0-$9,999	1.9
$10-,000-$19,999	3.2
$20,000-$29,999	5.1
$30,000-$39,999	4.5
$40,000-$49,999	10.3
$50,000-$59,999	5.1
$60,000-$79,999	14.1
$80,000-$99,999	12.2
$100,000-$119,999	10.3
$120,000-$139,999	7.1
$140,000-$159,999	9.0
$160,000-$199,999	5.8
$200,000+	7.1
Highest Education Level	
Less than high school	1.3
High school or GED	39.1
Some college	20.5
Associates degree/Technical certification	4.5
Bachelors degree	33.3
Masters degree	1.3
Currently Enrolled as a Student	66.7

Note.[a] Race/ethnicity not mutually exclusive. [b]4.5% of participants missing data on family income growing up.

Table 2

Correlations, Means, Standard Deviations, and Ranges for Model Variables

Variable	1	2	3	4	5	6	7	8	9	10	11
1. CTQ-SF	-	-.298**	-.131	-.065	.098	.184*	.004	.173*	.191*	-.264**	.311**
2. CGT-BC		-	.393**	-.124	-.213**	-.185*	.027	-.058	-.044	.107	-.078
3. N-Back			-	-.047	-.102	-.107	.117	-.094	.010	.185*	-.016
4. SSRT				-	.108	.052	-.100	.114	-.091	.099	-.083
5. CST-Lat					-	.071	.093	.279**	-.056	.025	.138
6. Lifetime Cannabis						-	-.337**	.619**	.501**	-.054	.135
7. Age of Onset							-	-.149	-.337**	-.062	-.008
8. Recent Cannabis								-	.217**	-.064	.070
9. Lifetime Alcohol									-	.373**	.294**
10. Recent Alcohol										-	.037
11. Family History											-
M	42.24	0.97	1.04	242.50	243.96	574.69	18.05	33.75	1612.16	63.86	
SD	14.88	0.06	1.70	49.72	183.88	1142.97	2.36	52.77	2052.76	56.34	
Range	25.00-94.00	0.69-1.00	-3.83-5.00	99.90-405.45	-138.37-869.00	0.00-5685.00	11.58-24.83	0.00-226.00	0.00-9999.00	0.00-246.00	

Note. M = Mean; SD = Standard Deviation; CTQ-SF = Childhood Trauma Questionnaire-Short Form; CGT-BC = Cambridge Gambling Task-Best Choice; SSRT = Stop Signal Reaction Time; CST-Lat = Category Switch Task – Latency; Lifetime Cannabis = Total Lifetime Grams Cannabis Flower Consumed; Age of Onset = Age of Onset for Regular Cannabis Use; Recent Cannabis = Past 90-day Grams Cannabis Flower Consumed; Lifetime Alcohol = Total Lifetime Standard Drinks; Recent Alcohol = Past 90-day Standard Drinks. ** $p < .01$; * $p < .05$.

Table 3

Mediation Path Model for Lifetime Use to Decision Making

	Estimate	LL 95% CI	UL 95% CI
Outcome: CGT-BC			
Lifetime Cannabis Use	-0.110	-0.307	0.030
Lifetime Alcohol Use	0.004	-0.205	0.188
CTQ-SF	-0.230*	-0.444	-0.007
Family History	0.058	-0.138	0.236
Sex	-0.107	-0.251	0.050
Age	0.069	-0.077	0.208
Family Income	0.142	-0.030	0.303
Premorbid Intelligence	0.168	-0.028	0.371
Outcome: Lifetime Cannabis Use			
CTQ-SF	0.107	-0.042	0.287
Family History	0.093	-0.079	0.270
Sex	-0.176*	-0.312	-0.020
Age	0.025	-0.121	0.154
Family Income	-0.008	-0.168	0.167
Premorbid Intelligence	-0.250*	-0.445	-0.037
Outcome: Lifetime Alcohol Use			
CTQ-SF	0.119	-0.055	0.307
Family History	0.296*	0.114	0.473
Sex	-0.245*	-0.365	-0.115
Age	0.273*	0.139	0.396
Family Income	0.137	-0.014	0.290
Premorbid Intelligence	0.011	-0.151	0.152
Covariance: Lifetime Alcohol Use with Lifetime Cannabis Use	0.490*	0.207	0.686

Note. N = 155. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; CGT-BC = Cambridge Gambling Task- Best Choice Index; CTQ-SF = Childhood Trauma Questionnaire-Short Form. * Indicates significant effect (i.e., 95% CI does not contain zero).

Table 4

Mediation Path Model for Lifetime Use to Working Memory Updating

	Estimate	LL 95% CI	UL 95% CI
Outcome: N-Back			
Lifetime Cannabis Use	-0.015	-0.153	0.159
Lifetime Alcohol Use	-0.015	-0.214	0.175
CTQ-SF	-0.043	-0.233	0.145
Family History	0.066	-0.097	0.223
Sex	-0.080	-0.244	0.086
Age	0.044	-0.130	0.221
Family Income	0.152	-0.008	0.290
Premorbid Intelligence	0.298*	0.119	0.470
Outcome: Lifetime Cannabis Use			
CTQ-SF	0.107	-0.040	0.286
Family History	0.092	-0.079	0.276
Sex	-0.175*	-0.315	-0.023
Age	0.026	-0.126	0.157
Family Income	-0.010	-0.174	0.170
Premorbid Intelligence	-0.248*	-0.448	-0.039
Outcome: Lifetime Alcohol Use			
CTQ-SF	0.112	-0.060	0.299
Family History	0.297*	0.112	0.479
Sex	-0.242*	-0.365	-0.108
Age	0.276*	0.139	0.397
Family Income	0.126	-0.027	0.282
Premorbid Intelligence	0.017	-0.142	0.161
Covariance: Lifetime Alcohol Use with Lifetime Cannabis Use	0.490*	0.192	0.681

Note. N = 154. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; CTQ-SF = Childhood Trauma Questionnaire-Short Form. * Indicates significant effect (i.e., 95% CI does not contain zero).

Table 5

Mediation Path Model for Lifetime Use to Inhibition

	Estimate	LL 95% CI	UL 95% CI
Outcome: SSRT			
Lifetime Cannabis Use	0.081	-0.085	0.297
Lifetime Alcohol Use	-0.031	-0.220	0.164
CTQ-SF	-0.070	-0.246	0.105
Family History	-0.066	-0.213	0.097
Sex	-0.030	-0.185	0.139
Age	-0.227*	-0.395	-0.059
Family Income	-0.153	-0.341	0.037
Premorbid Intelligence	-0.010	-0.177	0.158
Outcome: Lifetime Cannabis Use			
CTQ-SF	0.076	-0.082	0.274
Family History	0.145	-0.040	0.322
Sex	-0.145	-0.295	0.010
Age	-0.026	-0.167	0.108
Family Income	0.030	-0.145	0.211
Premorbid Intelligence	-0.258*	-0.472	-0.023
Outcome: Lifetime Alcohol Use			
CTQ-SF	0.086	-0.096	0.294
Family History	0.351*	0.170	0.524
Sex	-0.238*	-0.366	-0.100
Age	0.254*	0.117	0.387
Family Income	0.159	0.005	0.305
Premorbid Intelligence	0.017	-0.139	0.151
Covariance: Lifetime Alcohol Use with Lifetime Cannabis Use	0.421*	0.114	0.636

Note. N = 149. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; SSRT= Stop Signal Reaction Time; CTQ = Childhood Trauma Questionnaire-Short Form. * Indicates significant effect (i.e., 95% CI does not contain zero).

Table 6

Mediation Path Model for Lifetime Use to Set-Shifting

	Estimate	LL 95% CI	UL 95% CI
Outcome: CST-Latency			
Lifetime Cannabis Use	0.130	-0.103	0.295
Lifetime Alcohol Use	-0.170	-0.389	0.035
CTQ-SF	0.073	-0.075	0.224
Family History	0.156	-0.035	0.369
Sex	-0.027	-0.214	0.144
Age	-0.056	-0.215	0.108
Family Income	0.011	-0.161	0.195
Premorbid Intelligence	0.016	-0.220	0.261
Outcome: Lifetime Cannabis Use			
CTQ-SF	0.104	-0.045	0.284
Family History	0.091	-0.082	0.271
Sex	-0.173*	-0.306	-0.019
Age	0.028	-0.120	0.155
Family Income	-0.009	-0.171	0.165
Premorbid Intelligence	-0.252*	-0.450	-0.038
Outcome: Lifetime Alcohol Use			
CTQ-SF	0.113	-0.059	0.301
Family History	0.297*	0.116	0.472
Sex	-0.243*	-0.366	-0.114
Age	0.278*	0.145	0.400
Family Income	0.135	-0.017	0.287
Premorbid Intelligence	0.009	-0.150	0.152
Covariance: Lifetime Alcohol Use with Lifetime Cannabis Use	0.489*	0.206	0.685

Note. N = 155. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; CST-Latency = Category Switch Task Latency; CTQ-SF = Childhood Trauma Questionnaire-Short Form. * Indicates significant effect (i.e., 95% CI does not contain zero).

Table 7

Mediation Path Model for Recent Use to Decision Making

	Estimate	LL 95% CI	UL 95% CI
Outcome: CGT-BC			
Recent Cannabis Use	0.018	-0.106	0.147
Recent Alcohol Use	-0.051	-0.194	0.097
CTQ-SF	-0.257	-0.486	0.006
Family History	0.057	-0.140	0.236
Sex	-0.091	-0.233	0.071
Age	0.075	-0.054	0.209
Family Income	0.152	-0.011	0.310
Premorbid Intelligence	0.205*	0.006	0.410
Outcome: Recent Cannabis Use			
CTQ-SF	0.149	-0.009	0.330
Family History	0.031	-0.134	0.213
Sex	-0.265*	-0.411	-0.108
Age	-0.103	-0.249	0.042
Family Income	-0.024	-0.189	0.142
Premorbid Intelligence	-0.201*	-0.356	-0.035
Outcome: Recent Alcohol Use			
CTQ-SF	-0.263*	-0.377	-0.122
Family History	0.169*	0.029	0.325
Sex	-0.143	-0.292	0.015
Age	0.133	-0.021	0.269
Family Income	0.159*	0.013	0.300
Premorbid Intelligence	0.122	-0.038	0.251
Covariance: Recent Alcohol Use with Recent Cannabis Use	-0.020	-0.167	0.149

Note. N = 155. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; CGT-BC = Cambridge Gambling Task- Best Choice Index; CTQ-SF = Childhood Trauma Questionnaire-Short Form. * Indicates significant effect (i.e., 95% CI does not contain zero).

Table 8

Mediation Path Model for Recent Use to Set-Shifting

	Estimate	LL 95% CI	UL 95% CI
Outcome: CST-Latency			
Recent Cannabis Use	0.290*	0.125	0.432
Recent Alcohol Use	0.066	-0.102	0.248
CTQ	0.044	-0.106	0.202
Family History	0.097	-0.075	0.284
Sex	0.078	-0.090	0.233
Age	-0.080	-0.222	0.065
Family Income	-0.016	-0.177	0.159
Premorbid Intelligence	0.032	-0.205	0.259
Outcome: Recent Cannabis Use			
CTQ	0.141	-0.017	0.317
Family History	0.034	-0.129	0.218
Sex	-0.267*	-0.411	-0.106
Age	-0.097	-0.246	0.046
Family Income	-0.024	-0.190	0.146
Premorbid Intelligence	-0.200*	-0.356	-0.033
Outcome: Recent Alcohol Use			
CTQ	-0.263*	-0.381	-0.125
Family History	0.162*	0.026	0.312
Sex	-0.135	-0.282	0.018
Age	0.134	-0.015	0.271
Family Income	0.155*	0.008	0.295
Premorbid Intelligence	0.117	-0.041	0.248
Covariance: Recent Alcohol Use with Recent Cannabis Use	-0.025	-0.166	0.150

Note. N = 155. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; CST-Latency = Category Switch Task Latency; CTQ-SF = Childhood Trauma Questionnaire-Short Form. * Indicates significant effect (i.e., 95% CI does not contain zero).

Table 9

Mediation Path Model for Recent Use to Working Memory Updating

	Estimate	LL 95% CI	UL 95% CI
Outcome: N-Back			
Recent Cannabis Use	-0.036	-0.165	0.088
Recent Alcohol Use	0.080	-0.085	0.243
CTQ-SF	-0.019	-0.212	0.178
Family History	0.048	-0.115	0.202
Sex	-0.073	-0.240	0.091
Age	0.025	-0.132	0.187
Family Income	0.138	-0.016	0.282
Premorbid Intelligence	0.284*	0.112	0.458
Outcome: Recent Cannabis Use			
CTQ-SF	0.144	-0.016	0.319
Family History	0.035	-0.124	0.219
Sex	-0.269*	-0.413	-0.110
Age	-0.099	-0.242	0.045
Family Income	-0.021	-0.191	0.154
Premorbid Intelligence	-0.199*	-0.353	-0.034
Outcome: Recent Alcohol Use			
CTQ-SF	-0.267*	-0.386	-0.131
Family History	0.162*	0.023	0.316
Sex	-0.130	-0.279	0.023
Age	0.138	-0.016	0.274
Family Income	0.137	-0.004	0.276
Premorbid Intelligence	0.131	-0.035	0.258
Covariance: Recent Alcohol Use with Recent Cannabis Use	-0.023	-0.169	0.144

Note. N = 154. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; CTQ-SF = Childhood Trauma Questionnaire score. * Indicates significant effect (i.e., 95% CI does not contain zero).

Table 10

Mediation Path Model for Recent Use to Inhibition

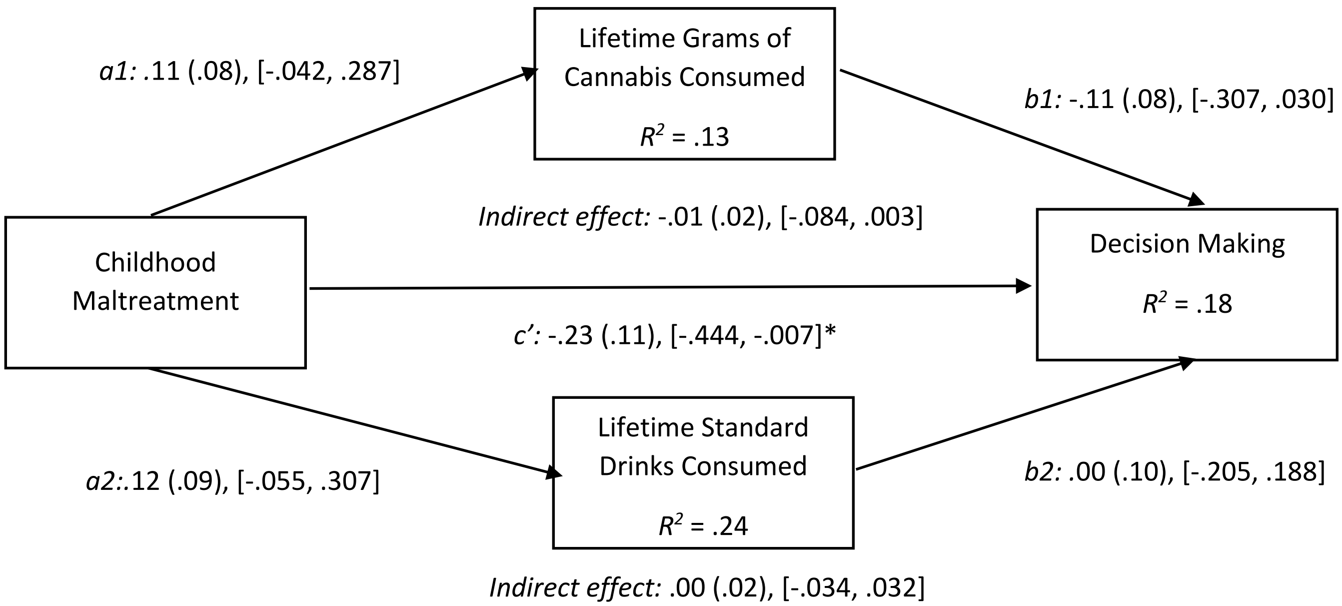
	Estimate	LL 95% CI	UL 95% CI
Outcome: SSRT			
Recent Cannabis Use	0.097	-0.072	0.258
Recent Alcohol Use	0.153	-0.024	0.323
CTQ	-0.036	-0.225	0.136
Family History	-0.099	-0.240	0.049
Sex	0.015	-0.142	0.185
Age	-0.243*	-0.393	-0.082
Family Income	-0.176	-0.360	0.003
Premorbid Intelligence	-0.028	-0.185	0.130
Outcome: Recent Cannabis Use			
CTQ	0.107	-0.053	0.311
Family History	0.092	-0.100	0.291
Sex	-0.237*	-0.389	-0.074
Age	-0.147	-0.295	0.006
Family Income	-0.010	-0.184	0.170
Premorbid Intelligence	-0.187*	-0.346	-0.010
Outcome: Recent Alcohol Use			
CTQ	-0.266*	-0.385	-0.124
Family History	0.162*	0.013	0.319
Sex	-0.170	-0.319	-0.006
Age	0.132	-0.019	0.270
Family Income	0.142	-0.007	0.280
Premorbid Intelligence	0.092	-0.077	0.232
Covariance: Recent Alcohol Use with Recent Cannabis Use	0.010	-0.142	0.181

Note. N = 149. LL 95% CI = Lower limit of 95% confidence interval; UL 95% CI = Upper limit 95% confidence interval; SSRT= Stop Signal Reaction Time; CTQ = Childhood Trauma Questionnaire-Short Form. * Indicates significant effect (i.e., 95% CI does not contain zero).

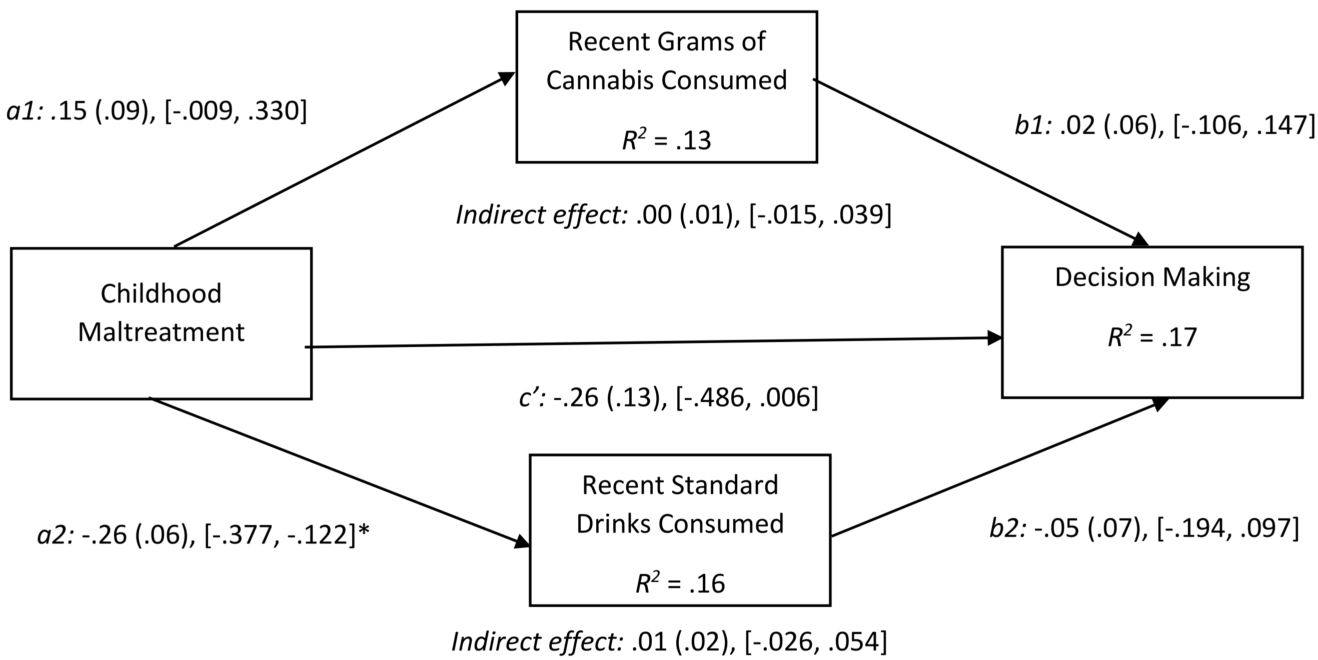
Figure 1.

Direct and Indirect Paths of Childhood Maltreatment to Decision Making Through Cannabis and Alcohol Use

a) Childhood Maltreatment to Decision Making Through Lifetime Use



b) Childhood Maltreatment to Decision Making through Recent Use

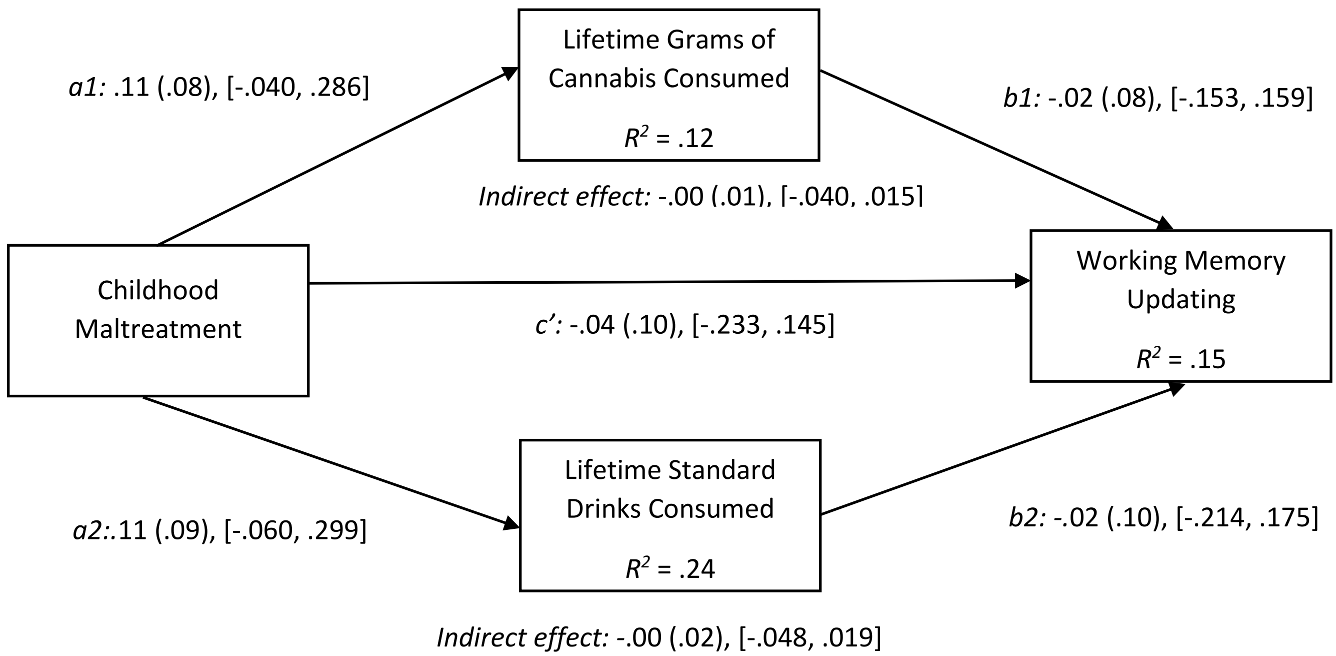


Note. Standardized coefficients, standard errors, and 95% confidence intervals are shown. *Indicates significant pathway (i.e., 95% confidence intervals do not include zero). Sex, age, family income, family history of addiction, and estimated premorbid intelligence included as covariates.

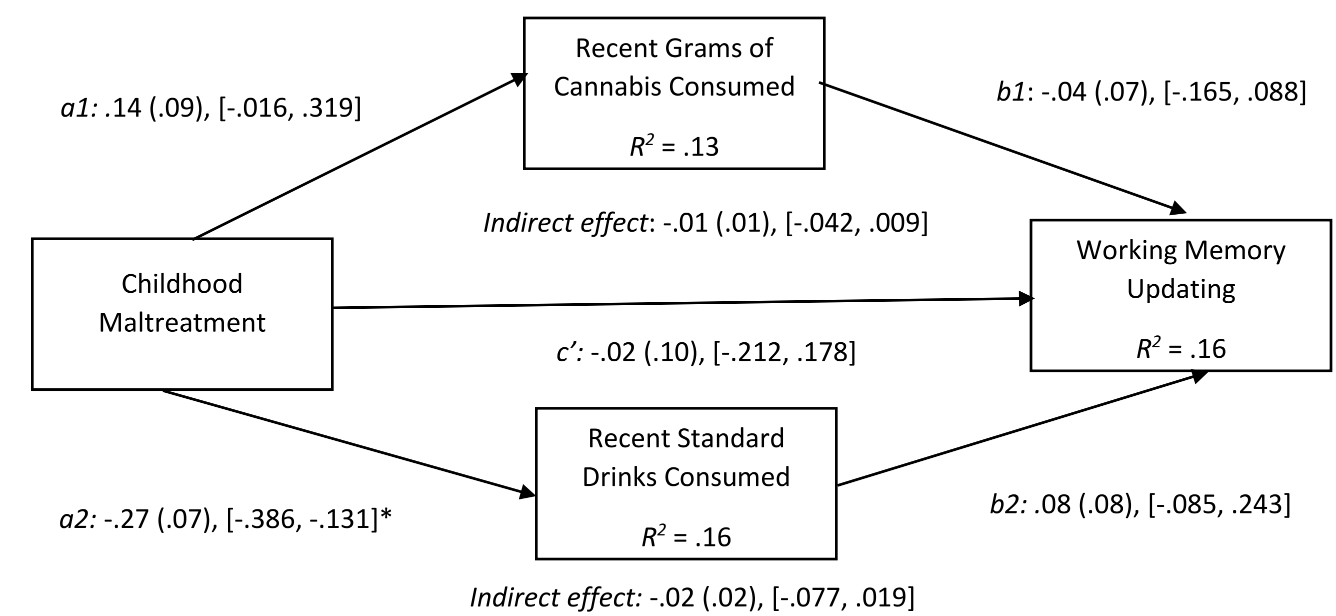
Figure 2.

Direct and Indirect Paths of Childhood Maltreatment to Working Memory Updating Through Cannabis and Alcohol Use

a) Childhood Maltreatment to Working Memory Updating Through Lifetime Use



b) Childhood Maltreatment to Working Memory Updating Through Recent Use

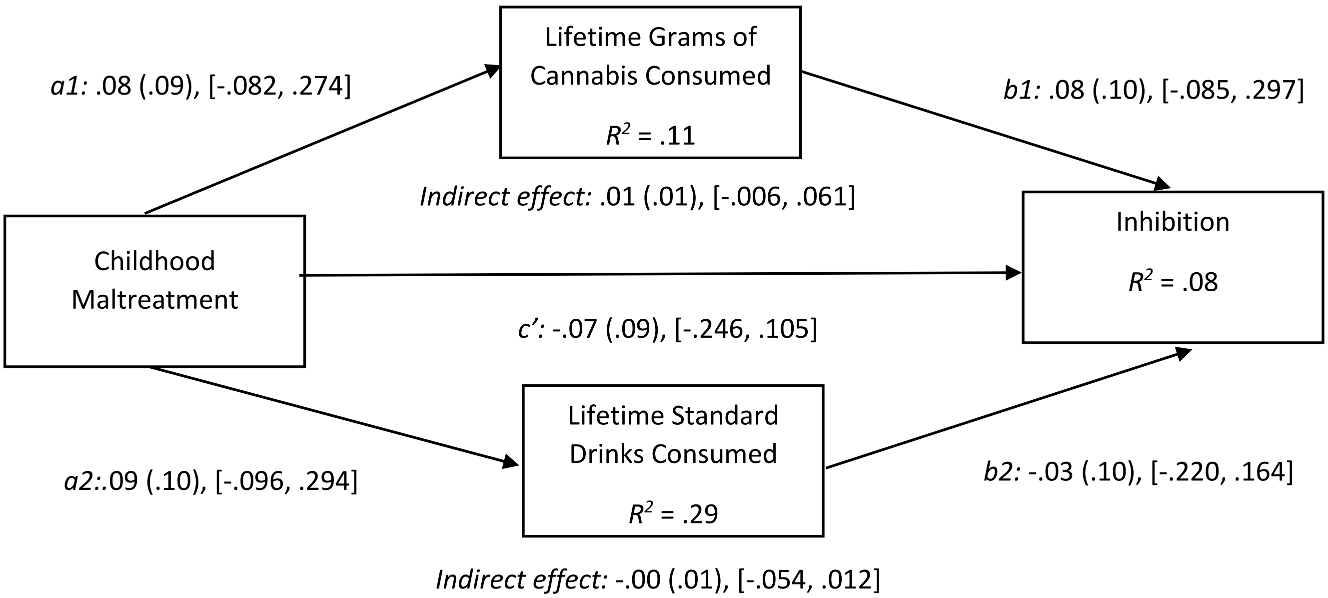


Note. Standardized coefficients, standard errors, and 95% confidence intervals are shown. *Indicates significant pathway (i.e., 95% confidence intervals do not include zero). Sex, age, family income, and verbal intelligence included as covariates. Sex, age, family income, family history of addiction, and estimated premorbid intelligence included as covariates.

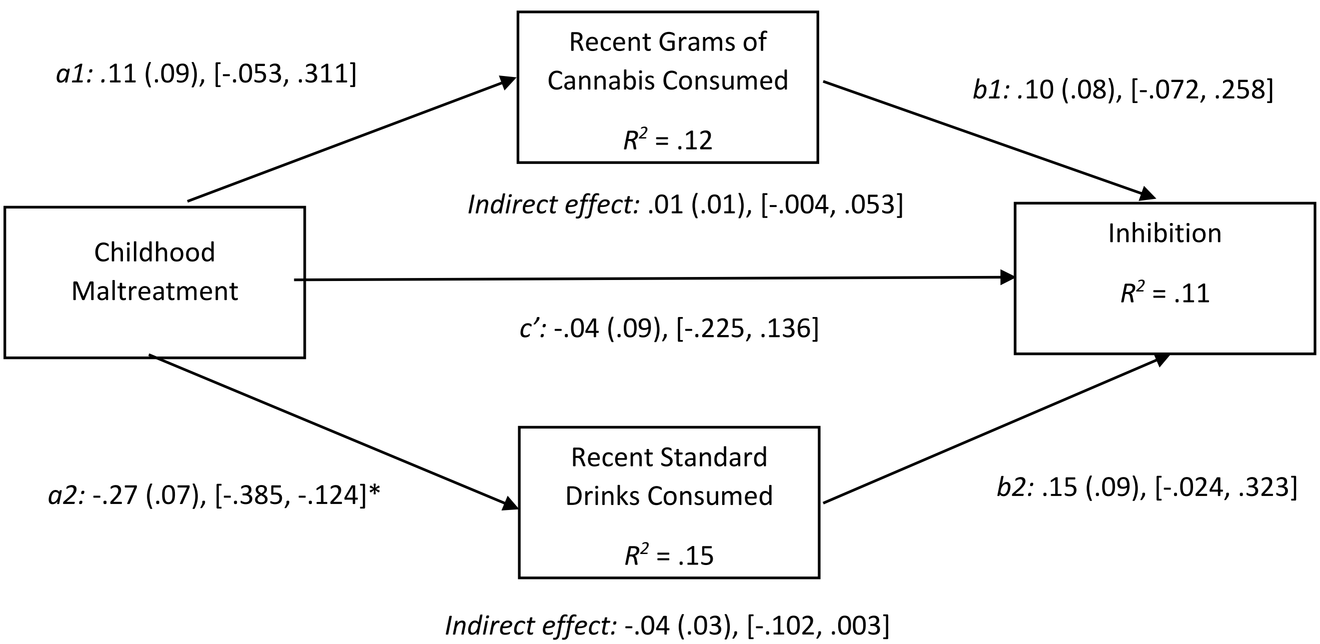
Figure 3.

Direct and Indirect Paths of Childhood Maltreatment to Inhibition Through Cannabis and Alcohol Use

a) Childhood Maltreatment to Inhibition Through Lifetime Use



b) Childhood Maltreatment to Inhibition Through Recent Use

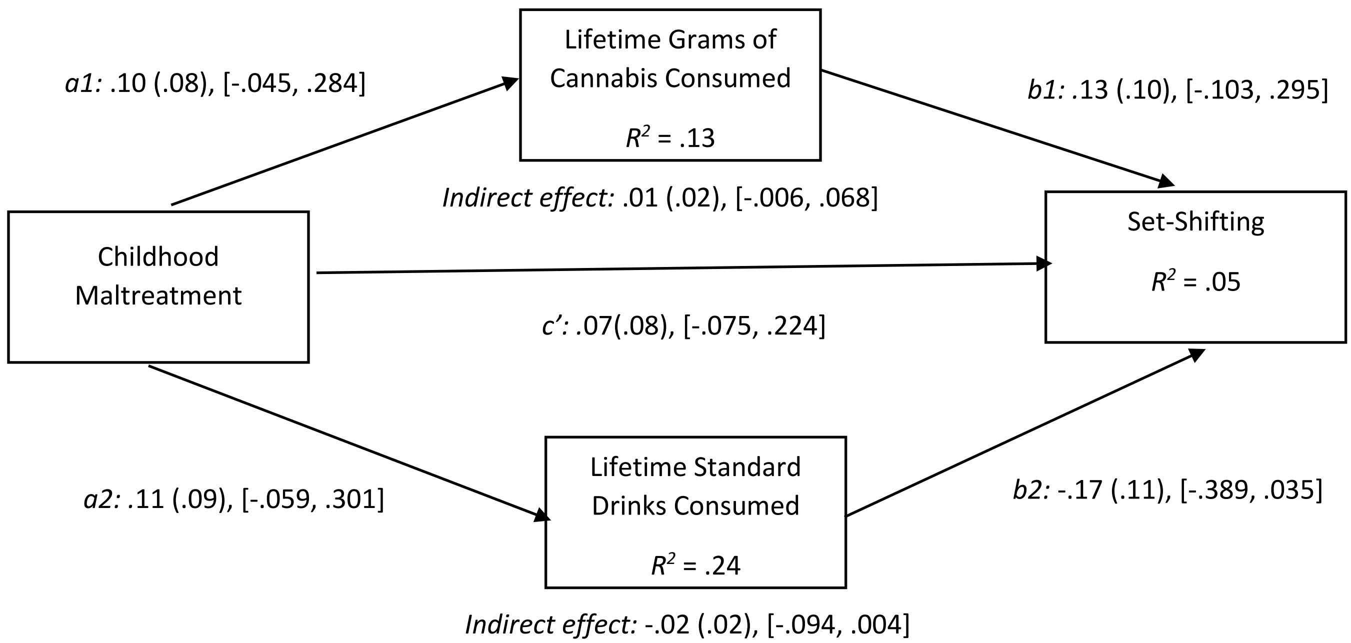


Note. Standardized coefficients, standard errors, and 95% confidence intervals are shown. *Indicates significant pathway (i.e., 95% confidence intervals do not include zero). Sex, age, family income, family history of addiction, and estimated premorbid intelligence included as covariates.

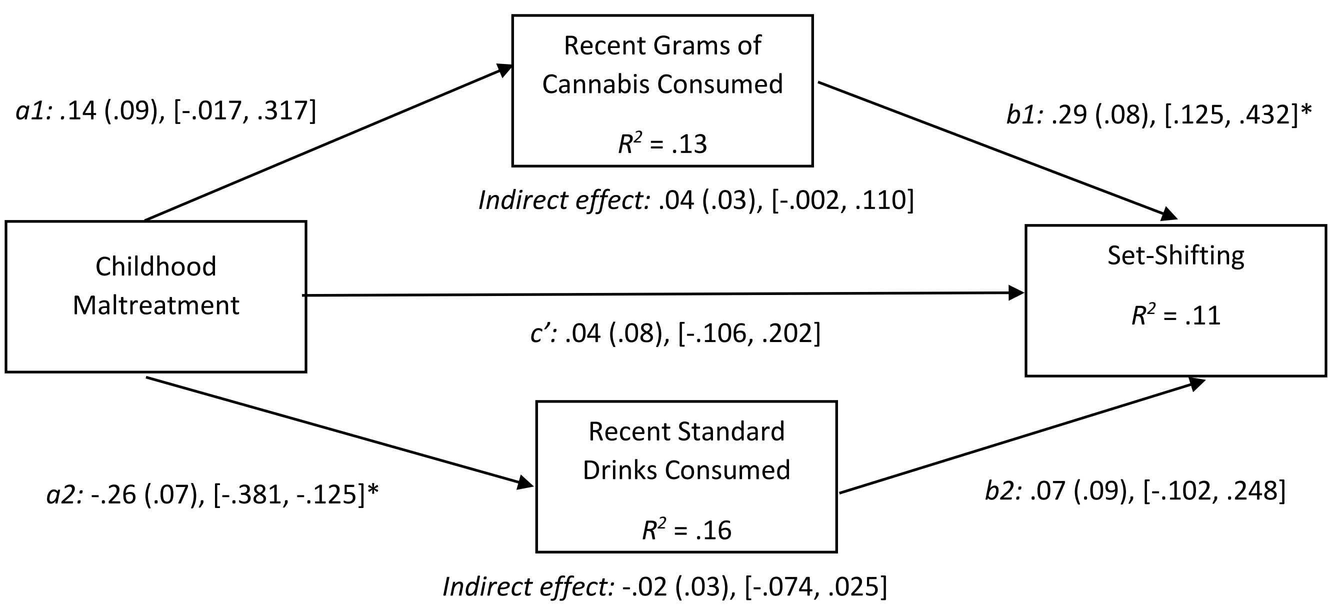
Figure 4.

Direct and Indirect Paths of Childhood Maltreatment to Set-Shifting Through Cannabis and Alcohol Use

a) Childhood Maltreatment to Set-Shifting Through Lifetime Use



b) Childhood Maltreatment to Set-Shifting Through Recent Use



Note. Standardized coefficients, standard errors, and 95% confidence intervals are shown. *Indicates significant pathway (i.e., 95% confidence intervals do not include zero). Sex, age, family income, family history of addiction, and estimated premorbid intelligence included as covariates.

Appendix A

Childhood Trauma Questionnaire (CTQ)

These questions ask about some of your experiences growing up as a child. Although these questions are of a personal nature, please try to answer as honestly as you can. For each question, pick the response that best describes how you feel.

When I was growing up...

	Never	Rarely	Sometimes	Often	Very Often
I got hit so hard that I had to see a doctor or go to the hospital.	☐	☐	☐	☐	☐
Someone in my family hit me so hard that it left me with bruises or marks.	☐	☐	☐	☐	☐
I was punished with a belt/board/cord/other hard object. I believe that I was physically abused.	☐	☐	☐	☐	☐
I was beaten so badly it was noticed by a teacher/neighbor/doctor.	☐	☐	☐	☐	☐
Someone in my family helped me feel important or special.	☐	☐	☐	☐	☐
I felt loved.	☐	☐	☐	☐	☐
People in my family looked out for each other.	☐	☐	☐	☐	☐
People in my family felt close to each other.	☐	☐	☐	☐	☐
My family was a source of strength and support.	☐	☐	☐	☐	☐
People in my family called me "stupid," "lazy," or "ugly."	☐	☐	☐	☐	☐
I thought that my parents wished I had never been born.	☐	☐	☐	☐	☐
People in my family said hurtful or insulting things to me.	☐	☐	☐	☐	☐
I felt that someone in my family hated me.	☐	☐	☐	☐	☐

I believe that I was emotionally abused.	☐	☐	☐	☐	☐
I didn't have enough to eat.	☐	☐	☐	☐	☐
I knew there was someone to take care of me and protect me.	☐	☐	☐	☐	☐
My parents were too drunk or high to take care of the family.	☐	☐	☐	☐	☐
I had to wear dirty clothes.	☐	☐	☐	☐	☐
There was someone to take me to the doctor if I needed it.	☐	☐	☐	☐	☐
Someone tried to touch me in a sexual way/made me touch them.	☐	☐	☐	☐	☐
Someone threatened me unless I did something sexual.	☐	☐	☐	☐	☐
Someone tried to make me do/watch sexual things.	☐	☐	☐	☐	☐
Someone molested me.	☐	☐	☐	☐	☐
I believe that I was sexually abused.	☐	☐	☐	☐	☐

Appendix B

Cannabis and Alcohol Lifetime History Script

CANNABIS and ALCOHOL LIFETIME HISTORY (LTH)

Modification of: *Lifetime Drinking History: Administration And Scoring Guidelines; Harvey A. Skinner Ph.D.; Addiction Research Foundation; 1979*

NOTE: To be completed after the TLFB, so that participant is already oriented to cannabis quantities, standard drinks, and has a general sense for the types of cues and probes that will be asked. Also, should know by now if the participant is a lifelong abstainer of tobacco, in which case, anything related to tobacco would be skipped.

General Introduction

"I am going to ask you questions about your lifetime history of cannabis use and alcohol use. This is to assess the frequency and quantity of your use of each substance for each year, starting from the first time you used each substance. To do this we'll complete a timeline together that we can use to note any significant life events that occurred over the years that may have impacted your use of these substances."

CANNABIS LIFETIME HISTORY

I. First Stage – Ages of first use

CA1. "First, I am going to ask you to try to remember how old you were the first time you used cannabis. For this, we are interested in the first time you tried any cannabis whatsoever, even if it was only a small amount (a puff or two of a joint or a little taste of an edible) and even if you don't think you felt any effects. Can you tell me how old you were the very first time you tried cannabis?

If participant just quickly gives an age, probe how they came up with that number: eg, "Do you remember the situation you were in when you first tried cannabis? Who were you with? Did you smoke it or use it some other way the first time? Are you sure it was definitely when you were XX years old?" (note, if they only tried it for the first time recently (age 18/19, less probing may be needed, but still check to make sure they are sure about the first use).

If not sure or seems tentative, use promts to get at accurate recall:

"Do you remember what grade you were in?

Do you remember the situation?

Was it a party or some other event?

Do you remember who you were with?

Do you remember where you got the cannabis?

Do you remember if it was marijuana or some other form like edibles?

Do you remember how you used it (joint, bong, pipe, etc.)?"

Once honed in on age, try to get month-level precision if possible. This could be possible if they know for example it was in the fall of grade 9 or new years eve when 16 y/o, then you can calculate exact age. If not, try to get them to make an estimate based on other cues of the situation (e.g., if at a party, do they remember if it was in the summer or during the school year, was it fall or winter, who was there, where was it, etc.)

Record age of FIRST TRY (CA1) in years and months- FIRST TRY will not go on the timeline, only in the margin. If they know the grade they were in or the calendar year/month, use this to calculate age. Do this verifying their year and month of birth and calculating it based on the age of first drink. Also, ask them to verify what grade they were in (you can calculate it yourself based on the typical grade/age chart and just verify age they started grade one and that they were not held back a grade before age of onset).

The goal is to use whatever information they can accurately give (either age, calendar date, or grade) and use this to calculate the other pieces of information, so that you can note age (year and month), date (calendar year and month), and grade in school for first use.

CA2. Now, thinking of this very first time you tried cannabis, did you use enough cannabis to feel some effects, meaning that you actually inhaled [if smoked] or you ate enough to feel a buzz or high [if eaten].

IF YES, age of FIRST USE (CA2) is equal to age FIRST TRY (CA1) obtained above. Record this, and move on to AA1. First USE is the first thing to record onto the calendar

IF NO: "Do you remember how old you were the first time you used enough cannabis to feel some effects?"

Probe and use same cues above to get accurate recall. Record age of FIRST USE (CA2) in years and months.

<u>II. Second Stage – Timeline/Life Events.</u>

Life events associated with major pattern changes in cannabis use:

“OK, so now that we’ve determined when you first began using cannabis, we are going to move on and assess your use of cannabis each year up to the present. In order to help us make sure the estimates are as accurate as possible, it will help to establish a timeline that we can refer to.

Pull out timeline form.

“So, you said you were [age] when you used cannabis. This would have been in [calendar year/month] when you were in grade [XX]. So, we’ll use this as our first year that we’ll discuss.

NOTE – here, beginning of timeline will be keyed to FIRST USE, not FIRST TRY/SIP.

MARK the dates in the left column of the timeline. THEN, in the “Events” column, put “FIRST USE of [substance] on the line corresponding to the month this occurred and confirm with the participant

Now, subsequently fill in all years and all information in left column and in events column put in all First use of, cannabis,

“Now that we have this basic timeline set up, in order to help you remember your patterns of use, let’s try to fill in some significant events <u>that may have occurred that impacted your patterns of cannabis use.</u> For this, we are interested in major things that you know led to increases or decreases in how often or how much cannabis you used for a period of time. Here are some examples of events that could impact your cannabis use (Show them the example of events paper AND GO OVER SOME OF THEM ALOUD WITH THE PARTICIPANT).

Start with the first year. **"*Did any important event or events occur during this period that impacted your cannabis use*?"**

Fill in and do for each subsequent year

If participant says none of the events were associated with changes in their use, ask them to remember periods of heavy and light cannabis use. Try to link those to events that occurred.

***USE COMMON CALENDAR ANCHORS IF HELPFUL, LIKE START OF NEW SCHOOL YEAR, SUMMER, MAJOR BIRTHDAYS (18, 19), TRANSITION FROM HIGH SCHOOL TO UNIVERSITY.*

NOTE: The goal here is a higher level outline of major events or calendar patterns associated with sustained changes in use or punctuating a period of heavier or lighter use to serve as anchors. Should be higher level and take only about 5 MINS to complete. Do not go through every single month or semester at this stage, can do that later in stage III.

III. Third Stage –Running estimates.

Instructions for interviewer:

Now you will begin probing the frequency and quantity estimates over the full timeline.

CF1. "Okay now that we have established a timeline, let's go through each year to assess patterns of your cannabis use. It's okay if you don't have an exact number- try to give your best estimate. So you first started using cannabis in 20xx, what was your cannabis use like that first month after you used? Specifically, how frequently were you using cannabis?

Record number of days (0-30). If says daily or once a week convert to days (i.e., 30 for daily; 4 for once/week).

Use probing strategies if necessary, and just check out with them their thought process for how they arrived at the estimate.

CQ1. "During the days you used cannabis that first month, did you use marijuana or some other form of cannabis?

IF NOT MJ: skip quantity estimate and move on.

CQM1. IF MARIJUANA: **"how many grams of cannabis would you typically consume in a given day?"**

Show them the standard MJ conversion chart and get them to estimate. Probe to try to get accurate estimate, including asking how they know the quantity (did they always buy a certain amount and roll a certain number of joints, etc.)

Record the average number grams per marijuana day during that period.

ONE FIRST MONTH ESTABLISHED, ASK IF PATTERN OF FREQUENCY/QUANTITY WAS ABOUT THE SAME FOR THE REMAINDER OF THE FIRST "CHUNK" OF TIME, E.G, THE SEMESTER/SUMMER OR UNTIL NEXT MAJOR EVENT ON CALENDAR, IF SO, FILL IN AND MOVE ON TO NEXT CHUNK.

**REPEAT FREQUENCY, QUANTITY FOR EACH CHUNK OF TIME

- *When doing this ask how the pattern changed, but also check for any significant life events and ask if it impacted their cannabis use.*

- *Remember to re-confirm quantities when there is a frequency change*
- *If no events, on calendar for long time span, at minimum probe the start of each semester and summer each year, at least for first couple until know there are no changes linked to those time periods.*
- ***IF pattern very stable at some point (i.e., went to daily use at age 16 and pretty much every day since then, at MINIMUM, probe the beginning of each school year just to confirm)*

Alcohol Lifetime History

I. First Stage – Ages of first use

AA1. "Now that we've completed cannabis, let's move on to alcohol, I'd like you to try to remember how old you were the first time you tried alcohol, even just a sip. This could have been a time your parents let you try a sip or when you first tried a sip with someone else or on your own.

> ***Use probing questions if necessary, ask if they remember what occasion it may have been (e.g., a toast at a wedding, new years eve, etc.), if they were with their parents or someone else, and what they tried. If need to ask if they think they ever tried just a sip or two before having their first full drink, or whether the first time they drank they consumed a full alcohol beverage (in which case, just move on to question below)*
>
> *** Record age of FIRST SIP (AA1) in years and months- do not add this to timeline. Also, calculate calendar month/year and grade.*

AA2. "Thinking about this very first time you tried alcohol, did you drink a full alcoholic beverage. (that is, not just a few sips, but a full can/bottle of beer, full glass of wine, full shot of liquor, etc.)[Refer to standard drink chart for drink sizes]

> *IF YES, age of FIRST USE (AA2) equal to age of FIRST SIP (AA1) above, note this and move on to TA1.*
>
> *IF NO:* ***"Ok, then how old were you the first time you drank a full alcohol drink?"***
>
> ***Use the same types of probing questions as for cannabis:*
>
> > *"Do you remember what grade you were in?*
> > *Do you remember the situation?*
> > *Was it a party or some other event?*
> > *Do you remember who you were with?*
> > *Do you remember where you got the alcohol?*
> > *Do you remember what kind of alcohol it was?*

***Also, for month-level probing, try to pinpoint the situation and see if they recall time of year like if it was summer or winter, etc.*

Record age of FIRST USE (AA2) in years and months- first use should go on timeline as the starting point. Also, calculate calendar month/year and grade.

II. Second Stage – Timeline/Life Events.

First Use and Life events:

"OK, so now that we've determined when you first began using alcohol we are going to move on and assess your use of alcohol year up to the present. Let's establish a timeline like before to make this easier.

Pull out timeline form.

"So, you said you were [age] when you used alcohol. This would have been in [calendar year/month] when you were in grade [XX]. So, we'll use this as our first year that we'll discuss.

NOTE – here, beginning of timeline will be keyed to FIRST USE (i.e., FIRST FULL DRINK, not FIRST TRY/SIP).

MARK the dates in the left column of the timeline. THEN, in the "Events" column, put "FIRST USE of [substance] on the line corresponding to the month this occurred and confirm with the participant.

Now, subsequently fill in all years and all information in left column and in events column put in all First use of alcohol

"Now let's try to fill in some significant events that may have occurred that impacted your patterns of alcohol use. Again, these events could be things that were related to increases or decreases in your use of alcohol (give participant example sheet)

NOTE: Can ask if any events on the cannabis timeline also would have impacted alcohol use and transfer onto alcohol timeline, then go on and ask about other events, referring again to event sheet.

Start with the first year**. "*Did any important event or events occur during this period*?"**

If participant can't recall events that changed their alcohol use ask them if they remember their heaviest or lightest drinking periods, and then try to link those to events that may have occurred around then.

***USE COMMON CALENDAR ANCHORS IF HELPFUL, LIKE START OF NEW SCHOOL YEAR, SUMMER, MAJOR BIRTHDAYS (18, 19), TRANSITION FROM HIGH SCHOOL TO UNIVERSITY.*

NOTE: The goal here is a higher level outline of major events or calendar patterns associated with sustained changes in use or punctuating a period of heavier or lighter use to serve as anchors. Should be higher level and take only about 5 MINS to complete. Do not go through every single month or semester at this stage, can do that later in stage III.

III. Third Stage –Periodic/ Running estimates.

Instructions for interviewer:

Now you will begin probing the frequency and quantity estimates over the full timeline.

***Start with the month of first full drink*

AF1. "Okay so now that we have established a timeline, let's go through each year and assess your alcohol use. It's okay if you don't have an exact number, try to give your best estimate. So you first started using alcohol in 20xx. How often did you drink alcohol that month?

Record number of days (0-30). If says daily or once a week convert to days (i.e., 30 or 4, for example).

Use same probing strategies as cannabis if necessary, and just check out with them their thought process for how they arrived at the estimate.

AQ1. "Ok, on those occasions that you drank alcohol that month, how many standard drinks did you typically consume on one occasion?

NOTE: Here you are getting AVERAGE number of drinks per drinking day averaged across the month

Show standard drink conversion and probe to get accurate estimate. Ask whether they were standard containers (can/bottle of beer) or poured themselves, ask what type of alcohol used, etc.

AHF1. "Now, during the same month, thinking of all the occasions you drank, how much many of the times did you consume (4 or more for women/5 or more for men) standard drinks in a single occasion?

NOTE: here, you want to know out of the days they drank that month, how many were above the 4/5 threshold

Record number of days (0-30; should be less than or equal to frequency in #1). If says daily or once a week convert to days (i.e., 30 days or 4 days, for example).If reporting frequency as less than once per month, then ask at yearly level instead.

AHF2. "How many of these days would you say you drank (8 or more for women/10 or more for men) drinks in one occasion?"

Record number of days (0-30; should be less than or equal to frequency in #1). If says daily or once a week convert to days (i.e., 30 days or 4 days, for example). If reporting frequency as less than once per month, then ask at yearly level instead.

ONCE FIRST MONTH ESTABLISHED, ASK IF PATTERN OF DRINKING WAS ABOUT THE SAME FOR THE REMAINDER OF THE FIRST "CHUNK" OF TIME, E.G, THE SEMESTER/SUMMER OR UNTIL NEXT MAJOR EVENT ON CALENDAR, IF SO, FILL IN AND MOVE ON TO NEXT CHUNK. **REPEAT FREQUENCY, QUANTITY, HEAVY DRINKING QUESTIONS FOR EACH CHUNK OF TIME

- *When doing this ask how the pattern changed, but also check for any significant life events and ask if it impacted their cannabis use.*
- *Remember to re-confirm quantities when there is a frequency change*
- *If no events, on calendar for long time span, at minimum probe the start of each semester and summer each year, at least for first couple until know there are no changes linked to those time periods.*
- ***IF pattern very stable at some point (i.e., went to daily use at age 16 and pretty much every day since then, at MINIMUM, probe the beginning of each school year just to confirm)*

Appendix C

Cannabis Flower Chart

Appendix D

Standard Drink Chart

*For light beer or light wine, standard drinks (SDs) are calculated in terms of a ratio (e.g. 12 oz. of 2.5% light beer = 0.5 SDs; 12 oz. of 4% light beer = 0.8 SDs)

*For malt liquor (~7%), standard drinks (SDs) are calculated in terms of a ratio (e.g. 12 oz. of 7% = 1.4 SDs; 16 oz. of 7% = 1.9 SDs).

*Each number in the silhouette of the drink is the number of standard drinks in that beverage and the top three examples (12 oz. of 5%, 5oz. of 12%, and 1.5 oz. of 40% are equal to 1 standard drink.

Appendix E

Timeline Follow Back Script

We will now use a CALENDAR to review your recent alcohol and cannabis use patterns, as well as other related activities, in a bit more detail. The questions I ask will cover the last 3 month time period which has been marked off on this calendar.

From: ___ ___(mm)___ ___(dd)___ ___(yy) Through: ___ ___(mm)___ ___(dd)___ ___(yy)

Show respondent.

What we want to do is get an idea of how much alcohol and cannabis you consumed each day over the past 3 months, as well as any other substances, including cigarettes, you have used. To make this easier, we will use a calendar because it gives us a visual picture of the dates and patterns of your use. What we have found is that calendars are very useful in helping people recall their drinking and drug use. I realize that it is hard for anyone to recall things with 100% accuracy, whether it is drinking or anything else. If you can't recall the specific day that you drank or the exact amount, that is okay, we will just ask you to give it your best guess.

For alcohol use, we will be recording the number of drinks you consumed each day, and to do this we will be using the following chart to determine number of standard drinks {*show respondent standard drink chart, and walk them through. Ask what type(s) of alcohol they usually consume and orient to standard size for that type of drink, for example if they drink wine, give them overview of how much wine in standard drink}*

For cannabis, we will be recording whether you used cannabis on each day. Cannabis is a broad term referring to marijuana (bud/leaf), concentrates (oils and extracts), and edibles with pure THC. **Marijuana in this study specifically refers to the marijuana bud/leaf. For the days that you use marijuana, we will be recording the amount of marijuana you used in grams.** To give you an idea of how much marijuana is in a gram, we have some examples here. {*Show respondent the chart as well as the example joint sizes. Ask participant what type of cannabis they usually use and if it's marijuana if they have a rough idea of how many grams in a typical joint. Also orient them to fact that if they split with others to divide by the number of people.}*

We will also ask about daily use of cigarettes other substances over the past 3 months. To give me an idea of how applicable this is to you, do you smoke cigarettes or use any other forms of tobacco?

> {If Yes, ask how often to get idea in mind and to help you know how to probe}
> {If No, confirm}: So you haven't smoked any cigarettes or used tobacco at all over the past 3 months, not even one time?

Also, what about using other recreational drugs or using prescription drugs to get high, get a buzz, or change your mood? {probe frequency and if denies any use confirm not at all over past 90 days}

<u>Marking off the significant events (5 min total):</u>

Ok, next, to help with memory, we are first going to identify several dates on the calendar that may be meaningful for you and may have been associated with occasions that you drank alcohol or used cannabis, such as special occasions (i.e., birthdays, holidays, weekends, vacations, meet-ups with friends, etc.). It would also help to establish routines or patterns when you may regularly use cannabis or alcohol (such as a weekly sport or hobby you do), or days when you typically would not use cannabis or alcohol, such as days when you worked, had class, or final exams.

Let's begin by starting with yesterday and working our way backwards. Do you have any special significant events or dates that you want me to mark on the calendar to help you better recall your use?

{if not sure or not giving much} People often find it helpful to check their calendar, phone, or social medial to help them recall what they did during this period. Would you like to check any of these sources to help recall different events that may be associated with drinking or cannabis use?

{Then get them to put in patterns they have} Ok, how about weekly routines or patterns, like work days, school days, other regular events you attend that would either be associated with drinking or cannabis or would not be days you typically drink or use cannabis

{Can also leave them for a few minutes to fill in their class schedule, exam days, etc.}

<u>Daily Timeline:</u>
Great! Now that we have identified days that stand out for you, let's work backwards from yesterday to determine how much alcohol and cannabis you used on each day

{beginning from yesterday, ask about daily alcohol AND cannabis use for 2 weeks straight. Don't forget to also ask about cigarettes if they reported they smoked or other drugs if that was reported. Afterwards, when pattern established, can ask in chunks for periods that are routine, for example, if the person doesn't usually drink on weekdays, can just lump all weekdays for each week and confirm no drinking unless there is an event on the calendar. For more irregular patterns, would be helpful to just chunk the periods of time between events on calendar to check in if it was regular pattern during that time.}

NOTE: Throughout this interview, should the respondent indicate that s/he is unable to remember specific information, ask for their best guess. Also, it may be difficult for participants to recall their use based on <u>standard drinks</u>. Therefore, ask follow up questions as needed to determine a best estimate for alcohol quantity (e.g., for beer, ask if tall cans or regular cans; for wine, ask how much wine is contained in a cup or how much of a bottle was consumed; etc).

Please take detailed notes as you will be converting this information to standard drinks after the assessment is completed.

Suppose that the participant names a prescribed medication they use(d)(i.e., a stimulant for ADHD). You will need to distinguish between recreational use and use as prescribed. If it was only used as prescribed, there is no need to record this in the calendar. However, if the use was recreationally, then make a note of it.