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Cannabis Use and Social Cognitive Ability

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Abstract

Over the past decade, the United States has had a 58% increase in the number of daily or near-daily cannabis users. Frequent cannabis users are at increased risk for developing cannabis use disorders (CUDs) and psychosocial dysfunction is a key criterion for CUDs. Recent studies demonstrate the association between cannabis use and interpersonal dysfunction, such as perceiving others to be more hostile, being socially withdrawn, and being less genuine during social interactions. One approach to better understand the interpersonal dysfunction associated with cannabis use frequency is by examining cannabis users' social cognitive abilities. The present study aimed to explore performance on an emotion recognition (Reading the Mind in the Eyes Test; RMET) and on mentalizing (Movie for the Assessment of Social Cognition; MASC), as two subcomponents of social cognitive abilities, in recent cannabis use and lifetime cannabis use by assessing varying use frequency, quantity, and duration. Results revealed that in a wide range of cannabis users, the number of days of recent cannabis use and the cumulative amount of cannabis they have been exposed to was not associated with social cognitive abilities.

Keywords: social cognition, mentalizing, theory of mind, social emotional functioning, social cognition, cannabis use

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Cannabis Use and Social Cognition

The United States has recently had a significant increase in the number of daily or near-daily cannabis users (World Health Organization, 2016; WHO), and cannabis continues to be the most commonly used illicit drug worldwide (United Nations Office on Drugs and Crime, 2016; UNODC). Most of the world's production and consumption occurs in North America (UNODC, 2016). Over the past decade, the United States has experienced significant increases in the potency of delta-9-tetrahydrocannabinol (THC), the main psychoactive ingredient in cannabis, which is likely due to cannabis plant growers breeding different strains (WHO, 2016). Also, the number of cannabis users who reported using 300 days or more in the past year has increased by 74% (WHO, 2016). Cannabis use frequency has been associated with increased risk for cannabis use disorders (CUDs). It is estimated that one in eleven persons who have ever used cannabis will develop CUDs; this proportion increases to one in three persons among daily users (UNODC, 2016; WHO, 2016). Psychosocial dysfunction is a crucial criterion for CUDs (American Psychiatric Association, 2013) and prior studies have identified associations between cannabis use and interpersonal difficulties that may contribute to this psychosocial dysfunction (Gruber et al., 2009; Stephens et al., 2002).

Cannabis Use and Interpersonal Dysfunction

There is growing evidence in the literature that cannabis users experience interpersonal dysfunction (Ansell, Laws, Roche, & Sinha, 2014; Trull, Wycoff, Lane, Carpenter, & Brown, 2016). Specifically, studies have shown that cannabis users reported adverse effects of their use on their social lives (Gruber et al., 2003), and negative consequences associated with their friends and family (Stephens et al., 2002). An experimental study by Janowsky and colleagues (1979) found that cannabis-intoxicated individuals reported feeling more detached from others, more sarcastic and less genuine during social interactions compared with trials during which they were sober. When rated by sober others, cannabis-intoxicated individuals were evaluated to be less empathetic, less accepting, and to have fewer social skills. In a similar study by Galanter and colleagues (1974), cannabis-intoxicated individuals showed a pattern of social withdrawal from others and less frequent engagement in social interactions compared to when they were sober. Despite being observed as detached from others, these cannabis-intoxicated individuals reported having increased insight into others' emotions, suggesting that cannabis users may be unaware of the effect cannabis is having on their interpersonal functioning.

More recently, ecological momentary assessment (EMA) studies (Ansell et al., 2014; Trull et al., 2016) have found similar indications of interpersonal dysfunction associated with cannabis use. A study by Ansell and colleagues (2014) found that on days when they used cannabis, relative to days when they did not use, recreational cannabis users reported increases in their hostile behaviors and increases in their perceptions of hostility in others. Another study by Trull and colleagues (2016) found that psychiatric outpatients with borderline personality or depressive disorders reported greater hostility while using cannabis but not while using alcohol. Additionally, patients' overall hostility throughout the twenty-eight-day study was associated with more frequent cannabis use. The previously mentioned studies provide evidence to support that cannabis users experience interpersonal dysfunction, but it is unclear how these effects are happening. One possible mechanism may be through the association of cannabis with altered social cognitive abilities.

Social Cognition

The terms social cognition, theory of mind, mentalizing, and emotion recognition are often used interchangeably. For the purposes of the discussion here, social cognition and social cognitive abilities will be used. Social cognition refers to the mental processes involved in gaining knowledge and understanding of social interactions. It involves (a) building a mental representation of social relationships, (b) inferring others' thoughts, emotions, and intentions, and (c) using this information to guide social behavior (Adolphs, 1994). In other words, it is our ability to accurately identify, perceive, and understand the intentions of others, so that we can then respond appropriately to social information (p. 176, Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001).

It is acknowledged that social cognition is spread out in the brain in a widespread neural network that is formed by the temporoparietal junction, precuneus, and prefrontal cortex (Amodio & Frith, 2006; Carrington &Bailey, 2009; Krall et al., 2014; Mar, 2011). The temporoparietal junction, precuneus, and prefrontal cortex brain regions have been found to be involved in the ability to shift attention to different stimuli (Krall et al., 2014), self-reflection (Quevedo et al., 2017), and in moderating social behavior (Pirau & Lui, 2018). Although social cognition is a highly distributed neurocognitive network, it is hypothesized by many that social cognition consists of lower- and higher-level processes that have been shown to occur in separate neural networks (Keysers & Gazzola, 2007; Shamay-Tsoory, 2011; Oliver et al., 2018; Herbert et al., 2014). Figure 1 illustrates a model of the lower- and higher-level facets of social cognitive abilities.

Lower-level social cognition, or "emotion recognition," involves inferring others' experiences using emotional empathy and basic emotion recognition (Baron-Cohen et al., 2001). In contrast, higher-level social cognition, or "mentalizing," is more complex as it requires an individual to integrate their perspective with the imaginative perspective of another individual by decoding their mental state and emotions from verbal (tone of voice), and non-verbal cues (e.g., body language). Despite findings supporting the distinction between these two subcomponents of social cognition, emotion recognition tasks are what constitutes the majority of the research on social cognitive abilities in cannabis use. Previous studies have linked social cognitive impairments to interpersonal dysfunction (De Meulemeester, Lowyck, Vermote, & Luyten, 2017; Preller et al., 2013) and multiple forms of psychopathology including, autism spectrum disorders (ASDs; Baron-Cohen et al., 2001; Martinez et al., 2016), personality disorders (PDs; Marissen, Deen, & Franken, 2012; Bo & Kogerslev, 2017), anorexia nervosa (Brockmeyer et al., 2016; Hamatani et al., 2016), and schizophrenia (Buck, Healey, Gagen, Roberts, & Penn, 2016; Martinez et al., 2016), to name a few.

Social Cognition and Interpersonal Dysfunction

Various studies have found an association between social cognitive abilities and interpersonal dysfunction. Specifically, individuals with lower scores on the Reading the Mind in the Eyes Test (RMET; a measure of emotion recognition), have been found to be more irritated by others' behaviors and consistently exhibit problematic behaviors themselves (Rodrigues, Ellerbeck, & Ansell, 2015). A study examining social cognition in individuals with borderline personality disorder (BPD) found that high scores on the Reflective Functioning Questionnaire (RFQ; a self-report questionnaire in which high scores reflect uncertainty about mental states), were associated with greater interpersonal distress (De Meulemeester et al., 2017). Social cognitive impairments have also been associated with reduced ability to feel empathy and compassion for others (Radke & de Bruijn, 2015), restricted social networks (Szanto et al., 2012), and decreased social support (Preller et al., 2013). A systematic review examining social cognitive abilities across different types of substance users found that alcohol users and methamphetamine users demonstrated significant impairments on emotion recognition tasks

(Sanvicente-Vierira et al., 2016). Consistent with these findings, recent meta-analyses have shown that individuals with alcohol use disorder (AUD) also display more significant impairment in their ability to identify emotions (Onuoha et al., 2016; Bora et al., 2016). Preller and colleagues (2013) found that both chronic cocaine users and recreational cocaine users performed more poorly on a mentalizing task compared to controls. Additionally, the cocaine users who performed more poorly on the mentalizing task experienced significant interpersonal dysfunction and had significantly smaller social networks. Fernandez-Serrano and colleagues (2010) found that the quantity and duration of the use of substances were significantly associated with poor recognition of basic emotions compared to controls. Functional magnetic resonance imaging (fMRI) studies support the previous finding by demonstrating that a variety of substances affect the brain regions associated with social cognitive abilities (Gorka et al., 2015; Maurage et al., 2012). Recent fMRI studies have also demonstrated alternations in neural networks and regions commonly associated with social cognition in cannabis users as well (Roser et al., 2012; De Luca et al., 2017). Taken together, these findings suggest that deficits in social cognition may contribute to the decline in social interactions and negatively impact relationships, playing an essential role in the development, progress, and treatment of psychological disorders.

Cannabis Use and Social Cognition

There is a growing body of literature demonstrating the effects of acute cannabis intoxication on brain regions associated with social cognitive abilities. Experimental fMRI studies have repeatedly found disruptions and alterations in the amygdala and prefrontal cortex in cannabis-intoxicated individuals (Phan et al., 2008; Bossong et al., 2013; Gorka, Fitzgerald, de Wit, Phan, 2015; Fusar-Poli et al., 2010). Specifically, Phan and colleagues (2008), Gorka and colleagues (2015), and Fusar-Poli and colleagues (2010) all found that non-cannabis users who were administered THC demonstrated poorer performance during emotion recognition tasks when compared to a sober control condition. In addition to poorer performance, cannabis-intoxicated individuals also demonstrated reduced amygdala and prefrontal cortex activity and connectivity. Alterations in the amygdala and prefrontal cortex regions have also been demonstrated in sober heavy cannabis users when they perform emotion recognition tasks (Gruber, Rogowska, & Yurgelyn-Todd, 2009; Roser et al., 2012; Wesley, Lile, Hanlon, & Porrino, 2016), which suggests that persistent cannabis use may have long-term effects on these brain regions. While the long-term consequences of cannabis use on social cognitive abilities have not yet been examined in the human brain, it has been examined in animal models. Findings from Rubino and Parolaro (2008) using experimental animal models suggest that heavy cannabis use consumption throughout adolescence may produce changes in the adult brain circuits by resulting in altered emotion recognition and social cognitive performance in adulthood. If these alterations occur as a result of cannabis use, then it is possible that social cognitive abilities may contribute to the interpersonal dysfunction observed in cannabis users. Overall, the above-mentioned fMRI results suggest that both occasional and prolonged cannabis use may affect regions of the brain associated with social cognitive abilities, which may then promote the interpersonal dysfunction that has been observed in cannabis users.

Although emotion recognition is an essential component of successful social cognition and social relationships, it is generally considered a lower-level social cognitive skill and does not measure mentalizing (a higher-level social cognitive skill). Very few studies have examined the factor structure (i.e., lower- and higher-level social cognition) of social cognitive abilities and to my knowledge, all studies have only examined lower-level cognitive skills in cannabis users using measurements of emotion recognition or emotional empathy. Clopton and colleagues (1979) administered cannabis and a placebo to thirty male regular users on two separate trials. In this study, regular users were individuals who used cannabis five to thirty days per month. Subjects were administered half of the Affective Sensitivity Scale (ASC; Danish & Kagan, 1971) before consumption, and then the second half after consumption. This study found that intoxicated subjects' performance on the ASC significantly declined after cannabis consumption. The ASC involved viewing filmed segments of encounters between individuals and then choosing the response that most accurately described what the individual was feeling in a specific scene. Examinees were instructed to choose (from multiple-choice items) the statements that best described the feelings of the individuals in each scene. It is of note, that although recent studies utilize filmed segments to assess mentalizing abilities (Dziobek et al., 2006; McDonald, Flanagan, & Rollin, 2011), authors of the ASC emphasize that this test measures only the ability to identify the emotions of the individuals in the scenes (Danish & Kagan, 1971). In an experimental study, Ballard and colleagues (2012) gave 7.5 and 15mg THC capsule or placebo capsule to twenty-five regular users in three separate sessions before performing an emotion expression morphing task (using Pictures of Facial Affect Set; Ekman and Friesen, 1976). Regular users were characterized as individuals who had used cannabis at least ten times in their lives and who were not currently using it more than three times per week. Subjects were shown four basic emotions (anger, fear, happiness, and sadness) that morphed from 10% to 100% of the emotion expression and then each emotion was then displayed in 10 levels of intensity. Intoxicated subjects displayed significant impairments in recognition of threat-related emotions (fear and anger) in both trails. These effects were dose-dependent, as greater impairments were observed in subjects with the 15 mg THC dose, compared to the 7.5 mg THC dose. Interestingly, cannabis consumption impaired emotion recognition of only highly intense threat-related (fear and anger) emotional facial expressions but did not display impaired emotion recognition of lower emotional intensity, or more subtle facial expressions.

There has been an increase in interest in the emotion type and cannabis dose that is most associated with impairments. However, findings from previous research are conflicting. Platt and colleagues (2010) found that compared to controls, heavy cannabis users who used at least fifteen days per month required greater intensity in all facial expressions (happy, sad, and angry) when they viewed morphing neutral faces before choosing the correct response (using the Dynamic Emotional Expression Recognition Task; DEER-T; Tottenham et al., 2009). This suggests that although there were no significant group differences on accuracy, heavy cannabis users took longer to respond suggesting difficulty identifying or processing the emotions compared to controls. In another study, Hindocha and colleagues (2014) also used a facial morphing task (using NimStim Face Stimulus Set; Tottenham et al., 2009) and found that when compared to non-users, frequent cannabis users (used cannabis twenty days per month, for the past six months) required greater intensity to accurately recognize all facial emotions except for surprise (i.e., fear, disgust, sadness, anger, happiness, and neutral). Emotion recognition deficits have also been examined in abstinent cannabis-dependent patients compared to healthy controls. Bayrakci and colleagues (2015) recruited thirty male cannabis-dependent patients who had been abstinent for at least one month and assessed their ability to recognize positive (happiness, surprise) and negative (sadness, anger, fear, shame) facial emotions on black and white photographs (using Facial Emotion Identification Test and Facial Emotion Discrimination Test; Kerr and Neale, 1993). Additionally, they asked subjects to pinpoint whether pairs of different emotional facial expressions were the “same” or “different.” Abstinent cannabis-dependent subjects demonstrated impaired ability to differentiate between facial expressions and impaired recognition of negative emotions. They did not, however, show impairments in recognizing positive emotions. Interestingly, Bayrakci and colleagues (2015) did not find within-group differences in the cannabis-dependent subjects, as the length of abstinence, the number of years of cannabis use, and the frequency or quantity of cannabis use before abstinence did not correlate significantly with scores on the FEIT. However, one limitation of this study is that they did not assess facial emotion recognition abilities in the cannabis dependent patients before their period of abstinence. Therefore, it is unclear whether use over the past thirty days may have systematically affected emotion recognition.

Altogether, these findings suggest that the association between cannabis use and social cognitive abilities is complex and inconsistent. Variations of study designs across studies may explain the inconsistency in previous findings. Several methodological issues in previous studies may also explain the inconsistency in findings. For example, previous studies used small sample sizes ranging from eleven to thirty cannabis-using participants, resulting in low statistical power. Despite findings supporting the discrepancy between lower- and higher- level cognitive abilities, prior cannabis use, and social cognition studies have mainly measured social cognitive abilities via emotion recognition tasks. Emotion recognition tasks measure one factor of social cognitive abilities and are not recommended to be used alone as a general measure of social cognitive abilities (Mitchell and Phillips, 2015). Thus, recent studies suggest that assessing both lower- and higher-level social cognitive abilities provide a more general assessment of social cognitive abilities (Turner and Felisberti, 2017). Previous studies mainly utilized an experimental design to assess emotion recognition in acute cannabis intoxication (Ballard et al., 2012; Clopton et al., 1979; Fusar-Poli et al., 2010; Phan et al., 2008; Gorka et al., 2015), while only a few studies used a cross-sectional design in heavy cannabis users (Platt et al., 2010; Hindocha et al., 2014) or abstinent cannabis dependent users (Bayrakci et al., 2015). The operationalization of heavy cannabis use also varied across studies, ranging from using at least ten times in their lifetime but no more than three times per week (Ballard et al., 2012), to at least fifteen times per month (Platt et al., 2010), or at least 20 times per month (Hindocha et al., 2014). Additionally, the findings of these cross-sectional studies assessed recent cannabis exposure only, so it is unclear whether social cognitive abilities differ across cannabis users who have been using for a longer duration of time. Lastly, although studies have compared social cognitive abilities in specific groups of cannabis users relative to controls, they have not examined how social cognitive abilities vary across the full spectrum of cannabis users. Clarifying how social cognitive abilities relate to cannabis use using a dimensional measure of cannabis use patterns may, therefore, expand our knowledge of how social cognition more broadly relates to the interpersonal dysfunction that is experienced by cannabis users.

The Present Study

Recent literature demonstrates that cannabis use is associated with interpersonal dysfunction; however, it is unclear how these constructs are linked. Neurobiological and experimental studies suggest that cumulative and acute cannabis use is associated with altered social cognitive abilities, which may last beyond the termination of use. Social cognitive abilities may underlie the interpersonal dysfunction that has frequently been observed in cannabis users (Ansell et al., 2014; Stephens et al., 2002; Trull et al., 2016). Researchers (Turner & Felisberti, 2017) have recommended examining lower- and higher-level social cognitive skills to obtain a more general measure of one's social cognitive abilities. Thus, incorporating both lower- and higher-level skills may help clarify where cannabis use effects are occurring. This may help clarify contradicting findings in previous cannabis use and social cognition research. In addition, although cannabis use has been suggested to have long-lasting social cognitive impairments (e.g., demonstrated in abstinent cannabis dependent patients; Hindocha et al., 2014; Wesley et al., 2016) no research to date has examined whether there are long-lasting social cognitive effects of cumulative lifetime cannabis use. Previous studies examined recent heavy cannabis use without assessing for the longevity of their use. Thus, computing cumulative cannabis exposure across the lifetime may also clarify the inconsistency in previous findings. Therefore, the goal of the present study is to measure lower- and higher-levels of social cognitive abilities in cannabis users with varying use frequency, quantity, and duration, using the Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al., 2001) and the Movie for the Assessment of Social Cognition (MASC; Dziobek et al., 2006).

Study Aim

Aim 1: To examine the association between recent cannabis use on social cognitive abilities. (Hypothesis 1) A greater number of days of recent cannabis use will be associated with lower scores on each of the RMET subscales (e.g., total, positive, negative, and neutral). (Hypothesis 2) A greater number of days of recent cannabis use will be associated with a lower score on the MASC total and higher scores on the incorrect subscales (e.g., hyper-mentalizing, under-mentalizing, and no-mentalizing).

Aim 2: To examine the association between lifetime cannabis exposure, or “joint-years” on social cognitive abilities. (Hypothesis 1) A greater number of joint-years will be associated with lower scores on each of the RMET subscales (e.g., total, positive, negative, and neutral). (Hypothesis 2) A greater number of joint-years will be associated with a lower score on the

MASC total score and higher scores on the incorrect subscales (e.g., hyper-mentalizing, under-mentalizing, and no-mentalizing).

Methods

Participants and Procedures

Two hundred and sixty-five individuals recruited from the community consented to patriciate in the parent study (R01: DA039924; PI; Ansell), which examined real-world daily experiences of cannabis users. Of the 265 consented participants, 249 completed the computerized social cognitive assessments; however, a computer error resulted in missing data and data on only 235 participants was available for use. Participants met the following inclusion criteria: (1) male or females ages eighteen to thirty years; (2) recreational cannabis users who reported using cannabis on two or more occasions per month for the past six months; (3) regular cannabis users who reported using cannabis a minimum of three times weekly for the past six months; (4) able to provide a negative toxicology screening for substances, except for cannabis; (5) able to read English. Participants were excluded if they endorsed: (1) past or current criteria for any substance dependence except nicotine; (2) current Axis I psychiatric disorders with acute symptoms (i.e., psychosis, suicidal, homicidal, current mania); (3) pregnant or nursing. Potential participants were screened by telephone to determine eligibility and were asked to attend three separate appointments. During the first appointment, participants provided demographic information and reported patterns of current and past substance use. Participants completed social cognitive assessments during their second and third appointments and were instructed to not use cannabis twenty-four hours prior to testing.

Measures

Sociodemographic Data. Age, gender, race, and ethnicity were obtained via self-report.

Recent Cannabis Use. The *Timeline Followback Questionnaire* (TLFB; Sobell et al., 1996) is a measure of assessing drug use frequency and quantity, including cannabis use frequency and has demonstrated reliability in the excellent range (.79 to .96; Robinson, Sobell, Sobell, & Leo, 2014). Prior to each social cognitive measure (e.g., RMET and MASC), participants were provided with a calendar of the last thirty days and were instructed to indicate the days in which they used cannabis, alcohol, tobacco, and any other drugs. The total number of days of cannabis use over the last thirty days was used as a measure of recent cannabis use (or recent cannabis exposure). Furthermore, the TLFB was used to categorize participants into a *regular* cannabis use group or a *recreational* cannabis use group. By adopting the definition of regular use from the Addiction Severity Index (ASI; McLellan et al., 1992), regular cannabis users were identified as individuals who reported consuming cannabis three or more times per week, while recreational cannabis users were identified as individuals who reported consuming cannabis two or less times per week. Additionally, alcohol use over the last thirty days was also assessed in order to be used as a covariate. This was assessed due to previous findings identifying worse social cognitive performance in alcohol users (Onuoha et al., 2016; Bora et al., 2016).

Lifetime Cannabis Use. In order to assess cumulative lifetime cannabis exposure, a joint-years measure was created to quantify each's level of cannabis exposure. This measure was adapted from the well-established "pack-years" measure of lifetime cigarette exposure used in nicotine/tobacco research (Bernaards, Twisk, Snel, Van Mechelen, & Kemper, 2001). Previous studies have attempted to calculate joint-years similar to how pack-years are calculated (Aldington et al., 2008; Aston, Metrik, & MacKillop, 2015); however, there have been many challenges and limitations to how this has been done. Namely, many cannabis users are unable to report their usage in the number of joints, particularly those who are infrequent users. In this study, joint-years was determined using information regarding the quantity of use in hits, which, being the smallest unit of measurement, was more reliable and generalizable across different users. Previous research has shown that one joint is roughly equal to approximately ten hits (Aston et al., 2015; Zeisser et al., 2012). The frequency of use and duration of use was assessed for each period of cannabis use over the lifetime. As a first step, the present study sought to identify periods of time defined by different patterns of use in terms of quantity, frequency, and duration; for example, using 0.5 grams of cannabis twice a week for a period of 8 months, and then using 0.2 grams of cannabis once a month for a period of 6 months. From this, an average number of daily hits across each period of use was calculated. Next, the total duration of use across different patterns of use was calculated in years. Finally, joint-years was calculated using the following equation: $\left(\frac{\text{hits per day}}{10}\right)$ X years of use.

Social Cognitive Assessments. Emotion recognition was measured using a computerized version of the *Revised Reading the Mind in the Eyes Test* (RMET; Baron-Cohen et al., 2001). The RMET has been successful at detecting individual differences in typically developing adult samples and clinical adult samples (Fossati et al., 2017). The RMET is an established measure of attribution and decoding of mental states from photographs of the eye region, and has been used in various substance use studies (Bora et al., 2016; Hysek, Domes, & Liechti, 2012; Kemmis, Hall, Kingston, & Morgan, 2007). Participants were presented with thirty-six black and white photographs of the eye region of men and women expressing different mental states. Four adjectives were displayed around each photograph and participants were asked to choose the best adjective describing a mental state. Participants received a list of all adjectives and their definitions if needed. Previous studies have found that mental state recognition varies across types of emotions. For this reason, in addition to calculating the RMET total score, Harkness and colleagues' (2005) algorithms were used to calculate correct responses for positive valance (eight items), negative valance (12 items), and neutral valance (16 items) mental states. In the present study, internal consistency for RMET total score revealed a Cronbach's alpha value of alpha = .57. Alpha ranged from .55 to .57 if item deleted, indicating that removal of any item would not result in a higher alpha.

The *Movie for the Assessment of Social Cognition* (MASC; Dziobek et al., 2006) incorporated metaphor and sarcasm to the traditional social cognitive concept of mental state recognition, to develop a more ecologically valid, multimodal (auditory and visual) assessment of social cognition that resembles real-life social interactions. The MASC has excellent internal consistency ($\alpha = .84$) and test-retest reliability (ICC = 0.97) and has been used to demonstrate social cognitive impairments in cocaine use disorder (Preller et al., 2013), alcohol use disorder (Maurage et al., 2016), anorexia (Brockmeyer et al., 2016), borderline personality disorder (Goodman & Siever, 2011), to name a few. The MASC operationalizes social cognition through a fifteen-minute video representing social interactions a way that they would likely happen in everyday life. The video depicts the interactions between four characters who each display stable character traits (e.g., shy, outgoing, self-centered) along with different motives for engaging in the social gathering. The video was paused after each scene, and participants were asked questions related to the characters' intentions, beliefs, and emotions such as: "What is Michael feeling?" "What is Sandra thinking?" "What is Cliff's intention?" Scores range from 0 to 46, and social cognitive ability is represented by the total number of items that are correct. In addition, each incorrect response can be indicated as hyper-mentalizing (overly interpreting the intentions and mental states of others), under-mentalizing (insufficiently interpreting the intentions and mental states of others), no mentalizing (completely lacking inference or understanding of the intentions and mental states of others). In the present study, internal consistency for MASC total score revealed a Cronbach's alpha value of alpha = .63. Alpha ranged from .61 to .63 if item deleted, indicating that removal of any item would not result in a higher alpha.

Verbal and Performance IQ. There is a growing body of literature demonstrating the association between social cognitive abilities (e.g., emotion recognition) and general mental/cognitive ability or intelligence quotient (IQ). A recent meta-analysis (Baker, Peterson, Pulos, & Kirkland, 2014), indicated a small correlation ($r = .24$) between the performance of the RMET and IQ. Intellectual functioning was measured by performance on the *Wechsler Abbreviated Scale of Intelligence* (WASI; Wechsler, 1999), a norm-referenced measure of intelligence that has well-established reliability and validity (Wechsler, 1999). The WASI two-subtest (Vocabulary and Matrix Reasoning) form was used to convert raw scores into T-scores which was then used to calculate a full-scale IQ (FSIQ-2). Vocabulary and Matrix Reasoning have demonstrated excellent reliability (.94) and excellent test-retest stability (.90 - .96; WASI; Wechsler, 1999). Therefore, this measure is considered an adequate measure of overall intelligence.

Power Analysis

Due to the dearth of literature examining associations between cannabis use and social cognitive abilities, studies that have examined social cognition in cannabis users versus non-users were reviewed to estimate effect sizes for the present study (Platt et al., 2010; Hindocha et al., 2014; Bayrakci et al., 2015). The effect sizes found in the literature ranged from $d = .34$ (small) to $d = .84$ (large), and an a priori one-tailed t-test power analysis was performed based on the pooled effect sizes ($d = 0.62$) for the differences in social cognitive scores between cannabis users and non-using controls. With an alpha = .05 and power = .90, an a priori effect size was estimated to be N = 92 (46 per group). Thus, the sample size of 235 was sufficient to detect statistical significance.

Data Analyses

Pearson linear correlation (see Table 3) were performed to identify potentially confounding variables including IQ, demographic (e.g., age, gender, race), and recent alcohol use on RMET and MASC performance. Age, gender, and IQ were significantly correlated with accuracy in social cognitive measures and were thus included as covariates in all analyses. Missing data were analyzed using SPSS Missing Values Analysis, and missing data were characterized as Missing Completely at Random (MCAR, p = .99). Thus, cases that accounted for 44.4% or more of total missing values (range: 44.4% to 77.8%) were deleted, resulting in a total sample of 235 participants. Limiting the sample to only cases with 0% missing values resulted in a total sample of 211 participants. Findings did not differ when all analyses were run with the 211 participants; therefore, only the larger MCAR sample is reported. The assumption of normality of all tested variables was assessed using Kolmogorov-Smirnov. A base-10 logarithmic transformation was performed for joint-years due to the highly skewed distribution. Outliers for joint-years were Winsorized at the top 5% and the bottom 5% in order to retain cases.

Separate hierarchical multiple regressions were run to assess the association between recent cannabis use and lifetime cannabis use (joint-years) on each of the RMET subscales (e.g., total, positive, negative, and neutral), and the MASC subscales (e.g., total, hyper-mentalizing, under-mentalizing, and no-mentalizing), controlling for covariates (e.g., age, gender, and FSIQ-2). Exploratory one-way analyses of covariance (ANCOVA) were conducted testing the overall effect of group (recreational users versus regular users) on the RMET subscales and MASC subscales. Lastly, given that response time on the RMET has been associated with deficits in social cognitive functioning in previous work (Platt et al., 2010), exploratory separate hierarchical multiple regressions were run to determine whether cannabis exposure (recent and joint-years) impacted response time to correct answers on the RMET. Exploratory one-way analyses of covariance (ANCOVA) were conducted testing the overall effect of group (recreational users versus regular users) on RMET response time. Due to multiple comparisons, familywise (FWER) Type I error rates were applied to each set/family of tests (e.g., recent cannabis use and the four RMET subscales; recent cannabis use and the four MASC subscales; lifetime cannabis use and the four RMET subscales; lifetime cannabis use and the four MASC subscales). Therefore, an alpha of .0125 was applied to each set of analyses to detect true differences while also maintaining control over multiplicity effects. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) versions 23 (SPSS, 2012).

Results

Descriptive statistics for participants are summarized in Table 1 and Table 2. Participants were primarily White (69.4%), female (55.7%; M age = 20.95), with an average IQ of 109 (SD = 11). The average number of days of recent cannabis use over the past thirty days was 10.10 (SD = 11), and the average number of lifetime cannabis use in joint-years was 1.31 (SD = 2.23). Demographic characteristics of recreational versus regular cannabis users were compared using ANOVA (for continuous variables) and Chi-square (for categorical variables). Recreational and regular cannabis users did not differ with respect to age, IQ, gender, or race. Analyses revealed that there were significant group differences in recent cannabis use ($p < .001$) and joint-years ($p = .001$). Regular users reported using four times more cannabis in the last thirty days than recreational users ($p < .001$). Similarly, regular users had approximately two times greater joint-years ($p = .001$).

RMET Results

A series of two-step hierarchical multiple regressions were run to determine the association between recent cannabis use and RMET total score and subscales after adjusting for covariates. See Table 4 for full details on each regression model. The full model of age, gender, and recent cannabis use (Model 2) were statistically significant for RMET total scores and RMET neutral scores. Recent cannabis use was significantly associated with RMET total score (R2 = .02, F = 5.56, $p = .02$). Recent cannabis use was significantly associated with RMET neutral score (R2 = .03, F = 5.23, $p = .02$). More days of recent cannabis use were associated with a higher number of correct responses on the total RMET and a higher number of correct responses to neutral emotion stimuli. After adjusting for multiple comparisons using the Bonferroni adjusted alpha level of $p < .0125$, recent cannabis use was no longer a significant predictor of RMET total score or RMET neutral score. Yet, it is of note that results are trending in a positive direction that does not survive correction for multiple comparisons.

The same analyses were run for all RMET variables using joint-years as a measure of lifetime cannabis exposure. Joint-years was not significantly associated with RMET scores. Results are presented in Table 6. To explore the possible overlap between IQ and cannabis on emotion recognition abilities, models were run without IQ in the model, and the results remained the same.

MASC Results

The above analyses were repeated to determine if recent cannabis use or joint-years were associated with MASC total score and subscales. The number of days of recent cannabis use did not emerge as a significant predictor of MASC scores. Similarly, joint-years was not associated with MASC scores. See Table 6 for full details on each regression model. To explore the possible overlap between IQ and cannabis on mentalizing abilities, models were run without IQ in the model, and the results remained the same.

Exploratory Results

Between-Group Comparisons. A series of repeated measures ANCOVAs, with age, gender, and IQ as covariates, were run to determine whether there was a statistically significant difference in RMET performance between recreational and regular user groups. Results revealed a statistically significant difference in RMET total score ($F = 4.32$, $p = .04$, partial $\eta2 = .019$) and RMET negative score ($F = 4.71$, $p = .03$, partial $\eta2 = .021$). Results suggest that regular cannabis users had a higher number of overall correct responses on the RMET and had a higher number of correct responses on negative emotional stimuli. Between-group comparisons on the RMET did not survive Bonferroni adjusted alpha level of $p < .0125$. It is important to note that the results were also trending in a positive direction. See Table 7 for full details on between-group comparisons in RMET scores.

These analyses were repeated to examine whether there was a statistically significant difference between groups on MASC performance. Results revealed a statistically significant difference in the subscale for under-mentalizing ($F = 13.45$, $p = .001$, partial $\eta2 = .058$), such that recreational cannabis users made more errors than regular cannabis users. See Table 8 for full details on between-group comparisons in MASC scores.

RMET Response Time. A series of two-step hierarchical multiple regressions were run to determine if recent cannabis use or joint-years were associated with the amount of time in milliseconds that it took to respond correctly. The number of days of recent cannabis use did not emerge as significantly associated with response time for correct RMET responses (see Table 9). Similarly, joint-years did no emerge as significantly associated with response time to RMET items (see Table 10).

Lastly, a series of repeated measures ANCOVAs, with age, gender, and IQ as covariates, were run to determine whether there was a statistically significant difference between recreational and regular cannabis users' response time. Results revealed no statistically significant difference in response time for RMET items. See Table 11 for full details on between-group comparisons in response time.

Discussion

Over the last ten years, there has been a 58% increase in the number of cannabis users who reported using cannabis twenty or more times in the past month (WHO, 2016), and frequent cannabis users are at higher risk for developing and maintaining CUDs (UNODC, 2016). Cannabis users have reported adverse effects of their use on their social lives (Gruber et al., 2003) including decreased social support (Preller et al., 2013) and restricted social networks (Radke et al., 2015). There is growing evidence that interpersonal dysfunction often experienced by those with CUDs may be in part due to social cognitive impairments (Clopton et al., 1979; Ballard et al., 2012). Previous research has found emotion recognition impairments in both cannabis-intoxicated individuals (Gruber et al., 2009; Roser et al., 2012; Wesley et al., 2016) and heavy cannabis users (Bayrakci et al., 2015; Hindocha et al., 2014; Platt et al., 2010). While informative, prior cannabis use research has not explored additional facets of social cognitive abilities, such as mentalizing. Thus, it remains unknown how recent cannabis use and cumulative cannabis exposure across the lifetime is associated with the subcomponents of social cognitive abilities (e.g., emotion recognition and mentalizing). The present study aimed to explore emotion recognition and mentalizing abilities, as two subcomponents of social cognitive abilities, in recent cannabis use and lifetime cannabis use by assessing varying use frequency, quantity, and duration.

Primary findings revealed that in a sufficiently powered sample, cannabis use was not found to be significantly associated with general social cognitive abilities. In other words, the number of days of recent cannabis use *and* cumulative lifetime cannabis use were not associated with overall performance on an emotion recognition task (e.g., RMET) and on a mentalizing task (e.g., MASC). Put another way, the number of days an individual used cannabis in the past month and the number of years of cannabis exposure were not associated with their ability to accurately perceive emotions or more complex social cues (e.g., the tone of voice, body language). When examining group differences between recreational users versus regular users, exploratory analyses revealed no significant differences in emotion recognition and mentalizing abilities. Despite no between-group differences in overall mentalizing performance, compared to regular users, recreational users made significantly more errors due to insufficiently interpreting the intentions and mental states of others. Notably, although regular cannabis users made fewer of these error types, findings did not indicate better mentalizing performance compared to recreational users. Given that there were no group differences associated with cannabis use and social cognitive abilities, further exploratory analyses examined whether increased cannabis use was associated with how long (i.e., milliseconds) it took individuals to accurately respond to the items on the emotion recognition and mentalizing tasks. However, no significant associations were found. On one hand, this finding is consistent with Platt and colleagues' (2010) finding that when compared to non-using controls, heavy cannabis users did not differ in the number of emotions they could correctly identify on the Dynamic Emotional Expression Recognition Task;

(DEER-T; Tottenham et al., 2009). In contrast, Platt and colleagues (2010) found that heavy cannabis users took longer to respond compared to non-using controls.

Taken together, the results of the present study indicate that in a large sample of cannabis users, no harmful effects of cannabis use on social cognitive abilities were detected. The present study's findings are contradictory with previous findings that suggest that sober heavy cannabis users may experience problems in recognizing basic emotions (Bayrakci et al., 2015; Hindocha et al., 2014; Platt et al., 2010). One potential explanation for this inconsistency might be that previous studies have not controlled for intelligence (IQ), which has been found to be associated with social cognitive performance (Baker et al., 2014). Though the present study's results cannot be explained by IQ, it was significantly associated with both social cognitive constructs. The removal of IQ in the analyses did not change the results; however, IQ did explain a significant amount of the variance observed. Prior studies examining cannabis use in social cognitive abilities have not assessed IQ (Bayrakci et al., 2015; Hindocha et al., 2014; Platt et al., 2010). Therefore, it is unclear whether their statistically significant results would still stand if IQ were included in the model. A second potential explanation for the inconsistency may be due to an imbalance of male to female gender ratios. For example, both Platt and colleagues' (2000) and Hindocha and colleagues' (2014) heavy cannabis use groups consisted of primary males (i.e., 26 males: 2 females and 19 males: 6 females, respectively), and Bayrakci and colleagues' (2015) study consisted of only male abstinent cannabis-dependent individuals. This is problematic because gender differences in emotion recognition abilities have been found with men performing poorer on emotion recognition tasks (Hall & Matsumoto, 2004; Hoffman et al., 2010; Forni-Santos & Osorio, 2015). In the present study, the male to female ratio was relatively balanced (i.e., 104 males: 131 females) and gender was significantly correlated with accuracy on both social cognition measures and thus, was included as covariates in all analyses.

A third potential explanation for the inconsistency in the present study's findings is that previous studies have compared heavy cannabis users to non-cannabis user control groups in their analyses. Given that the present study aimed to examine whether social cognitive abilities differed across cannabis users who had been using for a longer duration of time, a control group was not required for the present study's analyses. The present study's results show that in a wide range of cannabis users, the number of days of recent cannabis use and the cumulative amount of cannabis they have been exposed to was not associated with social cognitive abilities. Bayrakci and colleagues (2015) also found similar results. Specifically, they did not find between-group differences with regard to performance on an emotion recognition task in abstinent cannabis-dependent individuals based on the length of abstinence, the number of years of cannabis use, and the frequency or quantity. The combined results of the present study with previous studies raise the hypothesis that individuals with social cognitive impairments may be more likely to use cannabis as a way to cope with the interpersonal stress related to poor social cognitive abilities. If cannabis use occurs as a result of social cognitive impairments, then it is possible that social cognitive abilities contribute to the interpersonal dysfunction that is often observed in cannabis users. This hypothesis would then give an explanation for the lack of significant associations between recent cannabis use and lifetime cannabis use on social cognitive abilities. Consequently, the lack of distinction between the two subcomponents of social cognitive abilities (e.g., emotion recognition and mentalizing) may be due to the homogeneity of social cognitive abilities among cannabis using individuals.

Future research should aim to address several limitations in the present study. First, despite the MASC providing strong ecological validity, and being an assessment of social cognition that resembles real-life social interactions, it is a computerized assessment that uses a multiple choice answer method. Therefore, it is unclear how performance on the MASC translates to real-world abilities to infer the emotions and intentions of others during social interactions. Second, this study utilized a cross-sectional design, and therefore the directionality of the findings are not clear. Future research should also continue to explore emotion recognition *and* mentalizing abilities as two subcomponents of social cognitive abilities, specifically between cannabis users and non-using controls. Mentalizing abilities, using the MASC have been identified in abstinent alcohol-dependent individuals (Maurage et al., 2016), and in recreational and regular cocaine using individuals (Preller et al., 2014). The MASC is known to resemble real-life social interactions and be more representative everyday social interactions.

On a clinical level, understanding both the associations and distinctions between emotion recognition and mentalizing abilities in cannabis users will assist clinicians in developing and modifying interpersonal functioning-focused treatment programs for those with CUDs. Treatment interventions could then be tailored to focus on specific impaired cognitive abilities. In focusing on these impairments, an increase in social cognitive abilities may lead to an increase in social support and social networks, which have been found to serve as a potential buffer for the development and maintenance of substance use disorders (Dobkin et al., 2002; Wills & Vaughan, 1989).

Table 1
Participant Demographic Characteristics

	Total Sample (*N* = 235)			Recreational Users (*N* = 111)			Regular Users (*N* = 124)			ANOVA
	Mean	*SD*	*Median*	*Mean*	*SD*	*Median*	*Mean*	*SD*	*Median*	*p-value*
Age (in years)	20.95	2.22	20.47	21.11	2.31	20.68	20.83	2.15	20.12	0.34
FSIQ-2	109	11	109	110	10.66	111	107	12.22	108	0.06
Recent Cannabis Use (in days)	10.1	9.39	7	4.23	4.25	3	16.30	9.04	13	<.001
Lifetime Cannabis Use (in joint-years)	1.309	2.23	0.427	.739	1.47	.207	1.705	2.49	.765	0.001
RMET										
Total (out of 36)	25	3.81	26	25	3.94	26	26	3.69	26	0.23
Positive (out of 8)	5	1.37	6	6	1.46	6	6	1.29	6	0.55
Negative (out of 12)	8	1.88	9	8	1.78	8	9	1.95	9	0.17
Neutral (out of 16)	11	2.28	12	11	2.33	11	12	2.24	12	0.61
MASC										
Total Correct (out of 46)	36	4.19	37	36	4.49	37	37	3.86	38	0.09
MASC (incorrect)										
Hyper-mentalizing	5	2.51	5	5	2.63	5	5	2.44	5	0.53
Under-mentalizing	4	2.42	4	5	2.56	4	4	2.18	3	0.001
No-mentalizing	2	1.69	2	2	1.70	1	2	1.67	2	0.4

Note: M = Mean, SD = Standard Deviation

Table 2
Participant Demographic Frequencies

	Total Sample (N = 235)	Recreational Users (N = 111)	Regular Users (N = 124)	ANOVA *p-value*
Gender (% Female)	55.7	60.4	51.6	.17 (χ^2)
Race/ Ethnicity				.28 (χ^2)
% White	69.4	65.8	72.6	
% Black	9.8	11.7	8.1	
% Hispanic/Latinx	8.9	12.6	5.6	
% Asian	6.4	5.4	7.3	
% Other	5.5	4.5	6.5	

Table 3

Correlation Matrix

		1	2	3	4	5	6	7	8
RMET	1. Total	1							
	2. Positive	0.511**	1						
	3. Negative	0.731**	0.189**	1					
	4. Neutral	0.779**	0.105	0.302**	1				
MASC	5. Total	0.294**	0.036	0.304**	0.219**	1			
	6. Hyper-mentalizing	-0.062	0.002	-0.057	-0.058	-0.546**	1		
	7. Under-mentalizing	-0.271**	-0.044	-0.305**	-0.175**	-0.699**	-0.034	1	
	8. No-mentalizing	-0.275**	-0.149*	-0.252**	-0.162*	-0.562**	-0.054	0.368**	1
Cannabis Use	9. Recent Use (RMET)	0.072	0.031	0.011	0.092	0.059	-0.013	-0.119	-0.007
	10. Recent Use (MASC)	0.097	0.034	0.037	0.112	0.069	-0.012	-0.14*	0.006
	11. Lifetime Use	-0.006	0.094	-0.055	-0.021	0.013	-0.036	-0.07	0.097
Covariates	12. Age	-0.027	0.088	-0.082	-0.032	0.019	-0.055	0.027	0.01
	13. FSIQ	0.224**	0.067	0.204**	0.164*	0.26**	-0.147**	-0.167*	-0.214**
	14. Recent Alcohol Use (RMET)	-0.064	0.003	-0.091	-0.035	0.001	-0.025	-0.015	0.022
	15. Recent Alcohol Use (MASC)	-0.057	-0.003	-0.081	-0.027	-0.012	-0.023	-0.004	0.023

Note: * = Correlation significant at the .05 level, ** = Correlation significant at the 0.01 level.

Table 3 (continued)

Correlation Matrix (continued)

		9	10	11	12	13	14	15
RMET	1. Total							
	2. Positive							
	3. Negative							
	4. Neutral							
MASC	5. Total							
	6. Hyper-mentalizing							
	7. Under-mentalizing							
	8. No-mentalizing							
Cannabis Use	9. Recent Use (RMET)	1						
	10. Recent Use (MASC)	0.956**	1					
	11. Lifetime Use	0.373**	0.362**	1				
Covariates	12. Age	0.046	0.024	0.253**	1			
	13. FSIQ	0.055	0.06	-0.1	-0.081	1		
	14. Recent Alcohol Use (RMET)	0.489**	0.468**	0.023	0.065	-0.012	1	
	15. Recent Alcohol Use (MASC)	0.464**	0.449**	0.006	0.11	-0.023	0.951**	1

Note: * = Correlation significant at the .05 level, ** = Correlation significant at the 0.01 level.

Table 4
Regression Analyses for Recent Cannabis Use Predicting RMET Scores

RMET		R^2	F	B	SE(B)	β	p	95 % CI Lower Bound	95 % CI Upper Bound
Total									
1		.08	5.92**						
	Age			.00	.11	.00	.99	-.22	.22
	Gender			1.23	.50	.16	**.01**	.25	2.22
	FSIQ-2			.08	.02	.23	**<.01**	.03	.12
2		.10	5.56*						
	Age			-.01	.11	-.00	.97	-.22	.21
	Gender			1.33	.50	.17	**.01**	.35	2.30
	FSIQ-2			.07	.02	.23	**<.01**	.03	.12
	Recent Cannabis			.06	.03	.15	**.02**	.01	.11
Positive									
1		.03	2.02						
	Age			.07	.04	.11	.11	-.02	.15
	Gender			.32	.19	.12	.09	-.05	.68
	FSIQ-2			.01	.01	.08	.26	-.01	.03
2		.03	.50						
	Age			.07	.04	.11	.11	-.02	.15
	Gender			.33	.19	.12	.08	-.04	.70
	FSIQ-2			.01	.01	.08	.26	-.01	.03
	Recent Cannabis			.01	.01	.05	.48	-.01	.03
Negative									
1		.07	5.78**						
	Age			-.05	.06	-.06	.36	-.16	.06
	Gender			.62	.25	.16	**.01**	.13	1.10
	FSIQ-2			.03	.01	.21	**<.01**	.01	.05
2		.08	1.90						
	Age			-.05	.06	-.06	.34	-.16	.06
	Gender			.65	.25	.17	**.01**	.16	1.13
	FSIQ-2			.03	.01	.20	**<.01**	.01	.05
	Recent Cannabis			.02	.01	.09	.17	-.01	.04
Neutral									
1		.03	2.39						

	Age			-.01	.07	-.01	.85	-.15	.12
	Gender			.29	.31	.06	.34	-.30	.90
	FSIQ-2			.03	.01	.17	**.01**	.01	.06
2		.06	5.23*						
	Age			-.02	.07	-.02	.80	-.15	.16
	Gender			.35	.31	.08	.25	-.25	.95
	FSIQ-2			.03	.01	.16	**.01**	.01	.06
	Recent Cannabis			.04	.02	.15	**.02**	.01	.07

Note: F = for change in R^2; * = *p < .05;* ** = *p* < .01; *** = Only included if statistically significant on Bonferroni level (*p* < .0125).

Table 5
Regression Analyses for Recent Cannabis Use Predicting MASC Scores

								95 % CI	
MASC		R^2	*F*	B	SE(B)	β	*p*	Lower Bound	Upper Bound
Total									
1		.07	5.81**						
	Age			.06	.12	.03	.60	-.18	.30
	Gender			.60	.55	.07	.27	-.48	1.68
	FSIQ-2			.10	.02	.26	**<.01**	.05	.14
2		.08	.65						
	Age			.06	.12	.03	.61	-.18	.30
	Gender			.62	.55	.07	.26	-.46	1.71
	FSIQ-2			.10	.02	.26	**<.01**	.05	.14
	Recent Cannabis			.02	.03	.05	.42	-.03	.08
Hyper-mentalizing									
1		.03	1.92						
	Age			-.07	.08	-.06	.37	-.02	.15
	Gender			-.06	.34	-.01	.85	-.05	.68
	FSIQ-2			-.03	.02	-.15	**.03**	-.01	.03
2		.03	.38						
	Age			-.07	.08	-.06	.38	-.02	.15
	Gender			-.08	.34	-.02	.83	-.04	.70
	FSIQ-2			-.03	.02	-.15	**.03**	-.01	.03
	Recent Cannabis			-.01	.02	-.04	.54	-.01	.03
Under-mentalizing									
1		.03	2.16						
	Age			.02	.07	.02	.77	-.12	.16
	Gender			-.06	.33	-.01	.87	-.70	.59
	FSIQ-2			-.04	.01	-.17	**.01**	-.06	-.01
2		.04	2.39						
	Age			.02	.07	.02	.75	-.12	.17
	Gender			-.08	.32	-.02	.81	-.71	.56
	FSIQ-2			-.03	.01	-.16	**.02**	-.06	-.01
	Recent Cannabis			-.03	.02	-.10	.13	-.06	.01

No-mentalizing									
1		.05	4.02**						
	Age			-.01	.05	-.01	.90	-.10	.09
	Gender			-.26	.22	-.06	.24	-.71	.18
	FSIQ-2			-.03	.01	-.21	**<.01**	-.05	-.01
2		.06	.727						
	Age			-.01	.05	-.01	.89	-.1	.09
	Gender			-.25	.23	-.08	.26	-.70	.19
	FSIQ-2			-.03	.01	-.22	**<.01**	-.05	-.01
	Recent Cannabis			.01	.01	.06	.40	-.01	.03

Note: F = for change in R^2; * = $p < .05$; ** = $p < .01$; *** = Only included if statistically significant on Bonferroni level ($p < .0125$).

Table 6
Regression Analyses for Lifetime Cannabis Use Predicting RMET Scores

RMET		R^2	F	B	SE(B)	β	p	95 % CI Lower Bound	95 % CI Upper Bound
Total									
1		.08	6.29**						
	Age			-.01	.11	-.01	.95	-.23	.21
	Gender			1.20	.50	.16	**.02**	.22	2.18
	FSIQ-2			.08	.02	.24	**<.01**	.04	.12
2		.08	.10						
	Age			-.02	.11	-.01	.90	-.24	.21
	Gender			1.22	.50	.16	**.02**	.23	2.20
	FSIQ-2			.08	.02	.24	**<.01**	.04	.12
	Lifetime Cannabis			.11	.36	.02	.76	-.60	.83
Positive									
1		.03	2.02						
	Age			.06	.04	.10	.14	-.02	.14
	Gender			.33	.18	.12	.07	-.03	.69
	FSIQ-2			.01	.01	.08	.24	-.01	.03
2		.04	1.78						
	Age			.05	.04	.08	.25	-.03	.13
	Gender			.35	.18	.13	.06	-.01	.71
	FSIQ-2			.01	.01	.09	.21	-.01	.03
	Lifetime Cannabis			.18	.13	.09	.18	-.10	.44
Negative									
1		.08	6.55**						
	Age			-.05	.05	-.07	.32	-.16	.05
	Gender			.62	.25	.17	**.01**	.14	1.10
	FSIQ-2			.04	.01	.23	**<.01**	.02	.06
2		.08	.01						
	Age			-.05	.06	-.06	.34	-.16	.06
	Gender			.62	.25	.17	**.01**	.13	1.10
	FSIQ-2			.04	.01	.23	**<.01**	.02	.06
	Lifetime Cannabis			-.02	.18	-.01	.91	-.37	.33
Neutral									
1		.03	2.35						

	Age			-.01	.07	-.01	.85	-.15	.12
	Gender			.26	.31	.06	.41	-.35	.86
	FSIQ-2			.03	.01	.17	**.01**	.01	.06
2		.03	.04						
	Age			-.01	.07	-.01	.89	-.15	.13
	Gender			.25	.31	.06	.42	-.36	.86
	FSIQ-2			.03	.01	.17	**.01**	.01	.06
	Lifetime Cannabis			-.05	.22	-.01	.84	-.49	.40

Note: F = for change in R^2; * = $p < .05$; ** = $p < .01$; *** = Only included if statistically significant on Bonferroni level ($p < .0125$).

Table 7
Regression Analyses for Lifetime Cannabis Use Predicting MASC Scores

								95 % CI	
MASC		R^2	F	B	SE(B)	β	p	Lower Bound	Upper Bound
Total									
1		.08	6.02**						
	Age			.05	.12	.03	.68	-.19	.30
	Gender			.63	.56	.08	.26	-.46	1.72
	FSIQ-2			.10	.02	.27	**<.01**	.05	.15
2		.08	.41						
	Age			.04	.13	.02	.79	-.22	.29
	Gender			.67	.56	.08	.23	-.43	1.77
	FSIQ-2			.10	.02	.27	**<.01**	.05	.15
	Lifetime Cannabis			.25	.40	.04	.53	-.53	1.04
Hyper-mentalizing									
1		.03	1.90						
	Age			-.07	.08	-.06	.38	-.22	.09
	Gender			-.08	.35	-.02	.81	-.76	.60
	FSIQ-2			-.03	.02	-.15	**.03**	-.06	-.01
2		.03	.34						
	Age			-.06	.08	-.05	.47	-.21	.10
	Gender			-.10	.35	-.02	.77	-.79	.58
	FSIQ-2			-.03	.02	-.15	**.02**	-.06	-.01
	Lifetime Cannabis			-.14	.25	-.04	.56	-.63	.34
Under-mentalizing									
1		.03	2.37						
	Age			.04	.07	.04	.55	-.10	.19
	Gender			-.09	.33	-.02	.78	-.74	.55
	FSIQ-2			-.04	.01	-.17	**.01**	-.06	-.01
2		.04	2.15						
	Age			.07	.08	.06	.37	-.08	.21
	Gender			-.14	.33	-.03	.67	-.79	.50
	FSIQ-2			-.04	.01	-.18	**.01**	-.07	-.01
	Lifetime Cannabis			-.34	.23	-.10	.15	-.80	.12

No Mentalizing									
1		.06	4.22**						
	Age			-.01	.05	-.02	.78	-.11	.09
	Gender			-.24	.23	-.07	.30	-.68	.21
	FSIQ-2			-.03	.01	-.23	**<.01**	-.05	-.01
2		.06	1.30						
	Age			-.03	.05	-.04	.61	-.13	.08
	Gender			-.21	.23	-.06	.36	-.66	.24
	FSIQ-2			-.03	.01	-.22	**<.01**	-.05	-.01
	Lifetime Cannabis			.19	.16	.08	.26	-.14	.50

Note: F = for change in R^2; * = $p < .05$; ** = $p < .01$; *** = Only included if statistically significant on Bonferroni level ($p < .0125$).

Table 8

Analysis of Covariance of Recreational and Regular Use-Groups and RMET Scores

					Recreational Users	Regular Users
RMET		F	*p*	η^2	*M; 95 % CI*	*M; 95 % CI*
Total					25.14; 24.42 - 25.85)	26.18; 25.51 - 26.84)
	Use Group	4.32	**.04**	.019		
	Age	.02	.89	.000		
	Gender	7.30	**<.01**	.032		
	FSIQ-2	14.35	**<.01**	.062		
Positive					5.74; (5.47 - 6.00)	5.93; (5.68 - 6.18)
	Use Group	1.04	.31	.005		
	Age	2.79	.10	.013		
	Gender	3.35	.07	.015		
	FSIQ-2	1.62	.20	.007		
Negative					8.12; (7.77 - 8.47)	8.65; (8.32 - 8.98)
	Use Group	4.71	**.03**	.021		
	Age	.65	.42	.003		
	Gender	7.58	**<.01**	.034		
	FSIQ-2	11.86	**<.01**	.052		
Neutral					11.28; (10.84 - 11.72)	11.60; (11.18 - 12.01)

Note: M = Adjusted Means, * = Statistically significant on Bonferroni level ($p < .0125$).

Table 9

Analysis of Covariance of Recreational and Regular Use-Groups and MASC Scores

					Recreational Users	Regular Users
MASC		F	*p*	η^2	*M; 95 % CI*	*M; 95 % CI*
Total					36.15; 35.37 - 36.92)	37.48; 36.75 - 38.21)
	Use Group	6.04	**.02**	.027		
	Age	.47	.50	.002		
	Gender	1.75	.19	.008		
	FSIQ-2	18.79	**<.01**	.079		
Hyper-mentalizing					5.38; (4.90 - 5.89)	5.04; (4.58 - 5.50)
	Use Group	1.02	.31	.005		
	Age	.94	.33	.004		
	Gender	.08	.78	.000		
	FSIQ-2	5.59	.20	.025		
Under-mentalizing					4.52; (4.07 - 4.97)	3.36; (2.93 - 3.78)
	Use Group	13.45	**<.01***	.058		
	Age	.01	.94	.000		
	Gender	.25	.62	.001		
	FSIQ-2	8.91	<.01	.039		
No Mentalizing					1.85; (1.53 - 2.17)	1.92; (1.62 - 2.22)
	Use Group	.10	.76	.000		
	Age	.01	.92	.000		
	Gender	1.30	.26	.006		
	FSIQ-2	10.24	**<.01**	.044		

Note: M = Adjusted Means, * = Statistically significant on Bonferroni level (p < .0125).

Table 10
Regression Analyses for Recent Cannabis Use Predicting Latency of RMET Correct Responses

RMET		R^2	F	B	SE(B)	β	p	95 % CI Lower Bound	95 % CI Upper Bound
Total									
1		.03	2.24						
	Age			85.23	71.52	.08	.24	-55.71	226.18
	Gender			-533.21	320.25	-.11	.10	-1164.38	97.97
	FSIQ-2			20.62	13.81	.10	.14	-6.59	47.83
2		.04	1.72						
	Age			82.67	71.43	.08	.25	-58.11	223.44
	Gender			-498.43	320.83	-.10	.12	-1130.76	133.90
	FSIQ-2			20.23	13.79	.10	.14	-6.94	47.40
	Recent Cannabis			22.28	17.01	.09	.19	-11.24	55.79
Positive									
1		.03	2.42						
	Age			153.66	93.19	.11	.10	-29.99	337.31
	Gender			-579.03	417.30	-.09	.17	-1401.46	243.40
	FSIQ-2			27.97	17.99	.10	.12	-7.49	63.42
2		.05	2.91						
	Age			149.32	92.82	.11	.11	-33.62	332.25
	Gender			-520.23	416.92	-.08	.21	-1341.95	301.49
	FSIQ-2			27.32	17.92	.10	.13	-7.99	62.63
	Recent Cannabis			37.67	22.10	.11	.10	-5.89	81.22
Negative									
1		.03	2.12						
	Age			112.11	71.82	.10	.12	-29.43	253.65
	Gender			-388.63	321.60	-.08	.23	-1022.46	245.20
	FSIQ-2			21.14	13.86	.10	.13	-6.18	48.46
2		.04	2.03						
	Age			109.31	71.68	.10	.13	-31.96	250.57
	Gender			-350.70	321.95	-.07	.28	-985.24	283.84
	FSIQ-2			20.72	13.83	.10	.14	-6.55	47.99
	Recent Cannabis			24.30	17.07	.10	.16	-9.34	57.93
Neutral									
1		.03	2.00						

	Age			28.42	82.01	.03	.73	-133.20	190.05
	Gender			-765.80	367.24	-.14	**.04**	-1489.57	-42.03
	FSIQ-2			17.71	15.83	.08	.26	-13.49	48.91
2		.03	.45						
	Age			26.91	82.14	.02	.74	-134.98	188.80
	Gender			-745.27	368.96	-.14	**.05**	-1472.46	-18.08
	FSIQ-2			17.49	15.86	.07	.27	-13.76	48.73
	Recent Cannabis			13.15	19.56	.05	.50	-25.39	51.69

Note: F = for change in R^2; * = $p < .05$; ** = $p < .01$; *** = Only included if statistically significant on Bonferroni level ($p < .0125$).

Table 11

Regression Analyses for Recent Cannabis Use Predicting Latency of RMET Correct Responses

RMET		R^2	F	B	SE(B)	β	p	95 % CI Lower Bound	95 % CI Upper Bound
Total									
1		.03	2.13						
	Age			73.96	71.88	.07	.31	-67.72	215.64
	Gender			-514.39	322.41	-.11	.11	-1149.88	212.11
	FSIQ-2			22.21	13.85	.11	.11	-5.09	49.51
2		.03	.68						
	Age			60.93	73.64	.06	.41	-84.22	206.07
	Gender			-490.35	323.95	-.10	.13	-1128.91	148.20
	FSIQ-2			22.94	13.89	.11	.10	-4.44	50.32
	Lifetime Cannabis			193.89	234.41	.06	.41	-268.17	655.95
Positive									
1		.03	2.55						
	Age			143.07	92.91	.10	.13	-40.07	326.20
	Gender			-607.96	416.76	-.10	.15	-1429.42	213.50
	FSIQ-2			30.97	17.90	.12	.09	-4.33	66.26
2		.04	1.47						
	Age			118.40	95.01	.09	.21	-68.87	305.68
	Gender			-526.48	4167.99	-.09	.18	-1386.38	261.43
	FSIQ-2			32.35	17.92	.12	.07	-2.98	67.67
	Lifetime Cannabis			366.94	302.46	.08	.23	-229.24	963.12
Negative									
1		.03	1.92						
	Age			99.65	72.23	.09	.17	-42.72	242.01
	Gender			-351,99	323.98	-.07	.28	-990.56	286.59
	FSIQ-2			22.58	13.92	.11	.11	-4.86	50.01
2		.04	.68						
	Age			86.64	73.99	.08	.24	-59.22	232.49
	Gender			-327.99	325.53	-.07	.31	-969.66	313.67
	FSIQ-2			23.30	13.96	.11	.10	-4.21	50.81
	Lifetime Cannabis			193.56	235.56	.06	.41	-270.75	657.87
Neutral									
1		.03	1.88						

	Age			17.87	82.79	.02	.83	-145.31	181.05
	Gender			-736.90	371.35	-.13	**.05**	-1468.86	-4.94
	FSIQ-2			18.94	15.96	.08	.26	-13.51	50.39
2		.03	.27						
	Age			8.50	84.90	.07	.92	-158.84	175.84
	Gender			-719.62	373.50	-.13	.06	-1455.82	-16.58
	FSIQ-2			19.46	16.01	.08	.23	-12.11	51.03
	Lifetime Cannabis			139.42	270.26	.04	.61	-393.30	672.13

Note: F = for change in R^2; * = $p < .05$; ** = p < .01; *** = only included if statistically significant on Bonferroni level (p < .0125).

Table 12
Analysis of Covariance of Recreational and Regular Use-Groups for Latency of RMET Correct Responses

				Recreational Users	Regular Users
RMET	F	*p*	η^2	*M; 95 % CI*	*M; 95 % CI*
Total				6542.16; (6079.69 - 7004.62)	6767.08; (6335.23 - 7198.94)
Use Group	.48	.49	.002		
Age	1.51	.22	.007		
Gender	2.49	.12	.011		
FSIQ-2	2.48	.12	.011		
Positive				6252.93; (5649.93 - 6855.93	6439.11; (5876.02 - 7002.20)
Use Group	.20	.66	.001		
Age	2.78	.10	.013		
Gender	1.76	.19	.008		
FSIQ-2	2.56	.11	.012		
Negative				6141.88; (5677.81 - 6605.95)	6433.97; (6000.63 - 6867.32)
Use Group	.81	.37	.004		
Age	2.59	.11	.012		
Gender	1.21	.27	.006		
FSIQ-2	2.68	.10	.012		
Neutral				6974.23; (6443.88 - 7504.58)	7223.04; (6727.79 - 7718.28)
Use Group	.45	.50	.002		
Age	.15	.70	.001		
Gender	3.98	**.05**	.018		
FSIQ-2	1.44	.23	.007		

Note: M = Adjusted Means, * = Statistically significant on Bonferroni level ($p < .0125$).

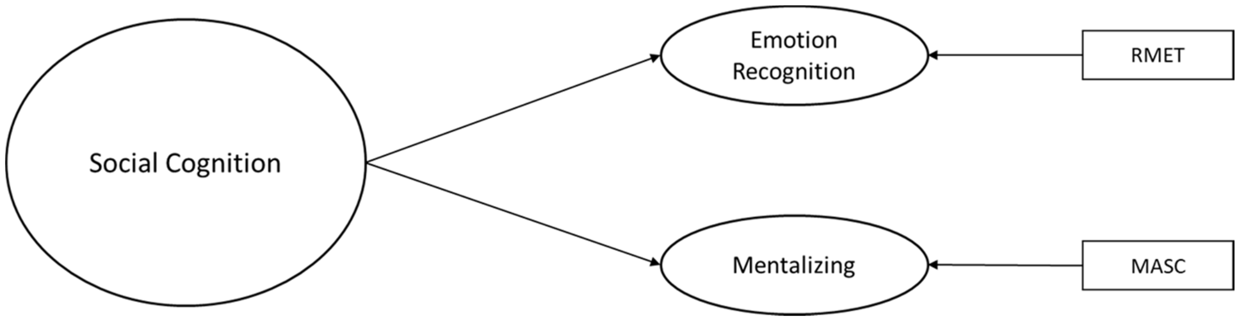

Figure 1. Model of lower- and higher-level aspects of social cognitive abilities.

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