The Social Cost of Pain: Rejection Sensitivity, Social Rejection, and Cannabis Use in Young Adults

Naomi Dambreville

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THE SOCIAL COST OF PAIN: REJECTION SENSITIVITY, SOCIAL REJECTION, AND CANNABIS USE IN YOUNG ADULTS

by

NAOMI DAMBREVILLE, MA

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

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The Social Cost of Pain: Rejection Sensitivity, Social Rejection, and Cannabis Use in Young Adults

by

Naomi Dambreville

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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ABSTRACT

The Social Cost of Pain: Rejection Sensitivity, Social Rejection, and Cannabis Use in Young Adults

by

Naomi Dambreville

Advisor: Eric A. Fertuck, Ph. D.

Cannabis has been implicated in relieving distress and social pain, an important area of research in young adult samples, given the saliency of peer and social networks to addiction. Cannabis, via opioid pathways, has been shown to reduce, or potentially buffer, the effects of social pain and rejection. Thus, cannabis may be protective against the painful feelings of social stress, particularly for heavier or more frequent users. However, findings are not wholly positive, as other research indicates cannabis may blunt affective responses and impair social processing. The effects of cannabis use in young adults are understudied, as well as its relationship to rejection sensitivity (RS). In this translational pilot study, we investigated the relationship between RS, social rejection, and cannabis use in moderate (using 1-3 times per week; n = 21) and heavy (using 4 or more times per week; n = 25) young adult cannabis users, compared to healthy controls (no cannabis use in past year; n = 24); rejection was longitudinally assessed at three levels: self-report, experimental, and daily diaries completed in naturalistic settings.

Seventy college-aged (M = 20.56, SD = 3.13) completed self-report measures assessing trait RS and cannabis use factors. Cyberball+, a laboratory-based manipulation of social exclusion that varies the rates of inclusion, was employed to investigate whether RS and cannabis use frequency influenced rejection distress to social exclusion. Ecological momentary
assessment (EMA) in the form of an online daily diary delivered via text message prompts and completed four times per day over the course of seven days was used to assess factors related to cannabis use and craving in real-world settings. Multi-level regression models were used to predict real-world cannabis craving and use from experimental and ecological experiences of rejection.

Results showed that while there were no significant group differences between moderate, heavy users, or controls on trait RS, controls reported significantly higher scores of the expectancy component of trait RS, reflecting the expectation of rejection may be more salient than the anxious rumination component and may maintain the fear that rejection will occur. A non-significant correlation between trait RS and rejection distress to social exclusion indicated these may be two distinct constructs where the former is related to emotional responses to rejection while the latter is associated with a greater desire for social attachment and a need to belong. In contrast to our hypothesis, trait RS and cannabis use frequency had no significant interaction effect on rejection distress. Notably, cannabis users reported a significantly greater increase in craving cannabis to achieve relief from negative mood and in anticipation of a positive outcome after social exclusion. Lastly, while experiences of real-world rejection were low during the one-week EMA period, heavy cannabis users reported more instances of rejection than moderate users. Results from mixed effects logistic regression models show increased rejection distress to experimental social exclusion is significantly associated with reduced odds (45%) of real-world cannabis craving but not use, while real-world experiences of rejection was not associated with craving or use.

To our knowledge, this study is the first to assess RS's relation to cannabis use and to provide converging evidence that experimentally induced rejection distress influences and is
prospectively predictive of reduced real-world cannabis craving. Findings from this study have important research and clinical implications and can provide guidance for identifying and treating cannabis use and its related problems on college campuses. Clinicians would benefit from incorporating evaluating the impact of RS on traditional psychotherapy treatments. Results can inform the development of EMA and text-messaging based interventions as a tool for targeted, real time substance use treatment, particularly for young adult cannabis users.
Acknowledgements

This dissertation was designed with the best of intentions to meaningfully contribute to my field but more importantly, to somehow capture the effects of substance use on interpersonal relationships. I believe deeply in the power of human connection and view it as a source of light in the darkest of times. Having witnessed the negative effects of substance use on individuals and their loves one as a clinician, I humbly hope my research in some way ignites a light to recovery and resilience.

Who I am as an individual and Psychologist at this moment is a result of the immeasurable love, support, guidance, and mentorship I have received over the past 6-years throughout this journey to obtain my doctorate. I have grown immensely as a Black woman, daughter, sister, friend, clinician, and researcher. To my lovely Haitian family: Mummy, Daddy, Dinah, Matt, Dixon and Chinois. You have celebrated my wins, pushed me to succeed and allowed me to come home and do nothing but eat and laugh. To my CCNY 2013 cohort mates: we’re the Dream Team and no one has ever done it better. Thank you for everything. Everything. To Tanya, Mariely, Esther, Esen, & Monet: you have seen me and held me through the good and bad, words are not enough so I promise to spend my life returning the favor. To my friends at home and at work: thank you for the daily laughs, power talks and power naps. To Richard and Vicky: thank you for listening, validating, encouraging, and pushing.

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Chapter 1. INTRODUCTION

Cannabis is the most commonly used illicit drug in the United States (US) and is an emerging public health concern (Center for Disease Control and Prevention (CDC), 2017). With approximately 22.2 million users and increasing rates of daily use, as well as a lowering age at initial use, the impact of cannabis on one’s physical and psychological health is widespread, particularly as recent changes in legislation have decriminalized and/or legalized recreational consumption (Carliner, Brown, Sarvet & Hasin, 2017; CDC, 2017). Emerging adults (18 to 25-year olds) consume more cannabis than any other age group, 20.8% percent were current users of cannabis, reflecting 7.2 million young adult past-month users (Substance Abuse and Mental Health Services Administration (SAMHSA), 2017). The present study aims to characterize and investigate cannabis use in young adults.

Research regarding stress and social factors that put young adults at risk was reviewed. Peer use and social context are several well investigated factors that place young adults at risk for cannabis use and cannabis use disorders. The effects of social exclusion and experiences of rejection on cannabis use and use-related factors in young adults have also been explored. A brief review of social exclusion theories is also presented. Ostracism, social exclusion, and rejection are concepts that refer to the ignoring and exclusion of individuals and groups by others (Williams, 2007). Exclusion has been shown to threaten an essential human need to feel included (Richard & Leary, 2009). When exclusion occurs, individuals may react in an adaptive manner or respond maladaptively, where the pain of rejection and exclusion can lead one to have internal negative emotional reactions, externally avoid others, or engage in risky behaviors to cope with the stress (Richard & Leary, 2009; Williams, 2007). Evolutionary theories posit an affective or social pain network exists that enables one to feel and react to social threats in a manner similar
One factor related to social exclusion may be individual differences in rejection sensitivity, where one tends to be anxious about or expect rejection in most situations (Downey & Feldman, 1996). Being more rejection sensitive leads to more perceptions of social exclusion and social stress (Olsson, Carmona, Downey, Bolger, & Ochsner, 2013; Pietrzak, Downey & Ayduk, 2005). This, in turn, may leave them more vulnerable or at risk for cannabis use, as research shows high comorbidity rates of cannabis use disorders in individuals with social anxiety and depression (Buckner et al., 2008; Degenhardt, Hall & Lynskey, 2003). These disorders are also associated with rejection sensitivity, implying that those high in this trait may be more at risk for cannabis use (Harb, Heimberg, Fresco, Schneier & Liebowitz, 2002; Lui, Kraines, Massing-Schaffer & Alloy, 2014).

Individuals often use substances to seek relief from negative emotions and stress (Hyman & Sinha, 2009). Rejection sensitivity may play an important role in individuals using substances to cope with the social distress of rejection. Studies have revealed the connection between opioid use in relieving social pain, but much fewer have assessed cannabis’ role despite the fact that its psychoactive component acts on opioid pathways, similarly to pain relievers (Deckman, DeWall, Way, Gilman, & Richman, 2013). Recent evidence suggest that rejection sensitivity is associated with both social pain and opioid pathways (Hsu et al., 2013; Slavich, Tartter, Brennan, & Hammern, 2014; Way, Taylor & Eisenberger, 2009). Independently, cannabis use has been shown to affect social processing and stress reactivity at the behavioral, physiological, and neurological level (Cuttler et al., 2017; Gilman, Curran, Caldenor, Schuster & Evins, 2016). One theory about this relationship is the social buffer hypothesis, where cannabis, particularly more
frequent use, may dampen emotional reactions to and be protective against the feelings of social pain (Deckman et al., 2013).

Cannabis factors (craving and motives for use) have been predominately assessed using self-report and lab-based assessments. Yet, contextual and subjective, momentary factors should be considered when investigating drug craving and motivations (Drummond, Litten, Lowman & Hunt, 2000; Sayette et al., 2000). One important limitation of these methods is their lack of ecological validity. Cyberball, a widely used paradigm of induced rejection and social exclusion, has been shown effective at assessing social pain (Williams, Cheung, & Choi, 2000). Cyberball studies with cannabis using adults have provided evidence of a significant relationship between use and impaired social processing (Gilman et al., 2016).

Another substantial limitation is recall bias, where individuals are asked to retrospectively self-report details about drug use over a specific time period (Stone & Shiffman, 1994). Responses may not be accurate and are subjected to various biases and error. The subsequent section presents research conducted using ecological momentary assessment (EMA), an ecologically valid method often used in drug research (Stone & Shiffman, 1994). Ecological momentary assessment allows for the study of cannabis use and social factors as they interact in the real world, an important insight into better understanding the effects of social processes. A review of several studies that have used EMA to investigate cannabis use is presented. Findings reveal it to be a feasible and valid method indicating cannabis use is associated with craving, motives for use, affect, and social factors, such as rejection and peer use, in a time and context dependent manner (Buckner et al., 2015; M. Phillips, Phillips, Lalonde & Dykema, 2014; Shrier, Walls, Rhoads & Blood, 2013). Lastly, studies using both Cyberball and EMA in research are reviewed (Eisenberger, Gable, & Leiberman, 2007; Eisenberger, Taylor, Gable, Hilmert &
Lieberman, 2007; Kashdan et al., 2014). Gaps in the literature and implications for clinical interventions are noted in support of the importance of investigating cannabis use in relation to rejection sensitivity and social rejection in young adults.

The present study investigated the relationship between rejection sensitivity and moderate and heavy cannabis use in young adults, compared to controls. To address the gaps in the field, we assessed social pain and cannabis use using a novel approach to Cyberball, where the rates of inclusion varied to include over- and under-inclusion conditions to assess the effects of rejection sensitivity at the state and trait (self-report) level. Additionally, cannabis users completed a one-week EMA period via a daily diary assessing cannabis use in the real world delivered through text messaging. To our knowledge, the present study was the first to use both Cyberball and EMA to assess rejection sensitivity, social rejection, and cannabis use to provide much needed converging evidence that interpersonal traits and social factors influence feelings of rejection experimentally and in the real world.

Using a translational approach, this study aimed to better understand the role of cannabis use and its relation to rejection sensitivity and social pain in young adults. Using multiple methods to understand cannabis use may help us further understand social factors related to addiction and mental health. Furthermore, the knowledge gained has important research and clinical implications for young adults, recreational users, and clinical populations using cannabis. Results gained from the study can provide guidance and support for increasing social support and identifying cannabis use and its related problems on college campuses, programs targeting young adults, and therapeutic treatment interventions. Moreover, this study added to the growing body of literature that notes the feasibility of research and clinical interventions using EMA and text-
messaging as a tool for targeted, real time substance use interventions, particularly for young adults.
Chapter 2. LITERATURE REVIEW

Cannabis Use in Young Adults

Cannabis (also known as marijuana, weed, etc.) is the most widely used and abused illegal substance in the US, with 24 million past-month users in 2016 (SAMHSA, 2017). Its rate of use continues to increase as cannabis accounted for 8.9% of the estimated 28.6 million Americans ages 12 or older using illicit drugs; 6.9 million individuals were abusing or dependent on illicit drugs in 2013 (National Institute Drug Abuse, 2015; SAMHSA, 2017).

Cannabis consists of two main components: Δ9-tetrahydrocannabinol (THC) and cannabidiol (CBD), both of which act on cannabinoid 1 (CB1) and 2 (CB2) receptors in the brain and body (Hill, 2015; Lorenzetti, Solowij & Yücel, 2016). Cannabis can be consumed in various forms: smoked via a joint or blunt (sometimes mixed with tobacco or other drugs), inhaled, baked (e.g., pot brownies), eaten via edibles (e.g., candy), and more (e.g., tinctures, vaping, dabbing). Its psychoactive component, THC, produces the effects of feeling intoxicated / high while CBD is non-psychoactive and has medicinal and healing properties. Users (either recreational and/or medicinal) and sellers can vary the ratio of THC to CBD to create countless strains of cannabis for purposes specific to the user (Hill, 2015; Lorenzetti et al., 2016). Given its naturally occurring properties, cannabis is often used to mitigate pain manifesting as physical ailments and/or emotional difficulties (Hill, 2015). Notably, the misuse of prescription pain relievers was the second most common illicit drug used in 2016, with 3.3 million users (SAMHSA, 2017).

Epidemiological data shows a wide prevalence of cannabis use in adults, often leading to drug addiction and significant rates of cannabis use disorder (CUD) symptoms (CDC, 2017). The distinct cannabis abuse and dependence diagnoses found in the Diagnostic Statistical Manual-
Fourth Edition (DSM-IV; American Psychiatric Association (APA), 2000) is now the singular cannabis use disorder in the fifth edition (DSM-5, APA 2013). One study found that 19.5% of lifetime users met criteria for DSM-5 CUD (Hasin et al., 2016). Cannabis use disorder is characterized by a problematic pattern of cannabis use leading to clinically significant impairment or distress over a 12-month period, with symptoms such as using in large amounts or hazardously, craving, developing a tolerance, and withdrawal. Additionally, individuals with CUD may use cannabis despite persistent interpersonal or social problems that may have been caused by using the drug itself and often have unsuccessfully attempted to quit (APA, 2013).

One study investigating the prevalence of CUDs using the DSM-5 criteria in a national sample of adults found increased odds of 12-month and lifetime CUD for men, low-income individuals, and young adults (Hasin et al., 2016). Compared to their older counterparts, 18 to 29-year-olds had a 7.2 times greater likelihood of 12-month CUD symptoms. This increased as the severity of CUD increased (evidenced by 6 or more DSM-5 symptom criteria). However, only 7.2% and 13.7% of respondents with 12-month and lifetime DSM-5 CUD utilized services for cannabis problems, respectively (Hasin et al., 2016). In a nationally representative adult sample, the likelihood of transitioning from cannabis use to DSM-IV cannabis dependence was 8.9% (Lopez-Quintero et al., 2011). Additionally, substance use was elevated in adults who reported any lifetime psychiatric disorder (e.g., mood, anxiety, and personality diagnoses) and rates for cannabis use in these populations was 31% (Lopez-Quintero et al., 2011). Medical cannabis reform and the legalization of recreational consumption in 23 states have had a large impact on cannabis use and misuse. According to Carliner and colleagues (2017), rates of use and CUD are increased in states with medical cannabis laws, compared to states where adults use illicitly. Given the prevalence rates of cannabis use and CUD in addition to the wider availability
with the legalization of cannabis, there is a high likelihood that the number of individuals initiating cannabis use in the future will continue to increase.

Cannabis use is associated with poor outcomes and is a steadily increasing public health issue. The physical and mental health implications for cannabis use include increased instances of respiratory illnesses, short-term impairments in motor coordination, and an increased risk for psychosis in those using high concentrations of THC (Hill, 2015). Cannabis-related visits to emergency departments increased 62% annually between 2004 and 2011, while users often underutilize services and resources aimed at cessation or treatment of related impairments (Carliner et al., 2017). Cannabis has short and long-terms effects on brain development and cognitive processes, such as memory, attention, and learning, and poor outcomes for heart, maternal and infant health (CDC, 2017). Cannabis has also been shown to impact brain development in young users (Hill, 2015). An MRI study with young adult non-dependent, recreational users found abnormalities in various brain regions, particularly the prefrontal cortex, a key factor in attention, decision making, and inhibition (Gilman et al., 2014). Moreover, THC is noted to be neurotoxic in brain areas with high densities of CB1 receptors, such as the hippocampus, amygdala, and prefrontal cortex, all areas important for memory and emotional processing (Lorenzetti et al., 2016). These are also critical areas for social and emotional development in adolescents and young adults.

Certain developmental periods seem to be pertinent to the initiation and maintenance of cannabis use, often with deleterious outcomes. Findings from the Monitoring the Future study reveal that, as of 2014, one in 17 high school seniors were daily cannabis smokers (defined as use on 20 or more occasions in the prior 30 days) and rates of daily cannabis use rose 3.5% in 2007 to 5.9% among college students and young adults (Johnston, O'Malley, Bachman,
Schulenberg & Miech, 2015). Hughes et al. (2014) found daily adult users consume cannabis multiple times per day and varied in their modes of administration, often using multiple methods in addition to joints to consume cannabis. Daily adult users were also chronically intoxicated, indicating high tolerance and likely impairments in cognitive functioning. The odds of having a mental disorder was significantly higher for young adult, frequent cannabis users with cannabis dependence, compared to non-dependent frequent users and healthy adults (Pol et al., 2013). Furthermore, individuals using more frequently had a 91% rate of persistent cannabis use, indicating a lesser likelihood to stop using or seek treatment. Consequently, it is imperative to explore cannabis use and the chronicity of use during the young adult years, as frequent users may differ from less frequent cannabis users in meaningful ways.

**Social Factors for Cannabis Use in Young Adults**

Once deemed harmful, unfavorable cultural attitudes led to federal prohibitions of cannabis in the 1960’s and 1970’s (Carliner et al., 2017). However, the socio-political climate regarding cannabis has changed over time, leading to more acceptance and less perceived risk by users and non-users alike (particularly among younger individuals). Among college students, it is common for individuals to have misperceptions about the prevalence of cannabis use among their peers, usually overestimating, which often have consequences on actual cannabis use rates (Kilmer et al., 2006).

There is evidence of a relationship between cannabis and interpersonal factors in young adults. Social norms are strong predictors of cannabis use and related problems among college students (Buckner, 2013). Descriptive norms (beliefs about others substance use) and injunctive norms (others’ approval of use) about friends, the most proximal reference group for college-aged adults, significantly predicted the frequency of self-use. Injunctive norms significantly
predicted coping motives for cannabis use and strongly predicted cannabis-related problems, reflecting greater impairments when using cannabis to manage distress (Buckner, 2013). Neighbors and colleagues (2008) found a significant relationship between the two norms and social expectancies in cannabis using college students. Specifically, injunctive norms were more strongly related to cannabis use but negatively correlated with problems when students reported greater social expectancies. The authors posit these results reflect users who accurately perceive less approval by their peers due to the negative consequences of their cannabis use (Neighbors, Geisner, & Lee, 2008).

Cannabis use has also been correlated with social factors such as seeing someone use and using with others (Hughes et al., 2014). Assessing the developmental trajectory of cannabis use in adolescence, one study investigated whether solitary cannabis use predicted young adult DSM-IV CUD at age 25 (Creswell, Chung, Clark & Martin, 2015). Adolescents who used cannabis alone, as opposed to those who used with or around others, used more frequently; concurrent peer use predicted more cannabis abuse symptoms in young adulthood, even when accounting for demographic characteristics and frequency of use (Creswell et al., 2015). Interestingly, the authors noted that adolescents tend to use cannabis in a consistent, stable manner across settings. In addition to highlighting important differences between adolescent and adult users, these results suggest social users and solitary cannabis users are distinct subtypes with unique traits, difficulties, and treatment needs (Creswell et al., 2015).

Additionally, stress serves as an important risk factor and motivation for cannabis use, for example, negative life events is related to using as a coping mechanism (Hyman & Sinha, 2009). Traditional models of substance use include the tension reduction model and the self-medication hypothesis. The former theorizes individuals use substances to reduce tension when experiencing
negative affective states (Buckner, Schmidt, Bobadilla & Taylor, 2006). Similarly, the use of substances to reduce negative emotions may then become negatively reinforced and individuals may engage in a cycle of self-medication (Simons & Carey, 2002). Using cannabis to cope is often associated with psychological distress and DSM-5 CUD among adults ages 18-25, compared to using for enhancement or social motives (Moitra, Christopher, Anderson & Stein, 2015). Affect dysregulation may also be related to use in that it impacts how one acts while under the influence of a substance as well as their ability to manage the consequences of drug use (Simons & Carey, 2002).

Research has also been done assessing the different motivations underlying substance use and what function any given drug serves for its user. The Motivational Model for Alcohol Use asserts that alcohol use is motivated by either a positive or negative outcome and via an internal or external source (Kuntsche & Kuntsche, 2009). There is an overlap between alcohol and cannabis use as “both drugs are associated with tension reduction, mood enhancement, and social bonding” (Simons, Correia, Carey & Borsari, 1998, pg. 265). Additionally, expansion motives have been incorporated into the field to address cannabis’ psychedelic properties and ability to expand perceptual and cognitive experiences (Lee, Neighbors & Woods, 2007). One study with 634 incoming college students asked to provide their motivations for cannabis use found participants endorsed using primarily for enjoyment/fun (52.14%), conformity (42.81%) and experimentation (41.25%), followed by social enhancement, boredom, and relaxation (Lee, Neighbors & Woods, 2007). The first three motives were ranked as most important, while experimentation accounted for the most variance in cannabis use and problems associated with use.
Young, or emerging, adults are in a developmental stage of transition from adolescence, a time characterized by identity formation, increased importance of peer relations, independence from parents and authority figures, and risk-taking. Initiation of substances during adolescence, particularly early onset use, is a risk factor for young adult use and dependence (Nelson, Van Ryzin, & Dishion, 2015). Young adults who began cannabis use during early adolescence are twice as likely to abuse cannabis and other illegal drugs (Stone, Becker, Huber & Catalano, 2012). Individuals ages 18 to 25 are still on the path to adulthood, as they learn to navigate and manage various roles and academic, career, financial, and social concerns on their own (Hudd et al., 2000).

Although the definition of stress varies both within the literature and amongst individuals, stressed college students report lower self-esteem and poorer health habits, particularly among women (Hudd et al., 2000). Nontraditional students (e.g., part-time employment, parents, and immigrants) are also becoming more common on undergraduate campuses and may experience increased sources of stress (Kohler Giancola, Grawitch, & Borchert, 2009). Substance use disorders are also a concern for students and young adults who identify as sexual minorities and those who have experienced a traumatic event (Read et al., 2012; Talley, Sher, & Littlefield, 2010). Furthermore, learning disorders and attentional difficulties often appear or are exacerbated during the first few years of college, leading to academic stress and vulnerability to use substances, particularly non-prescription stimulant use (DuPaul, Weyandt, O'Dell, & Varejao, 2009; Wolf, 2001). In fact, alcohol and cannabis seem to be the preferred substances of young adults with Attention-Deficit Hyperactivity Disorder (ADHD), a diagnosis that can cause cognitive and social impairments; 2 to 8% of the college population report clinically significant levels of ADHD symptoms (DePaul et al., 2009; Wolf,
Caldeira and colleagues (2008) found a 9.4% CUD prevalence rate among first-year college students and 24.6% among past-year cannabis users in a large cohort sample, reflecting a growing concern and need to investigate factors related to cannabis use in young adults.

Together, research suggests that young adults deal with a great amount of stress, a risk factor for substance use. An important, yet understudied, source of stress implicated in cannabis use is the experience of social exclusion and rejection as well as individual differences in rejection sensitivity.

Social Exclusion, Rejection Sensitivity, and Substance Use

Ostracism, the process of ignoring and excluding individuals or groups by other individuals or groups, has been pioneered by the work of Kipling D. Williams (2007). Constructs related to ostracism include rejection: an explicit declaration that an individual or group is not wanted and social exclusion: being kept apart from others; the three terms have often been used interchangeably.

Investigating the effects of social exclusion on health-related decisions, Stock, Gibbons, and Beekman (2105) provided evidence for the influence of social exclusion and social factors on substance use in young adults. The Prototype / Willingness Model suggests that risk-conducive social situations result in either reasoned (logical) or social reactions (Stock et al., 2105). The social reaction path involves a willingness to take the risk given the social context, while the former is more analytical and involves intention as the proximal antecedent. Given that willingness to take risks is more impacted by social situations and is a greater predictor of risky behavior, the authors posit it is an ideal model for assessing substance use and social exclusion.
The present study assessed how social rejection plays a role in cannabis use in young adults.

Social Pain Theories

Since humans are social creatures, ostracism can lead to prosocial or maladaptive behaviors because of a need to belong (Abrams, Weick, Thomas, Colbe, & Franklin, 2011; Richman & Leary, 2009; Williams, 2007). There may be an evolutionary explanation: ostracism puts one at risk for being excluded from group membership, mating, and safety. An ostracism-detection, or social monitoring, system may have evolved to signal humans to attend to the risk of being excluded and rectify the situation. This system uses a signal of emotional pain, which we immediately attend to, appraise, and attempt to reduce. To lessen the pain of ostracism, one would likely engage in behavior that increases the likelihood of inclusion. An emerging theory is the existence of an evolved social pain network, which may have been evolutionary mapped onto the physical pain system for humans to attend and respond to social threats (MacDonald & Leary, 2005; Williams, 2007). “Social pain refers to a specific emotional reaction to the perception that one is being excluded from desired relationships or being devalued by desired relationship partners or groups” (MacDonald & Leary, 2005, pg. 202). The social pain and physical pain network overlap in thoughts and behaviors of humans and share similar physiological mechanisms (MacDonald & Leary, 2005). Research has shown that acetaminophen, a pain reliever, reduces self-reported and neural activation of social pain (Dewall et al., 2010). Cannabis, through THC, acts through the same CB1 receptors as acetaminophen, suggesting it may also be helpful in alleviating physical and social pain, such as rejection (Deckman et al., 2013).
Williams (2007) argued there exists a temporal framework for responses to ostracism. First comes immediate or reflexive reactions that are painful and/or distressing and are resistant to moderation by individual differences or situational factors. Second, various fundamental needs are threatened which induces anger or sadness: the need for belonging, self-esteem, control, and meaningful existence. Lastly, individuals enter a reflective stage that uses cognitive appraisals to cope with the exclusion and rectify the most threatened need. If relational needs (belonging and self-esteem) are threatened, prosocial behavior will alleviate the ostracism. If ostracism activates the latter two needs, controlling or anti-social responses (a fighting response) may occur. Other reflective responses include being in a stunned and affectless state (a freezing response) or attempts to flee the situation (an avoidance response). Ostracism’s effect on mood is also reflexive while long-term ostracism can impair cognitive processes and emotion regulation capacities (Abrams et al., 2011; Williams, 2007).

Richman and Leary (2009) hold a different perspective on the effects of a threatened need to belong. What makes any negative interpersonal event difficult is that it can threaten and lower one’s perception of their relational value; this does not only happen because of ostracism but is a core feature of all rejection (Richman & Leary, 2009). Leary’s (2005) concept of relational value is defined as a foundation that organizes and guides relationship and the extent to which we feel we are important to others. This is such as defining feature of human nature that Leary posits the existence of an internal barometer, a sociometer, which measures relational value and impacts one’s self-esteem. One can perceive their relational value to be high or low, depending on the nature of the social interaction. Richard and Leary’s (2009) multi-motive theory states that there are three sets of motives one experiences after a rejection: a) a heightened desire for social connection; b) angry, anti-social urges to defend one’s self or hurt the source; and c) avoidance
of future rejection and associated feelings. These may happen simultaneously, or one may predominate depending on any given person’s perception of the event. William’s (2007) social monitoring system supports Richman and Leary’s model (2009), in which one attempts to regulate and achieve optimal levels of belongingness to maintain relational value.

Recurrent social exclusion or rejection is also noted as a condition warranting clinical attention in the DSM-5 if it impacts the presentation, prognosis, or treatment of an individual with a mental disorder, reflecting its relevance to impaired functioning (APA, 2013). Consequences of ostracism have been measured via self-reported distress, negative mood (usually sadness and anger), hurt feelings, diminished levels of belonging, self-esteem, control, and meaningful existence, and more direct measures of distress or pain (Williams, 2007).

Another effect of exclusion may be affective numbing, sometimes preemptively, or cognitive deconstruction (refusal to engage in meaningful thought and interpret the social exclusion to avoid associated emotions), which may indicate a lack of personal distress in some people (Stock et al., 2015; Twenge, Catanese, & Baumeister, 2003; Williams, 2007). Long-term ostracism, which would be unethical to induce experimentally, may deplete one’s resources and ability to cope, leaving them feeling helpless and hypersensitive to social cues (Williams, 2007). In their hypothesized model, Stock and colleagues (2015) postulate that use-as-coping and cumulative rejecting experiences may moderate the relationship between social exclusion and substance use.

**Rejection Sensitivity and Cannabis Use**

One potential consequence of social exclusion and its associated emotion dysregulation is the use of substances, such as cannabis, to cope with these intense symptoms and fear of rejection as well as its effects on one’s interpersonal interactions. In certain contexts, rejection sensitivity (RS) can be viewed as an interpersonal vulnerability (Pietrzak et al., 2005).
Individuals with higher RS traits may use cannabis due to social factors, emotional distress, or co-occurring psychological disorders that interfere with their desire or capacity to be with others.

Rejection sensitivity (Downey & Feldman, 1996) is a cognitive-affective processing disposition that stems from the anxious anticipation of and bias towards rejection (Staebler, Helbing, Rosenbach & Renneberg, 2011), due to many factors such as a learned hypersensitivity to rejection cues and an early childhood history of rejection. Olsson and colleagues (2013) found that RS may influence the social-learning process, where an individual who is hypersensitive to social cues may anxiously expect and perceive rejection, then behave in a manner that elicits actual rejection. This then confirms and reinforces the notion of constant rejection, creating a self-fulfilling prophecy (Olsson et al., 2013). “What follows are a lowered threshold for perception of negativity, an increased propensity for personalizing negative cues, and intense affect reactions” (Pietrzak et al., 2005, pg. 62). People with higher RS may act angry, aggressive, or hostile within relationships, withdraw from others, and are more susceptible to loneliness, social anxiety, and depression following rejection (Ayduk et al., 2000; Watson & Nesdale, 2012).

Social withdrawal was found to mediate the relationship between RS and loneliness in young adults transitioning to college (Watson & Nesdale, 2012). Rejection has also been shown to cause cognitive disorientation and self-defeating behaviors in adults (Baumeister, Twenge, & Nuss, 2002; Twenge, Catanese, & Baumeister, 2002).

The human desire to belong and have high relational value may cause one to seek out substances such as cannabis to mitigate the ramifications of social rejection. Being highly rejection sensitive may mean these individuals have a more sensitive sociometer, leaving them more susceptible to rejection experiences and less affectively regulated. Together, sensitivity to
rejection and the use of substance to cope or reduce tension and negative affect due to social stress or threatened needs may lead young adults to use cannabis in a maladaptive manner.

One area of study includes the relationship between emotional vulnerability factors and coping-oriented cannabis use, given that anxiety and depressive symptoms and their disorders co-occur with frequent and problematic cannabis use (Zvolensky et al., 2009). This is evidenced by the interpersonal impairments found in many psychiatric populations with high rates of cannabis use, such as those with social anxiety, depression, and borderline personality disorder (APA, 2013). Rejection sensitivity may be a shared trait underlying the etiology or maintenance of these diagnoses, particularly among those who also use cannabis to cope with distress. Rejection sensitivity itself may be a risk factor for cannabis use.

Rejection sensitivity is strongly related to and elevated in social anxiety (SAD) (Harb et al., 2002), an anxiety disorder marked by a persistent fear of various social situations and engagement in behaviors to avoid scrutiny from others (APA, 2013). SAD is also correlated with cannabis dependence at rates more than twice that of any other anxiety disorder (Buckner et al., 2008). Research shows that adolescents with SAD have five times the risk of developing cannabis dependence as an adult and SAD is strongly associated with cannabis use problems (Buckner, Bonn-Miller, Zvolensky & Schmidt, 2007; Buckner, Crosby, Wonderlich & Schmidt, 2012b), despite the finding that SAD is not associated with greater use frequency (Buckner & Schmidt, 2008).

Major depression (MDD) is a mood disorder that also greatly impacts one’s interpersonal functioning given its primary symptoms of depressed mood, loss of pleasure, social isolation, and decreased participation in once enjoyed activities (APA, 2013). A relationship between depression and RS exists (Lui et al., 2014) and can be found in college samples (Mellin, 2008).
and individuals experiencing physical pain during a depressive episode (Ehnvall, Mitchell, Hadzi-Pavlovic, Malhi & Parker, 2009). Individuals using cannabis more frequently also had a higher risk of having had an MDD episode (Degenhardt et al., 2003). Lifetime cannabis dependence was associated with 3.4 times the risk of MDD and those meeting cannabis use or dependence criteria within the past year had 6.4 times the odds of meeting criteria for MDD as well (Degenhardt et al., 2003).

Incidentally, depression and borderline personality disorder (BPD) populations share risk factors of depression severity, impulsivity, aggression, and childhood adversity. Gutz and colleagues (2015) note several symptoms of BPD, such as anger, emotional hyperreactivity, and aversive tension are triggered by social stressors. Experiences of insecure attachment, trauma, and instances of actual or perceived social exclusion have led to a core belief held by this population: the fearful expectation of rejection and abandonment by others (Gunderson, 2011; Gutz, Renneberg, Roepke, & Niedeggen, 2015; Paris, 2005; Staebler et al., 2011). Indeed, RS was found to mediate the relationship between experiences of parental/peer rejection and BPD traits with social support serving as a protective factor (Rosenbach & Renneberg, 2014). While reviews and studies have been conducted looking at the high rates of comorbidity between BPD and substance use (Gratz, Tull, Baruch, Bornovalova & Lejuez, 2008; Rizvi, Dimeff, Skutch, Carroll & Linehan, 2011; Trull, Sher, Minks-Brown, Durbin & Burr, 2000), there is little research assessing cannabis use in this population. The research and rates of cannabis use in psychiatric disorders strongly related to RS may provide evidence towards the psychological effects of social pain and attempts at coping.

**Assessing Social Rejection and Cannabis Use**
Experimental Paradigm of Social Rejection: Cyberball

One method of assessing social rejection is Cyberball, a validated experimental task for studying the effects of induced rejection and social exclusion (Williams et al., 2000). Cyberball is a virtual ball-toss game consisting of three conditions that differ in levels of inclusion: a) a control condition, where participants are a passive observer of two other players, b) inclusion condition, the participant is included in multiple rounds of virtual ball tossing and thrown the ball at a rate equivalent to the other two players, and c) exclusion, the third condition is the same as the second, except the participant is included for a period of time, but is then fully excluded by the other players for the last half of the ball tossing round. In reality, there are no other players and participants are playing with a computer. The behavioral measure in classic Cyberball is a post-game self-report of subjective emotional experience, allowing for immediate or state-level analyses of how exclusion affects participants.

Cyberball has been studied with functional magnetic reasoning imaging (fMRI) in nonclinical samples in several studies (Eisenberger, 2005; Eisenberger et al., 2003; Williams et al., 2000; Zadro, Williams, & Richardson, 2004). Eisenberger and colleagues (2003) found evidence for a social distress circuit that acts as an affective “alarm bell” for social exclusion. In this study, areas associated with self-reported distress were activated: the dorsal anterior cingulate cortex (dACC) which is often activated during exposure to physical pain (and loss of social connections), insula, and the right ventrolateral prefrontal cortex (rVLPFC), which regulates pain. Moreover, Riva and colleagues (2012) were the first to show the rVLPFC plays a role in reducing the experience of social pain after exclusion. Participant’s rVLPFC were stimulated either by transcranial direct current stimulation (tDCS) or by a sham stimulation for 15-minutes, the last five of which they completed Cyberball and were randomly excluded or
included. Excluded participants whose rVLPFC were stimulated by tDCS reported less unpleasantness and hurt feelings despite their report of feeling excluded, compared to those who received the sham stimulation (Riva, Lauro, DeWall, & Bushman, 2012). Neural results revealed that rVLFC activation lessened, or dampened, the painful effects of social exclusion.

Cacioppo and colleagues (2013) questioned whether social pain is figurative or literal by conducting a statistical Multi-level Kernel Density Analysis (MKDA), which quantifies the distribution of significant peak brain coordinates related to social rejection, in fMRI Cyberball studies with a total of 244 participants. Results contradicted findings in the general literature. Their meta-analysis showed activation in brain regions the authors posit are involved in social uncertainty, distress, rumination, and craving rather than social pain (Cacioppo et al., 2013). Since Cyberball did not activate areas associated with physical pain, they stated social pain is figurative and not literal. These results reflect the understudied nature of social pain and support the need for novel approaches to investigating such a complex construct.

Considering the focus of Cyberball, this approach has great potential in elucidating the substrates of interpersonal disturbances. One study found that reactivity to Cyberball (anxiety experienced during exclusion minus anxiety experienced during inclusion) but not a history of past teasing or current relational victimization predicted social anxiety symptoms two months later in a sample of college adults, suggesting one’s internalization of negative social interactions or subtle events may lead to anxious or fearful reactions (Levinson, Langer, & Rodebaugh, 2013). Zadro, Boland, and Richardson (2006) also found individuals high in social anxiety recovered from the effects of ostracism more slowly than others. An EEG-compatible version of Cyberball was used to assess bias in the early stages of social processing in individuals with BPD, SAD, and healthy controls (Gutz et al., 2015). Results showed while all participants had a
more pronounced P3b amplitude (a marker of brain activity reflecting the motivational salience of an event) when excluded, borderline patients also reported feeling more excluded during the inclusion trials of Cyberball. This finding, along with their report of higher RS, indicates an altered perception of social participation. Together, these results provide support for the social pain theory of ostracism.

Lastly, Fertuck and colleagues (2017) modified classic Cyberball to manipulate the rates of exclusion (Cyberball+) and assess state rejection and threatened needs in female healthy controls and BPD patients. Participants underwent five runs and were excluded 90%, 80%, 60%, 50%, and 40% of throws and completed a brief need threat scale after each run. Preliminary results indicated Cyberball+ is effective at inducing social pain and assessing rejection sensitivity in a novel manner (Fertuck et al., 2017).

**Cyberball, Rejection Sensitivity, and Substance Use**

Social exclusion and stress-related behaviors, such as substance use, has been investigated using Cyberball, particularly in racial and ethnic minorities individuals who often experience discrimination that may include perceived or actual social exclusion (Stock, Gibbons, Walsh, & Gerrard, 2011; Wirth & Williams, 2009). The Stress-Coping Theory, which emphasizes individual differences in coping tendencies, has been investigated in relation to developing patterns of coping that may moderate the relationship between stress and substance, leaving individuals experiencing chronic stress vulnerable to regular use (Gerrard et al., 2012; Wills & Shiffman, 1985). Gerrard and colleagues (2012) used a racial discrimination version of Cyberball (Goodwin, Williams, & Carter-Sowell, 2010) to test whether social exclusion affects African American participants using substances to cope with stress. Results showed excluded African American participants reported higher perceived discrimination and lower levels of
belonging; those who used to cope reported a higher willingness to use substances after the exclusion condition (Gerrard et al., 2012). These studies indicate that social exclusion and substance use are generally associated when exclusion threatens fundamental needs and may increase the likelihood of using substances in reaction to social distress.

Cyberball has also been used to reveal a connection between rejection sensitivity, social rejection, and pertinent drug pathways. The endogenous opioid system is associated with alleviating physical pain and has been implicated in regulating social distress, according to the opioid RS hypothesis (Hsu et al., 2013; Slavich et al., 2014). Way and colleagues (2009) investigated the relationship between opioids and social rejection and posited whether µ-opioid receptors may mediate signaling in both physical and social pain. Targeting a polymorphism (the A118G) on the µ-opioid receptor gene, they found it was associated with self-reported dispositional (i.e., trait) RS; individuals carrying the relevant allele were more rejection sensitive (Way et al., 2009). These results were corroborated by fMRI neuroimaging taken while playing Cyberball. Carriers had greater activation in the dACC and left anterior insula, areas important for processing social pain, as well as more activation in areas with greater concentrations of µ-opioid receptors than individuals without the A118G polymorphism. Furthermore, dispositional RS scores were associated with activation in the dACC; the authors posit “this may be an area where the A118G polymorphism influences sensitivity to rejection” (Way et al., 2009, pg. 15081). The support between self-reported RS and neural correlates of social exclusion strongly suggests there is a genetic and biological influence on the tendency to be rejection sensitive, particularly for those with reduced opioid expression. Research has also shown that µ-opioid pathways may also be responsible for blunting the negative affective responses seen after
targeted rejection experiences (Slavich et al., 2014). This has important implications for cannabis users, as THC indirectly operates on opioid pathways (Deckman et al., 2013).

Social Pain and Cannabis Use

Peer and social influences have been established as related to addiction. In a review of neural correlates of these factors in cannabis users, Gilman (2017) notes the overlap in brain areas implicated in drug craving, drug reward, habit learning, and decision making as well as those related to social rejection, social influence, and group cooperation.

The frequency and severity of cannabis use on psychological and social functioning is often understudied, as studies tend to collapse all cannabis users into one group, inaccurately generalizing findings and implications. Regular, heavy, and/or chronic cannabis use (defined as daily or near daily use) has been found to result in academic and cognitive impairment, psychotic and/or other psychiatric symptoms, respiratory and cardiovascular concerns, and stable adverse effects in brain structures (Hall & Degenhardt, 2014; Lorenzetti, Solowij, Fornito, Ian Lubman, & Yucel, 2014). Cuttler and colleagues (2017) found that chronic cannabis users did not differ in their cortisol (a stress hormone) response to an acute stress task from users who had not undergone the stress condition. Together with users reporting a significantly lower increase in subjective stress ratings than controls, these results provided evidence for blunted stress reactivity in chronic cannabis users. Furthermore, the discordance between their psychological and physiological responses (the lack of a strong cortisol response despite increased subjective stress) suggests potential impairments in the hypothalamic-pituitary-adrenal (HPA) axis, the brain area responsible for stress responses (Cuttler et al., 2017). This may affect cannabis users’ ability to adequately react to and recover from negative and stressful events.
Research has explored the relationship between social rejection and cannabis use in samples with different use frequencies, as assessed by Cyberball to explore the social pain hypothesis (Williams, 2007). Gilman and colleagues (2016) investigated the neural mechanisms underlying social exclusion in light-to-moderate, young adult cannabis users (defined as using at least once per week) compared to controls. Participants completed personality and suggestibility measures and underwent an fMRI while playing Cyberball with four conditions (control, inclusion, exclusion, and re-inclusion). While users and controls did not differ in their levels of distress to Cyberball, neural responses in cannabis users revealed dulled brain activation in known areas of social influence. Cannabis users had normative ventral nucleus accumbens (vACC) activation and no significant activation of the insula, reflecting intact affective monitoring but impaired social processing (Gilman et al., 2016). Together, results revealed that while cannabis users were cognitively aware of exclusion and even possibly ruminated on their negative emotions, (vACC), they were not emotionally responsive and had a dulled affective and neural response to rejection. Moreover, compared to controls, only cannabis users showed a significant relationship of vACC activation with peer conformity and overall suggestibility; the authors speculated these results in an adult sample reflect an “immature pattern of brain development” seen in research showing a negative relationship between activation in a part of the vACC and resistance to peer influence in adolescents (Gilman et al., 2016, pg. 157).

Given evidence of acetaminophen and THC’s effects at reducing physical pain, Deckman and colleagues (2013) investigated the hypothesis that cannabis can buffer individuals against the consequences of social pain. The authors conducted four methodologically diverse studies predicting elevated levels of cannabis use would attenuate the relationship between feelings of social exclusion and poor psychological well-being. The various samples included individuals
from an adult national comorbidity survey, a national youth risk behavior survey, and adults from Amazon’s Mechanical Turk. Results indicated that in lonely individuals with more frequent use, cannabis acted as a buffer against social pain as assessed by various measures: self-reported self-worth, mental health, the presence of a depressive episode, and social exclusion via Cyberball. For heavy users, there was a strong relationship between exclusion and lowered threatened needs, demonstrating that ostracism-related distress may be dependent on frequency of substance use and providing support for the author’s social buffer hypothesis (Deckman et al., 2013; Williams, 2007). Though limitations existed (such as using loneliness as a proxy for social pain), these results provide preliminary evidence for the role of cannabis and CB1 receptor activation in protecting one against feelings associated with social rejection, particularly for more frequent users. It is important to note these authors cannot draw conclusions as to whether cannabis causes emotional unresponsiveness; directional findings about cannabis’ effects on emotional and neural expression have not been established.

**Cannabis Use in Real-World Contexts**

**Assessing Cannabis Craving and Motivation for Use**

Much research has been conducted measuring the role of craving in drug use. Though there is an ongoing debate over the definition of craving (e.g., behavioral intention to use, desire for effects of drug), it is considered a relatively transient state that is expected to differ from one occasion to another (Sayette et al., 2000). Drummond and colleagues (2000) also conceptualized craving as both an entity (a phenomenon that is experienced) and a process (by interacting with other phenomenon). These authors offer many factors that need to be considered when assessing drug craving, including cue-elicited craving, determinants, mediators, and moderators of craving,
such as contextual cues and psychiatric comorbidity, and its predictive validity of future drug use (Drummond et al., 2000). For instance, antipsychotic medication may play a role in increased cannabis craving in patients with psychosis (Keupper et al., 2013).

Self-report measures are commonly used to assess drug craving, such as the Marijuana Craving Questionnaire (MCQ) created by Heishman and colleagues (2001) and its 12-item short form version (MCQ-SF; Heishman et al., 2009). Based on nicotine and alcohol craving research, this measure uses four factors to characterize cannabis craving: compulsivity, emotionality, expectancy, and purposefulness (Heishman, Singleton & Liguori, 2001; Tiffany, Carter & Singleton, 2000). Cue-reactivity paradigms are often used in drug and addiction studies, particularly cannabis (Gray, LaRowe & Upadhyaya, 2008; Gray, LaRowe, Watson & Carpenter, 2011; Henry, Kaye, Bryan, Hutchison, & Ito, 2014; McRae-Clark et al., 2011; Ruglass, Shevorykin, Dambreville & Melara, 2019). Participants are exposed to drug-related and other types of cues and their responses are observed and measured (Drummond, 2000). Cousijn and colleagues (2013) found that cue-induced brain activity in cannabis users seems to be primarily associated with problem severity, not frequency, of cannabis use in a sample of frequent, sporadic, and non-users.

Shrier and Scherer (2014) noted self-report or qualitative methods of motivations for substance use assumes “cross-situational consistency” (pg. 1760), where motivation is a stable, individual characteristic that can determine frequency of substance use and not a factor that fluctuates and influences other factors across context and time. Similarly, it is imperative to assess cannabis craving and factors related to use as it fluctuates and interacts with social factors. Investigating the role that rejection may play, both as an immediate reaction and as a stable,
interpersonal trait can better elucidate how individuals using cannabis handle real life social stressors.

Real World, Real Time Cannabis Use: Ecological Momentary Assessment

While addiction research has extensively used laboratory-based methods, such as self-reports, drug cue reactivity paradigms, and interviews to assess drug use, these methods have their limitations. Participants may be suggestible to social desirability responding and recall may be subjected to cognitive reappraisal (Shrier & Scherer, 2014). Additionally, cues or triggers in laboratory paradigms may have low ecological validity and may not accurately reflect factors that influence substance use in the real world (Serre, Fatseas, Swendsen, & Auriacombe, 2015). Another method of gathering drug use history is the Timeline Followback (TLFB) calendar, where participants are asked to recall information and behaviors each day for a specified period of time (usually 30 to 90 days). However, this technique is also prone to memory recall and susceptibility to bias (Phillips et al., 2014).

For years, the field has employed momentary sampling methods to study rejection and cannabis independently. Ecological momentary assessment (EMA; Stone & Shiffman, 1994) is an approach that allows for research using prospective, longitudinal designs. As noted by many researchers using this “in the moment” method, EMA involves daily monitoring of target behaviors. Some of the key benefits of EMA include: (1) collection of data in real-world environments, thereby enhancing ecological validity; (2) minimization of retrospective recall bias by assessing relations between affective states and behaviors while participants experience the affect and/or engage in the targeted behavior; and (3) aggregation of observations over multiple assessments to facilitate within-subject assessments of behaviors across time and context (Stone & Shiffman, 1994, Trull & Ebner-Priemer, 2009).
Given that cannabis is a social drug and craving is a transient state greatly affected by context (Drummond et al., 2000), recent studies have used EMA to conduct cannabis research. In their qualitative review of 91 studies using EMA to assess drug craving and substance use from 1996 to 2013, Serrre and colleagues (2015) found only three that investigated cannabis. All three studies used one item to assess craving in participants who were not quitting cannabis use or were pre-quit attempt; it is not clear how many excluded studies assessed cannabis (Serre et al., 2015).

Buckner and colleagues (2012a) used EMA to assess cannabis cravings, anxiety, and peer cannabis use among undergraduates over two weeks using personal digital assistants (PDAs). Data were collected at the daily level (use versus non-use days), momentary (whether craving and anxiety was related to use at that time), and antecedent level (whether craving and anxiety at one time predicted use at a later time). Anxiety was found to be significantly and positively related to craving at the moment and to later craving. Participants had higher craving levels on days they used cannabis, and cravings increased prior to and decreased after use. Looking at context and peer use, 77.3% of cannabis use occurred during social situations and 93.35% used when others were using cannabis as well (Buckner, Crosby, Silgado, Wonderlich & Schmidt, 2012a). Similarly, another study examined affect, withdrawal and craving in a racially diverse sample of college aged adults using cannabis (Buckner et al., 2015). All participants endorsed at least weekly past-month use (with 81.4% endorsing daily use) and 68.8% met DSM-IV-TR criteria for cannabis dependence and 18.3% met criteria for cannabis abuse, reflecting frequent use and greater impairment. Results indicated withdrawal, craving, and affect were strongly related to cannabis use; where use resulted in decreases in withdrawal, craving, and negative affect, thus supporting the hypothesis that these are high risk vulnerability factors for cannabis
use. Consistent with tension-reduction models, negative affect was greater when participants were about to use cannabis and use resulted in less negative affect but not less positive affect, despite enhancement being reported as the most common motive for use, indicating that cannabis use may be maintained by decreases in negative affect not by increases in positive affect (Buckner et al., 2015). Moreover, the majority of use occurred when others were also using cannabis. Interestingly, when withdrawal and negative affect were high (more than one standard deviation above the mean), participants were especially vulnerable to using cannabis for social and coping motives (Buckner et al., 2015). Another study assessed context, desire, and perceived availability of cannabis among those ages 15-24 over a two-week EMA period, finding that desire to use was stronger when around friends and when there was less perceived availability of cannabis (Shrier, Walls, Kendall & Blood, 2012). Overall, EMA was effective at assessing cannabis craving and factors related to use; results indicate that use and craving are related in a time-dependent manner and social context and affect in the real world play an important role in cannabis use.

One study was the first to demonstrate text messaging as a feasible variation of EMA using smartphones, a method of communication widely available and used by young adults, in a sample of college students using cannabis heavily (Phillips et al., 2014). Compliance was high (approximately 83%) in a two-week EMA study consisting of three text messaged prompts per day. Participants also completed a 30-day TLFB calendar within one week of the EMA period; they reported less cannabis daily use on the TLFB than recorded via EMA. Only 29% of instances matched across the two methods, indicating EMA may be able to help minimize recall bias in self-reported use (Phillips et al., 2014). Results from another study using the aforementioned sample, method, and data found craving significantly predicted the frequency
and amount of cannabis use at the next time point in a positive manner (K. Phillips, Phillips, Lalonde & Tormohlen, 2015). Moreover, as craving increased, academic effort and motivation decreased, indicating cannabis craving and use have implications for academic achievement in college students (Phillips et al., 2015).

Ansell and colleagues (2015) assessed levels of daily impulsivity and interpersonal hostility via text messaging in adults using recreational cannabis, tobacco, and alcohol. They found cannabis use was associated with more impulsivity in use days compared to non-use days. Furthermore, cannabis use was associated with increased interpersonal hostility in one’s self and perceived hostility from others on use days compared to days they did not use cannabis (Ansell, Laws, Roche & Sinha, 2015). These results are the first to show a directional effect of cannabis on impulsivity, a key factor in engaging in risky behaviors, self-regulation, and addiction (Ansell et al., 2015).

Lastly, another two-week momentary sampling study assessing individual and contextual factors related to frequently cannabis using youth ages 15-24 found that participants initiated use around 13-years-old and currently used an average of nine times per week (Shrier et al., 2013). Participants primarily used around friends (45.6%) or alone (26.2%), reported using for enhancement, expansion, or social reasons (85.8%) and had indicators of poorer mental health: higher state and trait anxiety, higher depressive and social anxiety symptoms, as well as higher negative and lower positive affect. The latter factor significantly predicted an increased likelihood of greater doses of cannabis (defined as 6 or more hits during a use event) and reporting a higher high. The authors’ methodology allowed for a more refined look into the relationship between cannabis frequency, dosage, and reported high in a sample of adolescents and adults (Shrier et al., 2013).
This brief review reveals EMA to be an established, feasible method of assessing cannabis use, craving, and motives for use as well as affective and contextual factors via conventional PDA or text messages. Research has also been conducted to investigate rejection sensitivity (RS) via EMA methods. One recently published study employed EMA in a sample of ethnically diverse, college students to explore the moderating role of RS between interpersonal and affective perceptions of others during face to face interactions in natural settings (Meehan, Cain, Roche, Clarkin & De Panfilis, 2018). Results revealed that individuals high in trait RS struggled to perceive positive emotions and actions, which limits their ability to match these interpersonal responses. Additionally, the high trait RS group tended to react coldly towards those they perceived as exhibiting negative and subdued affect and had difficulties interacting with and reciprocating in kind with others who were more agentic or dominant. To our knowledge, no study has yet assessed how trait RS and experiences of rejection play a role in real-world cannabis use in young adults.

Mixed-Methods: Cyberball and EMA Studies of Social Rejection

There is scarce converging evidence of the relationship between social rejection, personality factors, and substance use from studies using both experimental and EMA methods. To investigate the effects of self-esteem and negative emotion differentiation on social exclusion, Kashdan and colleagues (2014) had adult students complete a daily online diary assessing self-esteem and negative emotional experiences over a three-week period. During this time, participants had been taking either daily doses of acetaminophen or placebo as part of a separate study on the effects of this drug on neural responses to social exclusion. Afterwards, they participated in Cyberball while undergoing an fMRI scan. Results showed that lower self-esteem was associated with greater neural activation in regions associated with social rejection in
individuals with low emotion differentiation, indicating individual differences in interpersonal traits gained from real-world responses can predict reactions to induced social exclusion (Kashdan et al., 2014). Another mixed-methods study with adult women found that individuals who showed greater fMRI activity in regions associated with affective and pain processing during Cyberball reported feeling greater momentary social distress during their daily social interactions (Eisenberger et al., 2007). These results significantly link neural and behavioral responses in controlled environments, such as a laboratory, with human behavior and environmental contexts in the real world.

Several studies have examined how decision-making processes and interpersonal factors relate to substance use using Cyberball and EMA. For example, Papinczak, Connor, Harnett and Gullo (2018) tested a biosocial cognitive theory of cannabis use that integrates personality traits, such as impulsivity, and social cognition, finding that positive cannabis expectancies and cannabis refusal self-efficacy partially mediated the association between reward sensitivity and cannabis use in young adults. Reward sensitivity, defined as decreased sensitivity in reward circuits in the brain, has been implicated in addiction research (Volkow et al., 2010). Two studies were conducted to assess the effect of social stress on reward sensitivity (Kasanova, 2016). First, female participants completed a reward task followed by Cyberball with a stress or control condition. Stress participants reported more social stress and lower positive affect and self-esteem than controls. Kasanova (2016) then conducted a separate EMA study using a different sample of 17 adult men and women, who completed 10 assessments per day over the course of six days. The assessments consisted of as many of the same momentary social stress and affect items from the experimental study as possible, measuring social stress, positive and negative affect, and the pleasantness of a recent past and a future event (i.e., consummatory and
anticipatory reward). The former reward, the extent to which positive affect rises in response to recent pleasant event, was found to be moderated by the degree of social stress. Higher levels of social stress were associated with lower positive affect. Anticipatory reward, the capacity to look forward to pleasant events in the upcoming hour, decreased with increases in current social stress. Together, results from these two studies indicate social stress operates as a naturalistic stressor that may cause reward dysfunction (Kasanova, 2016). This line of research may have implications for cannabis users.

To date and to the best of our knowledge, no study has investigated cannabis use by itself or in relation to rejection sensitivity and social exclusion using both Cyberball and EMA.

**Summary and Study Aims**

In summary, cannabis use in young adults is an alarming concern given the high rates of use and CUD in addition to the deleterious effects on one’s physical, mental, and social health. Cannabis has been implicated in relieving social pain, an important area of research in young adult samples, given the saliency of peer and social networks to addiction. Stress is also a common feeling in young adults, serving as a risk factor for cannabis use, as this population often views cannabis as a less risky and more acceptable means of managing distress. Research shows that rejecting experiences and social exclusion are perceived to be just as painful as physical pain. Evolutionary frameworks posit that a social monitoring system or affective alarm exists to warn us of social pain and mitigate the distress. Cannabis, via THC, has been shown to reduce, or potentially buffer, the effects of social pain and rejection. This could mean that for some individuals, possibly those using more frequently, cannabis may be protective against the
painful feelings of social stress. These findings are not wholly positive though, as other research indicates that cannabis may blunt affective responses and impair social processing.

A relationship between social rejection and cannabis use has been established using self-report, behavioral, and neural data. Rejection sensitivity (RS) as a specific factor in this relationship has been understudied, but research suggests it is strongly associated with social rejection and exclusion. However, RS as it relates to cannabis use is yet to be explored. To the best of our knowledge, there are no studies assessing social exclusion, RS, and cannabis use.

Furthermore, a review of the social exclusion literature reveals an important gap that we aimed to explore. Self-report assessments do not fully capture one’s perceptions and reactions to rejection. Classic Cyberball has standard conditions of exclusion and inclusion, which does not accurately reflect how social rejection operates in real life. Often exclusion and feelings of rejection are perceptions held by an individual as situations can be subtle, ambiguous, or not as extreme as the complete exclusion that occurs in Cyberball. Individuals are often left on their own to interpret the relational value they hold to others. The present study aimed to employ the Cyberball+ paradigm with its more varied range of inclusion rates across five conditions. Responses to social exclusion may depend on the nature of the interaction and level of rejection; varying inclusion rates in Cyberball may provide a more nuanced assessment of RS and improve the external validity of this methodology. Findings may have important implications for scientists assessing social rejection and clinicians who want to better understand how rejection experiences play a role in substance use, particularly young adult cannabis users.

More research with young adult cannabis users is greatly warranted, particularly those using tools relevant for this population, such as cell phones. Conducting phone application or text-messaging based EMA research allows for innovative data collection and treatment.
intervention. Additionally, no studies have been conducted that provide converging evidence of the mechanisms underlying cannabis user’s response to social exclusion and rejection in both experimental and real-word contexts. Doing so will further validate social stress and rejection as important interpersonal and contextual factors that should be incorporated into interventions aiming to address psychosocial and mental health needs of young adult cannabis users need to be further explored.

Study Aims

Using a translational design, the first aim of this study was to better understand the role of cannabis use and its relation to rejection sensitivity (RS) in young adults using moderate and heavy levels of cannabis compared to healthy, non-cannabis users. We characterized factors of cannabis use (i.e., age of initiation, current use pattern, perceived health risk, craving, motives for use, and DSM-IV clinical symptoms) and social coping styles. Regarding RS, we hypothesized that heavy cannabis users will report higher trait RS than moderate users and healthy controls.

Second, we assessed the influence of social exclusion on rejection sensitivity and frequency of cannabis use using the novel Cyberball+ paradigm. We hypothesized that: a) rejection distress (RD) to social exclusion will be correlated with self-reported trait RS; b) there will be an interaction effect between cannabis use frequency and trait RS on RD; and c) social exclusion will have an effect on cannabis craving. Given the limited research on rejection sensitivity in cannabis users and mixed findings regarding the effects of cannabis use frequency on feelings of exclusion and rejection, we did not make directional inferences. Therefore, our hypotheses remained exploratory.
To our knowledge, no study has used both Cyberball+ and EMA to assess the relationship between RS, cannabis use, and both experimental and real-world social rejection. An EMA design allows us to explore the ecological validity of this relationship. Thus, the third aim of the present study examined the influence of rejection distress to experimental social exclusion and experiences of real-world rejection on 1) cannabis craving and 2) cannabis use in naturalistic settings in an exploratory manner. We hypothesized: a) experiencing real-world rejection will be associated with greater craving and use; and b) greater rejection distress to Cyberball+ will be associated with greater craving and use.
Chapter 3. METHODS

Participants

Seventy college-aged adults \( (M = 20.56, SD = 3.13; \text{Range} = 18-30) \) participated in the present study (see Figure 1.). Participants were 50% men and 50% women who were primarily non-Hispanic/Latino (61.43%) and English speakers (85.71%), see Table 1. for full demographic characteristics. The sample was ethnically diverse, with approximately 60% of participants identifying as a racial minority. Participants were predominately unmarried (98.57%), employed either full or part-time (60%) and reported their parents as the primary source of annual income (47.14%). Most participants were freshman (37.14%). Participant’s cannabis use fell into three categories: 24 (34.29%) healthy controls (i.e., HC) and 46 (65.71%) cannabis users, of which 21 (30.0%) were moderate users defined as one to three occasions of use per week (i.e., CB-Mod) and 25 (35.71%) were heavy users defined as four or more cannabis use occasions per week (i.e., CB-Heavy).

Inclusion criteria: Participants were CCNY undergraduate students eligible to receive research credit as compensation for participation. Those who were not registering for course credit and instead were voluntarily willing to participate were eligible as well. Healthy controls must be physically healthy. Cannabis users must currently have been using at least once per week over the last 30 days, must not be seeking drug/addiction treatment, and had a smartphone with text messaging capabilities. All participants must be able to read and understand English and had good or corrected eyesight.

Exclusion Criteria: Students under the age of 18 and over 30 were excluded as we focused on emerging and young adulthood. CCNY’s student population consists of many older individuals (ages 24 and up) studying at the undergraduate level so the age range was increased
Healthy controls cannot have used cannabis more than 10 times in their lifetime and must not have used within the past year. All participants using illicit drugs other than cannabis, consuming alcohol at levels indicating possible misuse, or who had skin allergies were also excluded.

**Procedures**

All study procedures were approved by the Institutional Review Board at CCNY (IRB# 2016-0540). Participants were recruited from the undergraduate student population at CCNY through the SONA system, a cloud-based participant pool management system (https://ccny.sona-systems.com). Advertisement flyers were posted throughout the CCNY campus including notice boards, department offices, and classrooms. Please see Figure 1. for participant enrollment and study flow. Participants contacted the study via email or SONA and were asked to verbally consent to a 15-minute telephone screen to determine suitability of participation. The screen consisted of a brief description and logistics of the study as well as eligibility questions. If an individual met the eligibility criteria, they were scheduled for Phase I of the study. If they were not interested after hearing about the study or were determined ineligible, their screening form was shredded. Participant information was kept in a password protected file only accessed by research staff and all data was de-identified. All study documents were kept in a secure, locked cabinet located in a secure office.

**Phase I Procedures**

Participants attended a 3-hour study visit, where they were first asked to take a rapid drug urine test using the 10 Panel iCup to confirm cannabis use in reported users and non-use for HC’s. After the drug urine test, participants read the consent form and verbally consented. To protect participant confidentiality in a study assessing illicit drug use, we asked that they not sign
the form; research staff signed on their behalf. Participants were given an opportunity to ask questions. They then completed an approximately 45-60-minute online Qualtrics survey consisting of demographic information, cannabis use history and related factors, cannabis craving and motives, psychiatric symptoms, mood, and coping questionnaires comprising the baseline self-report assessment at a computer in a private booth. The relevant measures are listed below.

Next, participants completed a modified Cyberball+ paradigm. They were told the study aim was to assess mental visualization skills and asked to envision playing the ball-toss game with two other players. They were also told the two player icons represented real students at other locations and efforts were made to ensure participants believed that staff was interacting with other study personnel and participants at other “locations”. Participants underwent five Cyberball+ runs of various inclusion percentages (Fertuck et al., 2017). After each run, participants filled out a brief need threat survey. Lastly, after Cyberball+, participants completed the cannabis craving measure for a second time. Participants were then asked to respond to open-ended questions from research staff about their experience during the game using a manipulation checklist and debriefed about the true aim of the study to ensure no lasting effects of the deception.

During Cyberball+, perspiration, respiration, and heart rate were recorded continuously using skin conductance response (SCRs) and an electrocardiogram (ECG) from the Biopac Inc. physiological recording equipment pack. The experimental task took approximately 30 minutes to complete and three course credits were given upon completion. For HC’s, their participation ended at this phase. As this study aimed to assess cannabis craving, use, and factors related to use in real-world contexts via EMA, HC’s were not eligible for the daily diaries due to their lack
of use. As a pilot study, the smaller subset of the sample (cannabis users) was deemed sufficient to carry out analyses given the nature of EMA methods and its resulting large dataset.

Phase II Procedures

Cannabis users who completed Phase I were eligible to participate in the second phase, which consisted of the one-week (7-days) Daily Mood and Social Diary. These participants were asked to re-consent immediately after Phase I and given instructions about completing the daily diaries. They were asked to self-generate an ID number to use on the daily diaries using an algorithm. Participant’s phone numbers were registered with Survey Signal (http://surveysignal.com), a text messaging system that prompted the participant to complete the daily diary using a Qualtrics link. Registration was completed by research staff to ensure verification of registration and receipt of text messages. Participant’s names and emails were not entered into Survey signals; IDs and the study email were substituted in.

Participants were randomly prompted four times per day within a pre-established window of time for a period of 7 days between the hours of 9:00am and 11:59pm. Reminder prompts were sent within 15-minutes after the first prompt for that time signal if the diary had not yet been completed and the link became inactive after 30-minutes. The daily diary took less than five minutes to complete. Participants were contacted the day after the EMA period ended, notified of Phase II completion, and invited to receive their compensation of $25.00. The compensation was received in cash or through electronic transmissions (Quickpay). Participants were compensated regardless of the number of diaries completed.

Measures

Baseline Assessments
**Demographics:** Participant’s age, sex, race/ethnicity, primary language, religion, education, employment, income, and academic standing (undergraduate year) were self-reported.

**Drug Use History and Biological Confirmation:** Participants completed a 9-item drug use history measure (partially adapted from the then available CUNY Health Survey) and reported current cannabis use pattern, age of initiation, normative beliefs about family and peer cannabis use, and lastly, perceptions of cannabis health risks (see Appendix A.). Confirmation of use for reported cannabis users and non-use for HC’s were assessed using a 10-panel urine drug cup test (www.homehealthtesting.com). The iCup tests for the presence of cannabis using a 50-mg/mL cutoff over a 15 to 30-day detection period. It also tests for the presence of nine additional drugs.

**Rejection Sensitivity:** The *Rejection Sensitivity Questionnaire - Adult version* (A-RSQ; Berenson et al., 2009) is an 18-item self-report measure assessing the anxious-expectation components of rejection sensitivity (RS) across nine situations using a Likert of 1 to 6 for concern/anxiety (very unconcerned to very concerned) and expectations (very unlikely to very likely). Scores are computed by multiplying the ratings of rejection concern/anxiety by ratings of rejection expectancy in each situation, and averaging the resulting scores. Total and subscale RS scores range from 1 to 36. The A-RSQ shows good validity and reliability (Berenson et al., 2009; Berenson, Downey, Rafaeli, Coifman & Paquin, 2011). Internal consistency was excellent in this sample, Cronbach’s α = 0.81.

**Cannabis Craving:** The *Marijuana Craving Questionnaire - Short Form* (MCQ-SF; Heishman et al., 2009) consists of 12 items assessing four subscales of cannabis craving: (1) *compulsivity*, an inability to control cannabis use, (2) *emotionality*, use of cannabis in anticipation of relief from withdrawal or negative mood, (3) *expectancy*, anticipation of positive outcomes from smoking cannabis, and (4) *purposefulness*, intention and planning to use cannabis
for positive outcomes. Items were rated on a Likert scale from 1 (strongly disagree) to 7 (strongly agree). Scores were obtained by summing the three items in each subscale, yielding a score ranging from 3 to 21. The MCQ-SF has good validity and internal reliability (Heishman et al., 2009) but showed mixed internal consistency in this sample; at baseline: Emotionality Cronbach’s α = 0.77, Compulsivity α = 0.13, Expectancy α = 0.47, and Purposefulness α = 0.73 and post-Cyberball+: Emotionality Cronbach’s α = 0.73, Compulsivity α = 0.58, Expectancy α = 0.30, and Purposefulness α = 0.75.

Motives for Cannabis Use: The Marijuana Motive Measure (MMM; Simon et al., 1998): A 25-item measure assessing motives for cannabis use. The five subscales and representative items are as follows: enhancement (e.g., “I use marijuana to get high”), item coping (e.g., “I use marijuana to forget my worries”), social (e.g., “I use marijuana to be sociable”), conformity (e.g., “I use marijuana so I won’t feel left out”), and expansion (e.g., “I use marijuana to expand my awareness”). The MMM items are scored from 1 (almost never/never) to 5 (almost always/always) yielding subscales ranging from 4 to 16, 5 to 25, or 6 to 30 with excellent validity and reliability in high school and college student samples and a Dutch sample of adult frequent cannabis users (Benschop et al., 2015; Chabrol, Duconge, Casasa, Rouraa & Carey, 2005; Simons et al., 1998). Internal consistency in this sample ranged from good to excellent: Conformity Cronbach’s α = 0.76; Enhancement α = 0.84; Social α = 0.82; Coping α = 0.88; and Expansion α = 0.93.

Cannabis Misuse: The Cannabis Use Disorder Identification Test-Revised (CUDIT-R; Adamson et al., 2010) is a brief, 8-item screening measure of problematic cannabis use over the past six months. Items assess the frequency of cannabis use behaviors and consequences on a 0 to 4 scale. Total scores range from 0 to 32; scores of 8 or higher indicate hazardous use; 12 or
higher indicate probable DSM-IV Cannabis Use Disorder (CUD). The CUDIT-R is a widely used measure with excellent psychometric properties and has been used in college populations (Adamson et al., 2010; Schultz, Bassett, Messina & Correia, 2019). Internal consistency was good in this sample, Cronbach’s \( \alpha = 0.71 \).

Copied Measures

**Social Coping:** The *Coping Styles Questionnaire for Social Situations* (CSQSS; Antony, McCabe & Fournier, 2001) is a measure of coping strategies used when faced with six anxiety-provoking social situations (e.g., “Imagine going to a party given by a co-worker/classmate. There will be a lot of people you don’t know”) as assessed by two subscales: monitoring (the degree to which individuals seek out information pertaining to a threatening situation) and blunting (the degree to which individuals seek out distraction when confronted by a threatening situation) (Mezo, McCabe, Antony & Burns, 2005). These six situations include 18 monitoring and 18 blunting items rated on a Likert scale of 0 to 4, with a total scale score ranging from 0 to 72 for each coping style (Mezo et al., 2005). The validity and reliability of the CSQSS appear to be satisfactory (Mezo et al., 2005). Internal consistency was good in this sample: Cronbach’s \( \alpha = 0.79 \) for monitoring; \( \alpha = 0.76 \) for blunting.

**Cyberball+ Task**

We employed the animated Cyberball+ version of the game (adapted from Williams et al. 2000) with three avatars presented on screen: the middle one represented the participant and the other two represented the virtual players. The participant chose which virtual player to toss the ball to by pressing one of the two buttons. The game was programmed using Matlab 6.1 (www.mathworks.com) and Psychtoolbox (www.psychtoolbox.org) on a desktop computer. Cyberball+ consists of five, 3-½ -minute runs. The inclusion rate on each run was varied by
changing the frequency of ball throws to the participant such that the participant was included 10% (hyper-exclusion condition), 20%, 40%, 50%, and 60% (hyper-inclusion condition) of throws (Fertuck et al., 2017). The runs were presented in a pseudo-randomized, counterbalanced order, but the experiment always started with a 50%-inclusion run in order to establish a baseline. During the task, skin conductance response (SCRs), heart rate (HR), and respiration were recorded continuously using Biopac Inc. physiological recording equipment.

**Need Threat Scale:** At the end of each run, participants completed a 14-item questionnaire adapted from the Need Threat Scale (NTS; Jamieson, Harkins & Williams, 2010; Van Beest & Williams, 2006) that asks about their feelings of self-esteem (e.g., “I felt liked”), belongingness (e.g., “I felt rejected”), meaningfulness (e.g., “I felt invisible”), and control (e.g., “I felt powerful”) on a Likert scale of 1 (*Very Unconcerned*) to 6 (*Very Concerned*). See Appendix B. for all items. Ratings on positive items were reversed such that all the items measured feelings in reaction to social exclusion were in the same direction. Higher scores reflect more threatened needs. The present study used the NTS items to create a measure of rejection distress. The NTS has good validity and reliability (Jamieson et al., 2010; Van Beest & Williams, 2006). Internal consistency was good in this sample: Cronbach’s $\alpha = 0.90$.

**EMA Items** (See Appendix C.)

- **Craving:** One binary item assessed a “strong desire or urge to use” cannabis.
- **Use:** One binary item assessed use of cannabis, one free response item requested amount used since the last prompt, and one binary item assessed whether they are using at the time of the current prompt (use now).
- **Social Context:** One binary assessing whether cannabis use since the last prompt was solitary or in a social context.
Peer Use: If in a social context, one binary item asked if others were using or about to use as well.

Affect: Participants complete a modified version (Shrier et al., 2012) of the Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988). Responses to each item were on a 5-point Likert-type scale from 1 (Not at all) to 5 (Extremely). Responses were summed to create separate subscale scores (range of 6–30) for positive affect (interested, strong, proud, alert, inspired, determined) and negative affect (distressed, upset, guilty, scared, hostile, irritable). The adapted PANAS had good psychometrics for both subscales (Shrier et al., 2012). Internal consistency was excellent in this sample, Cronbach’s $\alpha = 0.87$ for positive affect; $\alpha = 0.84$ for negative affect.

Life Events: Participants respond yes or no to whether they have encountered any of nine positive or negative life events. For this study, the life event of interest was experiences of rejection (e.g., “Felt rejected by someone”).

Data Analytic Plan

To address the first aim of the study, Chi-Square tests and descriptive statistics were used to characterize young adults, cannabis use factors, and social coping styles in this sample. Regarding motivations of cannabis use, an error was made in the creation of the Marijuana Motives Measure (MMM) online survey resulting in a 4-point Likert scale (1 to 4) instead of a 5-point (1 to 5) scale. Results regarding MMM are reported using this 4-point scale and resulting scores range from 0 to 16 and 0 to 20; z-scores were created to account for this error and allow for quantitative comparison between subscales given the differing number of items across
subscales. Related to aim one, to test our hypothesis that heavy cannabis users will report higher trait rejection sensitivity (RS) than moderate users and controls, ANOVA tests were conducted.

To investigate the influence of social exclusion on RS and frequency of cannabis use, our second aim, Fertuck and colleagues (2017) have identified a measure of rejection distress (RD) resulting from Cyberball+: ratings on the Need Threat Scale (NTS) items, except for “included” which was not found to load onto either of the two identified principal components. This first principal component was replicated and used in this study, accounting for the most variability in subjective ratings categorically discriminating between positive and negative NTS items. Parameter estimates were obtained from a linear regression of the rejection distress versus inclusion probability. The slope was used as an index of how rejection distress varies as a function of inclusion probability. A correlation significance test was conducted to test hypothesis 2a: there will be a significant relationship between trait-RS and RD. A Two-Way ANOVA test was conducted to assess hypothesis 2b: there will be an interaction effect between trait RS and cannabis use frequency on RD as a function of inclusion probability. Lastly, to assess whether social exclusion has an influence on cannabis craving (hypothesis 2c), Repeated-Measures T-Tests or Wilcoxin matched-paired sign-tests were conducted on each of the four craving subscales as appropriate.

The third and final aim of the study was to assess the relationship between RS, cannabis use, and both lab-based and real-world social rejection. Descriptive statistics (means, percentages) were used to summarize EMA compliance and response rates as well as cannabis craving, use, social context, peer use, rejection, positive and negative life effects and positive and negative affect over the 1-week period. Multilevel, mixed effect logistic regression models were conducted on each binary outcome variable of interest: cannabis craving (hypothesis 3a) and
cannabis use (hypothesis 3b). Multilevel models were employed to analyze EMA responses of cannabis users due to the longitudinal and hierarchical character of the data: within-subject momentary ratings at each time point (Level 1) are nested within individuals (Level 2). In addition, due to the nature of EMA data, there were unequal numbers of responses across participants. Multilevel models are able to accommodate variability in the number of responses across participants as well as take into account the dependency of repeated measures within the same person. Individuals were entered as a random intercept in the model; all other variables were fixed effects. An iteration of models was run from the unconditional model with solely the outcome variable and individual as a random effect, thereby depicting the overall variance of the model, to final models that included all predictors and covariates. Fixed effect predictors included time, cannabis use frequency (moderate/heavy users), experiences of real-world rejection (yes/no), and Cyberball+ rejection distress as a function of inclusion probability (RD); craving (yes/no) was an additional predictor in the cannabis use model. Binary variables were dichotomized and categorical variables were dummy coded. Age and sex were included as fixed effect covariates in both models; age was mean centered, and RD was standardized and mean centered.

Model iterations demonstrate how the inclusion of predictors and covariates influenced model fit. Models were fit with a maximum likelihood estimation and an independent covariance structure. A series of model diagnostics were performed, including log likelihood (-2LL), Intraclass correlation (ICC), Akaike’s information criteria (AIC), Bayesian information criteria (BIC), and the Likelihood ratio (lr) test. The ICC is the proportion of the variance in the outcome variable that is explained by the grouping structure of the hierarchical model; an ICC > 0.10 provides justification of employing multilevel modeling. The lr test, AIC, and BIC values were
compared for superior model fit. For both sets of analyses, a model was run to examine whether a quadratic function of time fit the data better than a linear function. Fit statistics suggested that a linear growth model was better fit to the data.

Parameter estimates of a mixed effects logistic regression model are presented as coefficients and are interpreted as odds ratios (OR) of expected counts (e.g., slopes, predictors). Odds ratio represents the constant effect of a predictor on the likelihood that one outcome will occur; specifically, the logit of the conditional probability that the outcome variable equals one (yes to cannabis craving or use) over the probability that it equals zero (no to cannabis craving or use). In other words, the intercept is the odds of the event when all other predictors are equal to zero and the slopes are the OR associated with one unit change in a predictor (Sommet & Morselli, 2017).

The principal component and linear regression analyses to obtain Cyberball+ rejection distress slopes were conducted in Matlab. All other analyses were completed in STATA 15.0 (StataCorp, 2017).
Chapter 4. RESULTS

Aim 1: Characterize factors related to cannabis use factors and social coping styles in young adults.

1.1 Cannabis Use Characteristics

As can be seen in Table 1., healthy controls (HC), moderate cannabis users (CB-Mod), and heavy cannabis users (CB-Heavy) in our sample significantly differed on religion ($\chi^2 = 17.77$, Fisher’s exact $p = .006$); the effect size of this difference was moderate (Cramer’s $V = 0.36$). Participants were similar on all other demographic characteristics. All participants completed items assessing their cannabis use history, normative beliefs about other’s use, and cannabis health risks (see Appendix A.). Fifty-two (74.29%) participants reported lifetime cannabis use with an average age of initiation of 15.94 ($SD = 2.70$) years; one participant’s data was excluded due to entry error. Of current (past 30-day) cannabis users, 20 (28.57%) reported using 1-3 times per week and 26 (37.14%) reported using at least 4 or more times per week. Of the heavy users (4 or more times per week), 53.84% (n = 14) of participants reported using at least 7 times per week. On average, 20% of all participants were considered daily users. Approximately 45.71% (n = 32) of participants reported having immediate family members who use cannabis. Regarding participant’s perceptions of health risks related to cannabis use, 68.57% (n = 48) reported cannabis has slight or no harm to health, 25.71% (n = 18) reported that cannabis is somewhat harmful, and 5.71% (n = 4) reported it is very or extremely harmful.

On average, current users were engaging in problematic cannabis use as assessed by the CUDIT-R (n = 47, $M = 11.85$, $SD = 5.50$). In fact, 31.43% of individuals (n = 22) had a likelihood of receiving a DSM-IV Cannabis Use Disorder diagnosis based on their CUDIT-R
score ($M = 16.68; SD = 3.48$), while $18.57\%$ ($n = 13$) were using cannabis in a hazardous manner (CUDIT-R score: $M = 9.85; SD = 0.99$). When assessed on cannabis craving (MCQ-SF) at baseline (see Table 2.), current users ($n = 44$) reported greater purposefulness craving scores, followed by craving cannabis for expectancy and emotionality urges; they reported craving compulsively the least. Current users ($n = 46$) also completed the MMM to assess their motives for cannabis use (see Table 3.). The highest rated motive for cannabis use was enhancement ($M = 16.33, SD = 3.11$). The second highest motive for cannabis use was social for CB-Mod and expansion for CB-Heavy users.

Lastly, participants also completed the CSQSS to explore coping styles related to social situations. Participants reported a greater use of monitoring coping strategies ($M = 44.56, SD = 10.38$) than blunting strategies ($M = 22.11, SD = 9.82$), see Table 4.

1.2 Do participants differ on trait Rejection Sensitivity?

High and low RS was determined by using the median (8.27) as a cut off. The sample consisted of individuals equally high ($n = 35$) and low ($n = 35$) in trait RS ($M = 8.73, SD = 4.02$). A One-Way ANOVA was completed to assess group differences on trait RS. Two outliers in the trait RS total score were replaced with the next highest value, per the Winsorization method (Kwak & Kim, 2017; Reifman & Keyton, 2010), resulting in a mean trait RS total score of 8.53 ($SD = 3.46$) (see Table 5.). No significant differences were found between HC, CB-Mod, and CB-Heavy users on trait RS, $F(2, 67) = 1.27, p = 0.29$.

To assess whether participants differed on rejection anxiety and rejection expectancy, the two components of trait RS, independent One-Way ANOVA’s were conducted. There was a significant, large effect of cannabis use frequency on rejection expectancy scores, Welch’s $F(2,$
43.86) = 4.71, p = 0.01, d = 0.90. A Dunnett C post-hoc comparison test revealed that HC reported significantly higher rejection expectancy scores than CB-Mod users (Dunnett t = -2.55, p = 0.02), but not CB-Heavy users (Dunnett t = -1.53, p = .23), (see Table 5.). The CB-Mod participants did not significantly differ from CB-Heavy on rejection expectancy (p > .05). No significant differences were found between HC, CB-Mod, and CB-Heavy users on rejection anxiety, F(2, 67) = 0.26, p = 0.77.

**Aim 2: Assess the influence of social exclusion (Cyberball+) on rejection sensitivity and frequency of cannabis use.**

Sixty-nine individuals participated in Cyberball+; one participant voluntarily ended participation mid-way through the task. Thirteen participant’s data was deemed invalid and excluded from analyses due to a pattern of responses that indicated they were not fully and meaningfully participating in the task (e.g., participants who responded 1 to all items on all trials); therefore, results are presented on 55 participants. As a validity check for the efficacy of the Cyberball+ paradigm, Figure 2. demonstrates that participants rated negative items higher as the probability of inclusion decreased, providing evidence that the varied rates of inclusion in Cyberball+ elicited negative thoughts and emotions associated with threatened social needs (i.e., responses to Need Threat Scale (NTS) items). For the results presented below, thirteen outliers were Winsorized in the slopes measuring rejection distress as a function of inclusion probability (RD).

2.1 *Is rejection distress (RD) to social exclusion associated with trait rejection sensitivity?*
There was a negative, non-significant association between trait RS and rejection distress as a function of inclusion probability (RD) ($r = -0.02, p = 0.88$).

2.2 Is there an effect of trait-rejection sensitivity and cannabis use frequency on rejection distress induced by social exclusion?

A Two-Way (2 x 3) ANOVA revealed there was no main effect of trait RS (low versus high) ($F(1, 54) = 0.22, p = 0.64$) or cannabis use frequency (HC, CB-Mod, versus CB-Heavy) ($F(2, 54) = 2.29, p = 0.11$) on RD as a function of inclusion probability. There was no significant interaction between trait RS and cannabis use frequency on RD as a function of inclusion probability, ($F(2, 54) = 0.40, p = 0.67$, see Figure 3.).

2.3 Does social exclusion have an effect on cannabis craving?

Participants completed the MCQ-SF at baseline and after completing Cyberball+. To assess the effects of social exclusion on cannabis craving, a Repeated-Measures t-test was conducted on each of the four MCQ subscales (see Table 2.). Participants demonstrated a significant increase in MCQ-emotionality ($t(43) = 2.56, p = 0.01$, Cohen’s $d = 0.31$) and MCQ-expectancy ($t(43) = 2.12, p = 0.03, = d = 0.19$) scores from pre- to post-Cyberball+. One outlier was Winsorized in the MCQ-expectancy difference score.

Due to non-normality, a Wilcoxon matched-paired sign-test was completed to assess the effect of social exclusion on MCQ-compulsivity. One outlier from the pre-MCQ-compulsivity score and three outliers from post-MCQ-compulsivity score were Winsorized. While the median of the difference between pre- and post-MCQ-compulsivity score did not differ for CB-Mod
users ($p = 1.0$), it approached significance for CB-Heavy users ($p = 0.06$); one-tailed results for CB-Heavy users were significant ($p = 0.03$).

No effect of social exclusion was found for MCQ-purposefulness, $t(43) = 0.43, p = 0.66$. Two outliers were Winsorized from this difference score.

**Aim 3: Investigate the relationship between experimental and ecological social rejection and cannabis craving and use in naturalistic environments.**

3.1 EMA Compliance and Characteristics of Cannabis Use Factors

Over the 7-day EMA period, a total of 1,204 text message prompts (occasions) containing the diary link was sent to 43 participants. A total of 664 responses were received, resulting in an overall response rate of 55.15%; 540 prompts (44.85%) went unanswered. Of responses, participants completed the diary in full on 646 occasions (97.29%). When examined by cannabis use frequency, for those who responded to prompts, CB-Mod completed the diary on 258 occasions while CB-Heavy completed the diary on 406 occasions. Descriptive statistics for EMA demographics and daily diary responses are presented in Table 6.

3.2 Is there an association between experimental and/or ecological rejection and real-word cannabis craving?

Parameter estimates and fit statistics for the following models are presented in Table 7. Parameter estimates are presented as odds ratios (OR).

*Unconditional growth model (Model 1).* A linear growth model (time) was fit to the data with a random intercept (individual). Results of this model indicated that the slope of the
relationship between time and cannabis craving varied across individuals (OR = 0.97, SE = 0.01, 
p = .01). Specifically, for every one unit increase in time was associated with 3% lower odds of 
craving. The Intraclass correlation coefficient (ICC) indicated that 43% of the variance in 
cannabis craving is due to variability among participants.

**Model including cannabis use frequency and EMA rejection (Model 2).** Cannabis use 
frequency group and experiences of real-world rejection were included in the model as fixed 
effect predictors. Cannabis craving was not significantly associated with cannabis use frequency 
(OR = 2.44, SE = 1.30, p = .09). A one unit increase in real-world rejection was significantly 
associated with craving (OR = 2.16, SE = 0.79, p = .04); specifically reporting a rejection 
experience, as opposed to not reporting a rejection experience, is associated with a 116% higher 
ods of craving. With the inclusion of these predictors in the model, the slope of the relationship 
between time and cannabis craving across individuals remained varied and unchanged. Fit 
statistics (smaller AIC and BIC) demonstrated that model 2 fit the data better than model 1.

**Model including Cyberball+ Rejection Distress (Model 3).** Rejection distress (RD) 
slopes measuring the level of RD as a function of inclusion probability were included in the 
model as a fixed effect predictor. This variable was standardized and mean centered, so that a 
one-unit change in RD as a function of inclusion probability represents a one standard deviation 
change in RD. Results show that change in RD as a function of inclusion probability was 
significantly associated with cannabis craving (OR = 0.52, SE = 0.13, p = .009). Specifically, a 
one standard deviation increase in RD as a function of inclusion probability was associated with 
a 48% lower odds of craving. With the inclusion of RD in the model, there was a significant 
effect of cannabis use frequency: being classified as a heavy user, as opposed to being classified 
as a moderate user, was associated with a 286% higher odds of craving (OR = 3.86, SE = 1.99, p
The slope of the relationship between time and cannabis craving across individuals remained varied and unchanged. Experiencing real-world rejection was no longer a significant predictor (OR = 1.90, SE = 0.73, p = .09). Fit statistics (smaller AIC and BIC) demonstrated that model 3 fit the data better than the two previous models.

**Final, adjusted model including covariates (Model 4).** The last model included sex and mean-centered age as fixed effect covariates. Neither age (OR = 1.02, SE = 0.79, p = 0.84) nor sex (OR = 0.80, SE = 0.41, p = 0.67) were significant covariates of cannabis craving. With the inclusion of these covariates, cannabis use frequency (OR = 3.67, SE = 1.95, p < .01) and RD (OR = 0.55, SE = 0.15, p = .03) remained significant predictors. Specifically, being classified as a heavy user, as opposed to being classified as a moderate user, was associated with 267% higher odds of craving while a one standard deviation increase in RD as a function of inclusion probability was associated with 45% lower odds of craving. The slope of the relationship between time and cannabis craving across individuals remained varied and unchanged. Specifically, for every one unit increase in time was associated with 3% lower odds of craving.

Experiences of real-world rejection remained a non-significant predictor and unchanged (p = .09). A likelihood ratio test ($\chi^2 = 0.22, p = .90$) and fit statistics (larger AIC and BIC) demonstrated that model 4 did not fit the data better than model 3. Thus, Model 3 is the most parsimonious model.

**3.3 Is there an association between experimental and/or ecological rejection and real-world cannabis use?**

Parameter estimates (odds ratios) and fit statistics for the following models are presented in Table 8.
**Unconditional growth model (Model 1).** A linear growth model (time) was fit to the data with a random intercept (individual). Results of this model indicated that the slope of the relationship between time and cannabis use significantly varied across individuals (OR = 0.97, SE = 0.01, p = .025). Specifically, a one unit increase in time was associated with a 3% lower odds of cannabis use. The ICC indicated that 25% of the variance in cannabis use is due to variability among participants.

**Model including cannabis use frequency and EMA craving and rejection (Model 2).** Cannabis use frequency group and experiences of real-world craving and rejection were included in the model as fixed effect predictors. Cannabis use was significantly associated with cannabis use frequency (OR = 3.28, SE = 0.97, p = <.001): being classified as a heavy user, as opposed to being classified as a moderate user, was associated with a 228% higher odds of use. Endorsing cannabis craving, as opposed to not endorsing craving, was associated with a 478% higher odds of use (OR = 5.78, SE = 1.26, p = <.001). Experiences of real-world rejection was not significantly associated with cannabis use (OR = 0.92, SE = 0.32, p = .813). With the inclusion of these predictors, the slope of relationship between time and cannabis use no longer significantly varied (OR = 0.98, SE = 0.01, p = .103). Fit statistics (smaller AIC and BIC) demonstrated that model 2 fit the data better than model 1.

**Model including Cyberball+ Rejection Distress (Model 3).** Rejection distress (RD) as a function of inclusion probability was included in the model as a fixed effect predictor. Results show that a one standard deviation increase in RD as a function of inclusion probability was not significantly associated with cannabis use (OR = 1.02, SE = 0.15, p = .892). With the inclusion of RD in the model, cannabis use frequency (OR = 3.15, SE = 0.97, p = <.001) and craving (OR = 4.74, SE = 1.06, p = <.001) remained significant predictors of use. Specifically, being
classified as a heavy user, as opposed to being classified as a moderate user, was associated with a 214% higher odds of use. Endorsing cannabis craving, as opposed to not endorsing craving, was associated with a 374% higher odds of use. Experiences of real-world rejection (OR = 0.72, SE = 0.26, p = .372) and time (OR = 0.98, SE = 0.01, p = .096) remained non-significant predictors of use. Fit statistics (smaller AIC and BIC) demonstrated that model 3 fit the data better than the two previous models.

**Final, adjusted model including covariates (Model 4).** The last model included sex and mean-centered age as fixed effect covariates. Neither age (OR = 1.02, SE = 0.04, p = 0.671) nor sex (OR = 0.99, SE = 0.30, p = 0.980) were significant covariates of cannabis use. With the inclusion of these covariates, cannabis use frequency (OR = 3.04, SE = 0.97, p = <.001) and craving (OR = 4.72, SE = 1.06, p = <.001) remained significant predictors of use. Specifically, being classified as a heavy user, as opposed to being classified as a moderate user, was associated with a 204% higher odds of use. Endorsing cannabis craving, as opposed to not endorsing craving, was associated with a 372% higher odds of use. Experiences of real-world rejection (OR = 0.72, SE = 0.26, p = .376), time (OR = 0.98, SE = 0.01, p = .098) and RD as a function of inclusion probability (OR = 1.01, SE = 0.17, p = .946) remained non-significant predictors of use. A likelihood ratio test ($X^2 = 0.18, p = .92$) and fit statistics (larger AIC and BIC) demonstrated that model 4 did not fit the data better than model 3. Thus, Model 3 is the most parsimonious model.
Chapter 5. DISCUSSION

Using a translational approach, this pilot study aimed to explore the relationship between rejection sensitivity (RS), cannabis use, and experiences of social rejection among young adults using self-report, experimental, and ecological methods. The most commonly used illicit drug in the US, research has shown that young adults are at an increased risk for cannabis use and its associated problems, particularly when using substances to cope with stress. Rejection sensitivity, the tendency to anxiously expect or avoid rejection, is related to intra- and interpersonal distress that can serve as a source of stress for young adults. Frequent and/or chronic cannabis use has been implicated in impaired social processing and dampened affective responses to social stress, social exclusion in particular. This study aimed to explore whether young adults vulnerable to social stress due to heightened RS may use cannabis in a manner that potentially buffers them from the psychological and emotional effects of rejection. In this case, cannabis use would be deemed protective against social pain and a positive motivator for continued use despite its deleterious outcomes. As rates of cannabis use continue to increase, investigating the influence of rejection in the context of coping with social stress is salient for young adult cannabis users, particularly in naturalistic settings. To our knowledge, the present study is the first to simultaneously assess multiple facets of rejection and its influence on cannabis use. Findings reveal that laboratory-based responses to induced social exclusion are prospectively predictive of real-world cannabis craving, suggesting a causal relationship. The present study and findings have important implications for clinical interventions and future research.

Cannabis Use Characteristics in Young Adults
This sample is characterized by young adults with several risk factors of cannabis use. When examining the full sample, participants reported initiating cannabis use in adolescence at the average age of 15 and 74% have used at least once in their life. Of current (past 30-days) cannabis users, 37% self-reported using frequently (4 or more times per week), while 20% self-reported daily use. On average, current users were engaging in problematic cannabis use. In fact, according to CUDIT-R results, 31% of current users had a likelihood of receiving a DSM-IV Cannabis Use Disorder (CUD) dependence diagnosis ($M = 16.68; SD = 3.48$), while 19% were using cannabis in a hazardous manner ($M = 9.85; SD = 0.99$). When applied to DSM-5’s emphasis on clinical severity, CUDIT-R scores in our sample revealed that 31% of individuals meet criteria for probable moderate and severe CUD and 19% meet criteria for probable mild CUD (Bruno, Marshall & Adamson, 2013). This is in line with findings showing that 11-30% of US cannabis users report having a CUD (Budney, Sofis & Borodovsky, 2019; Hasin et al., 2016). Despite the high risk for clinical symptoms of cannabis use and abuse, the majority of participants (69%) in our sample reported that cannabis use had slight to no harm, suggesting reduced perceptions of cannabis-related health risks. Research shows that young adults have a greater likelihood of past year CUD symptoms compared to their older counterparts, are less likely to perceive great risk of regular cannabis use, and experience prevalent cannabis-related problems despite not meeting DSM-IV CUD criteria (Caldeira, Arria, O'Grady, Vincent, & Wish, 2008; Hasin et al., 2016; Pacek, Mauro & Martins, 2015). In fact, studies have established an inverse relationship between perceived harmfulness and cannabis use (Hasin, 2018). Schultz and colleagues (2019) note that CUDIT-R cut-off scores may need to be lowered in adolescent and young adult cannabis users to accurately capture clinical risk, indicating many young adults with problematic use may currently be under-diagnosed. Additionally, adults with a college
education are more likely to support the legalization of cannabis, which falls in line with overall changing attitudes regarding legalization of recreational use (Carliner et al., 2017; Pacek et al., 2015). Despite the risk for increased cannabis use severity, utilization of treatment services for CUD and its associated problems is low in young adults (Hasin et al., 2016).

Interestingly, there was a moderate, significant difference on the demographic variable of religion in this sample (see Table 1.). Endorsing their religious denominations, across all groups, individuals identifying as Jewish were not cannabis users. Within cannabis use groups, those who self-identified as Christian were predominately moderate cannabis users (57%) and those who self-identified as not religious (“None”) were predominantly heavy cannabis users (52%). While religion has been noted as a protective factor against substance use, assessing religious denomination, religiosity (i.e., being connected to or public membership in a religious institution), and spirituality (i.e., personal connection to a higher power potentially unaffiliated with a specific and any religious doctrine) are all important components of this relationship (Gmel et al., 2013). There is evidence to support an inverse relationship between religiosity and substance use; certain religions may have strong proscriptions that directly or indirectly influence engagement in substance use (Gmel et al., 2013; Moscati, & Mezuk, 2014). For example, Islam may be protective against substance use while research has shown that US Catholics may be more vulnerable to alcohol use given the strong ritual connection to wine, which is used during worship (Gmel et al., 2013). Overall, religious belief and having a stronger sense of intrinsic religiosity may be more pertinent to protecting against substance use (Moscati, & Mezuk, 2014). A search for information regarding religious affiliations among the CUNY undergraduate population was unsuccessful as it appears data is not collected on this demographic characteristic. However, extrapolating from the varied racial/ethnic and international student
population at CCNY, this study’s finding of religious group differences in cannabis use frequency likely reflects the saliency of religious affiliation and religiosity in relation to substance use.

**How is Rejection Experienced? Exploring Rejection at the Trait, State, and Event Level**

*Differences in Trait Rejection Sensitivity*

In the present study, rejection sensitivity was assessed via multiple methods: first at the self-report level as participants responded to hypothetical rejection scenarios on the A-RSQ. Results showed that the three groups did not differ on trait RS, in contrast to our hypothesis of group differences. While heavy cannabis users reported higher levels of trait RS than moderate participants, healthy controls reported higher levels of trait RS than both of their counterparts. Notably, though all participants reported higher scores on the rejection anxiety component of trait RS, significant differences were only found for ratings of rejection expectancy between healthy controls and moderate users. The effect of this significance was large. Together, it appears that controls in our sample have higher trait RS and that the *expectation* of acceptance or rejection seems to be more salient to them than the anxious concern aspect of RS. In other words, while internal rumination about potential rejection is high for everyone, the outcome or behavior of others is more important than the anxiety regarding rejection for controls compared to cannabis users.

This is in line with theories stating the RS system is threat-focused; there is a bias towards focusing on rejection cues (Romero-Canyas & Downey, 2013). Detecting, appraising, and responding to rejection is a cognitive-affective process that becomes stored as past experiences and informs behavioral responses to future rejection experiences (Kawamoto, Ura &
The expectation of rejection may lead to more readily perceiving rejection and/or acting in a manner that increases the likelihood of rejection. The social expectancy violation theory plays a pertinent role in RS: when rejection occurs unexpectedly the ‘surprise’ of rejection activates cognitive conflict and affective responses of managing the resulting distress (i.e., social pain) (Kawamoto et al., 2015; Sun & Yu, 2014). Research investigating the feedback related negativity (FRN) component related to expectancy violation notes that social communication depends on two related but distinct systems: social feedback (‘good or bad’) and detecting social prediction errors (‘expected or unexpected’); thus one can react negatively to rejection even if they are not surprised that it occurred (Sun & Yu, 2014). For individuals high in RS, the persistent fear and/or expectation that rejection will occur as well as inaccurate perceptions of rejection may lead to a lower threshold for interpersonal situations and heightened social pain, resulting in a lesser cognitive and emotional capacity to rebound from rejection.

Our results showing no significant differences on trait RS between cannabis users and controls may be viewed in light of the social buffer hypothesis and research findings that cannabis affects cognitive processes, impairs social processing, and dampens/blunts affective responses and stress reactivity to social stress (CDC, 2017; Cuttler et al., 2017; Deckman et al., 2013; Gilman et al., 2014; Gilman et al., 2016; Lorenzetti et al., 2016). Cannabis users in this sample reported levels of trait RS, RS-anxiety, and RS-expectancy similar to healthy controls, indicating that while they are noting concern when evaluating hypothetical rejection scenarios, they may potentially be buffered from experiencing related distress. Thus, cannabis could be influencing their responses to this self-report measure by biasing their self-perceptions regarding how they would react to rejection scenarios. Another result of this buffer may manifest as lower expected trait RS scores in cannabis users than reported in this study. As directional results have
not yet been established, it is unclear for whom, how, and under what circumstances cannabis may be a protective factor against social pain. Furthermore, healthy controls in this sample are healthy with respect to cannabis use; it is possible that these participants may differ on important psychological factors, such as anxiety or trauma, which may leave them more vulnerable to greater expectancies of rejection.

Cannabis Use and Rejection Distress to Induced Social Pain

To explore the relationship between rejection sensitivity and cannabis use on social rejection in experimental conditions, we used a version of Cyberball that varied the rates of inclusion. Cyberball+ (Fertuck et al., 2017) was found to be a valid assessment of social exclusion, as the paradigm elicited responses reflecting threatened social needs (i.e., the fundamental need to belong). Contrary to our hypothesis, there was a non-significant relationship between self-reported trait RS and rejection distress as a function of inclusion probability (RD) during social exclusion. This result may indicate that RD as measured in reaction to social exclusion is not a state-based correlate of trait RS as assessed by a laboratory-based task. Beekman and colleagues (2016) note that RS and the need to belong (NTB) are two distinct traits: the former is related to emotional responses to rejection while the latter is associated with a greater desire for social attachment and awareness of social cues, thereby leaving individuals more sensitive to social exclusion. One event-related potential (ERP) study evidenced neural and behavioral responses to perceived distress as a result of Cyberball: both explicit rejection and perceptions of micro-rejection events at the end of a fair play condition are associated with self-reported exclusion distress (Crowley et al., 2009). A greater late positive potential response (in the frontal-medial frontal brain region) for rejection events predicted less exclusion distress post-rejection, reflecting how cognitive processes were activated to alleviate the experience of social
exclusion. Another study investigated the effect of both RS (as assessed by the Age-Based Rejection Sensitivity Questionnaire) and the NTB on the psychological and physiological responses to Cyberball assessed social exclusion and found that excluded individuals high in trait NTB reported greater perceived stress and negative affect as well as higher post-exclusion cortisol levels (Beekman, Stock, & Marcus, 2016). Trait RS was not found to be correlated with exclusion and cortisol level nor did it exhibit a moderating effect on perceived stress and affect. In an adolescent population, those greater in trait RS displayed increased activation in the insula, a brain area associated with pain and negative affect, in response to Cyberball elicited social exclusion (Masten et al., 2009). Notably, adolescents rated as more interpersonally competent were also found to be neurally sensitive to exclusion and were more sensitive to relational issues, which can manifest as engagement in regulating rejected related distress or heightened RS. Overall, perceiving and/or experiencing social exclusion and the subjective, emotional responses to social rejection appear to be distinct concepts that can be assessed separately yet it is difficult to disentangle the relationship between the two. Thus, while the present study uses the terms social rejection and social exclusion interchangeably, Cyberball+ may be activating threats to the need to belong more than emotional responses to rejection, reflecting distress to exclusion but not rejection. Conversely, for those high in RS, social exclusion may in fact activate rejection-related emotional responses but they may be desensitized to reporting their distress due to repeated exposure to rejection (Beekman, Stock, & Marcus, 2016).

Notably, one item on the Need Threat Scale (NTS), ‘included’, did not load onto the rejection distress principal component. Given that being included is, by definition, the opposite of being excluded, one is left to wonder how this item is being perceived by participants. In Cyberball+, which differs from the traditional paradigm in that there is no condition where a
participant is completely excluded after a certain point, participants may be responding in an objective manner (i.e., I was always included in the game). If fundamental social needs are being threatened, then the more ambiguous inclusion conditions may result in a diminished emotional state related to feeling included or wanted as a player in the game. However, exclusion in Cyberball, regardless of inclusion rates, may not “explicitly connote low relational evaluation in the same way that rejection does” (Beekman, Stock, & Marcus, 2016, pg. 132). Moreover, Bernstein and Claypool (2012) note that the nature and severity of the social pain as measured by a social exclusion task has relevance to whether participants respond with emotional distress, as expected, or emotional numbing, similar to what occurs when suffering a severe physical injury (e.g., going into shock after a traumatic bodily injury) given overlapping physical and social pain neural networks. Measuring the construct of the ‘need to belong’ does not appear to be standardized: our NTS measure contained 14-items (see Appendix B.) while others have used a 10-item scale (Beekman, Stock, & Marcus, 2016) and 20-item scale (Crowley et al., 2009); thus it is possible that the NTS in this study may not be accurately measuring feelings of rejection as intended.

Additionally, we found that trait RS and cannabis use frequency had no significant main or interaction effect on rejection distress as a function of inclusion probability: cannabis users did not significantly report lower RD than controls. At face value, these findings do not support the social buffer hypothesis that states more frequent cannabis use may be protective against the effects of social pain (Deckman et al., 2013). However, moderate cannabis users reported lower RD than healthy controls and those high in trait RS reported lower RD than moderate users low in trait RS, potentially reflecting a buffering effect of cannabis use to social pain. Prior research has shown blunted stress reactivity to an acute stress task in chronic cannabis users (Cuttler et al., 2013).
2017) and neural evidence of impaired social processing in light-to-moderate cannabis users in response to social exclusion (Gilman et al., 2016). Relatedly, we explored coping styles related to social situations. At baseline, all participants reported a greater use of the monitoring coping style versus blunting coping style when responding to social situations, reflecting a greater tendency to seek out information pertaining to a threatening situation as opposed to using distraction. This may potentially be related to RS and/or the need to belong but this relationship has not yet been explored. Interestingly, heavy cannabis users reported lower use of both coping styles in comparison to their moderate and non-cannabis using counterparts. This may indicate potential differences in how individuals using cannabis at varied frequencies may perceive social situations as threatening and engage in coping strategies. Heavy cannabis users may possibly perceive negative social situations as non-threatening (a potential product of affective numbing), feel less motivated to enact any adaptive coping strategy, or use cannabis at greater rates to cope, particularly if they are low in trait RS. Additional research assessing the influence of rejection sensitivity on Cyberball+ responses in cannabis use samples is warranted.

Real-World Rejection and Cannabis Use

To assess ecological experiences of rejection, a third measure of rejection was employed to assess real life events: ecological momentary assessments (EMA) in the form of a brief daily diary completed four times per day for seven-days. We found the text-messaging approach to be a feasible method of assessing cannabis use in young adults. Over the seven-day EMA period, 37.03% of participants reported experiencing cannabis craving and 37.54% of participants reported experiencing cannabis use (i.e., responded yes to prompt across all occasion responses). Heavy cannabis users reported a higher prevalence of craving and use since the last assessment occasion and use at the current assessment occasion (i.e., using right now) compared to their
moderate using counterparts. Of the 42 participants included in EMA analyses, only 4 (9%; all heavy users) were identified as daily users. While these patterns of use may have been expected, it is important to note that EMA compliance was higher in the heavy use group (406 occasions) compared to the moderate use group (258 occasions).

The prevalence rate of real-world experiences of rejection was low across all participants (9%) during the EMA period. Heavy cannabis users reported experiencing rejection on 11% of occasions and moderate users reported experiencing rejection on 7% of occasions. Mixed effects models were used to investigate the association between experimental and ecological rejection on cannabis craving and use in naturalistic settings. Results revealed that endorsing experiences of real-world rejection was significantly associated with a 116% higher odds of cannabis craving prior to the influence of Cyberball+ elicited rejection distress as a function of inclusion probability (RD). This association was not found in relation to cannabis use. Once RD was included in the craving model, real-world rejection was no longer a significant predictor of craving. Results from the final, adjusted models indicate differences in factors related to real-world cannabis craving and use. Only heavy use and endorsements of craving were associated with a 204% and 372% higher odds of cannabis use, respectively. However, for cannabis craving, heavy use had a 267% higher odds of craving while a one standard deviation increase in RD had a significant influence on reducing the odds of craving by 45%. In other words, greater RD to experimental social exclusion is associated with reduced odds of real-world cannabis craving but not use while real-world experiences of rejection was not associated with craving or use.

These findings are in contrast to our hypotheses, as we expected both facets of rejection would increase real-world craving and use, and again highlights the difference between social
rejection and social exclusion. It is important to note that participants were asked to simply report whether or not they had a rejection experience. Given the cognitive-affective processes involved in the RS system, endorsing rejection requires one to evaluate and reflect on whether rejection took place and/or if they subjectively experienced a situation as rejecting. We did not obtain information on the type or qualitative nature of the rejection experience and participants will have had different definitions and perceptions of rejection based on personal experiences and sensitivities. We also did not obtain information on the emotional response to their experiences of rejection, an important factor potentially related to cannabis craving and use. Lastly, it is possible that participant’s experiences of rejection in the real-world were really experiences of exclusion, which would threaten social attachment and need to belong but not necessarily activate negative emotional responses, as research has shown that reactions to rejection could include minimization or denial of the subjective effects of social pain, particularly in cannabis users.

The finding that these two measures of rejection were differentially related to real-world cannabis craving and use is very important. It appears that experiencing craving and being a heavy user is more salient to increased cannabis use. For urges to use, it was expected that being a heavy cannabis user would be associated with increased craving; however the finding that an increase in RD to social exclusion in the laboratory decreased the likelihood of real-world craving raises many questions and is pertinent to potential areas of clinical intervention as understanding factors related to reductions in craving should lead to reductions in cannabis use. At baseline, cannabis users reported greater craving due to the intention and expectation/anticipation of positive outcomes; their cravings were reportedly least due to compulsivity. Behavioral findings revealed that experiences of social exclusion had a significant,
small effect on cannabis cravings. Participants reported greater increase in craving for emotionality and expectancy reasons after Cyberball+, indicating social exclusion increased an urge to use cannabis to achieve relief from negative mood and in anticipation of a positive outcome. Thus, participants are both acknowledging social exclusion occurred and report experiencing a negative emotional response (rejection, social pain) that activates the need to employ a management strategy in an attempt to lessen their distress (cannabis use). These findings support the tension reduction model of substance use as a means of coping with social stress (Buckner, Schmidt, Bobadilla & Taylor, 2006). In fact, we found one-tailed significant increases in heavy cannabis users report of craving compulsively (i.e., an inability to control cannabis use) after Cyberball+ but not in moderate users.

This is interesting in light of results indicating that increased RD decreases the likelihood of real-world craving, findings in the opposite direction of those from experimental assessments. For heavy users, compulsive urges (i.e., craving) may be a stronger motivator for cannabis use, regardless of experiencing stress. The greater odds of increased craving due to heavy use may cancel out the lesser odds of craving associated with rejection distress to social exclusion in the real-world. Alternatively, heavy cannabis use could be viewed as a maladaptive coping strategy to help cope with rejection or social distress. Either notion may potentially serve to mitigate against the subjective feelings of social pain, in line with the social buffer hypothesis. Another potential explanation for these conflicting findings may lie in the distinction between expecting and/or encountering a rejection/exclusion situation and experiencing the ‘hurt’ and/or painful feeling of rejection in response. In the real-world, perceiving or encountering rejection and exclusion tend to have greater implications and consequences than laboratory paradigms and elicited responses. Yet only RD was found to be significant predictor of real-world cannabis use.
behaviors (craving). If in fact Cyberball+ and RD assesses distress to social exclusion (as opposed to rejection distress or sensitivity), then experiencing a threat to one’s need to belong, the desire to maintain social connection, and having a high relational value to others may be a more potent predictor of cannabis craving than the subjective, emotional responses to rejection. While exclusion distress may increase cannabis craving and use, some individuals may instead either minimize their distress or feel such high levels of distress that they engage in affective numbing, resulting in a lesser (or lack of a) subjective experience of pain or ‘hurt’ feelings. In turn, less painful feelings results in a lesser need to cope by craving and using cannabis.

Alternatively, we found that young adult cannabis users in this sample reported being most motivated to use cannabis for its ability to enhance cognitive and perceptual experiences given the psychoactive properties of THC. This drug differs in this respect from other widely used and generally accepted substances, such as alcohol and nicotine. While motives for use were not assessed post social exclusion or via EMA in the present study, one relevant motive for cannabis craving and use could simply be to get high. Furthermore, in naturalistic settings, participants predominantly reported using cannabis in social settings with others 63% of the time over the EMA period. When they endorsed experiencing a craving or using, individuals in our sample also reported their peers were concurrently using cannabis on 74% of occasions. While solitary cannabis presents its own risk for cannabis use problems (Creswell, Chung, Clark & Martin, 2015), particularly when initiated during adolescence, using in social contexts means there is a greater exposure to substance using peers and greater perceived prevalence of use amongst peers that results in greater substance use over time. As the average age of cannabis initiation in our sample is 15, the prevalence of potential CUD symptoms seen in the present study may reflect the influence of social context and peer use. Research has shown that social
contact and the presence of social support (e.g., peer acceptance and engagement in cannabis use) releases endogenous opioids that have stress-relieving effects; this may attenuate any rejection-related distress that may be present in interpersonal interactions (Eisenberger, Taylor, Gable, Hilmert & Lieberman, 2007). Coupled with the analgesic effect of cannabis on the social pain network, individuals with heightened RS may be doubly protected against the cognitive and emotional effects of the fear of rejection by using in social settings with peers. Similar to the present study’s aim of correlating experimental and ecological social processes, one study investigated daily social support via EMA in relation to physiological and neural stress reactivity to social exclusion (Eisenberger, Taylor et al., 2007). Participant’s cortisol reactivity to a social stressor was assessed before and after completing the Trier Social Stress Task (TSST). They were then asked to rate their perception of the typical level of closeness, comfort, and support provided by their most recent social interaction partner in the real-world on at least 4 occasions over 10-days on a palmtop device. One week later, participants underwent an fMRI while participating in Cyberball. Results showed that individuals who reported daily social support exhibited less activity in brain areas associated with social distress, which was also associated with decreased cortisol reactivity, reflecting a stress-protective effect of social support (Eisenberger, Taylor et al., 2007). Findings suggest social support can alter and modulate the perception of social threats, such as rejection, so that it is no longer distressful. More research is needed investigating rejection and social stress within and across experimental and ecological settings, particularly in cannabis users.

Clinical Implications
The study findings have several implications for clinical interventions. Despite the various problems associated with heavy or chronic cannabis use (i.e., CUD symptoms, cognitive, emotional, and interpersonal dysfunctions, and increased likelihood of risky behaviors), only 7-8% of past-year users in the US have engaged in treatment services (Budney et al., 2019). Referrals for cannabis treatment appear to primarily come from the court system followed by self/family referrals (Budney et al., 2019). Therefore, young adults who do not perceive their cannabis use as problematic or do not experience associated problems that result in contact with the criminal justice system are not likely to engage in treatment. Additionally, cannabis withdrawal from regular use has been associated with a syndrome consisting of vacillating changes in craving, behavioral, mood, and physical symptoms often leading to relapse in both outpatient and inpatient settings (Bonnet & Preuss, 2017). Chronic use, heavier use and severe CUD symptoms are more likely associated with experiencing cannabis withdrawal syndrome and women were found to experience stronger physical symptoms when withdrawing (Bonnet & Preuss, 2017). Furthermore, psychiatric comorbidities often confound the clinical picture. Rates of comorbid cannabis use are high in individuals with social anxiety and major depression, diagnoses that are also associated with elevated RS and impaired interpersonal functioning (Buckner et al., 2008; Harb et al., 2002; Lui et al., 2014). Evidence shows that cessation of cannabis use is characterized by shifts between usual use patterns, reduction, and abstinence; heavy cannabis users often make multiple quit attempts and most users do not achieve abstinence or seek treatment (Bonnet & Preuss, 2017; Marshall-Berenz, Vujanovic, Bonn-Miller, Bernstein & Zvolensky, 2010). Thus, it is important to better understand cannabis use and develop targeted interventions.
Cannabis use treatments have predominantly employed psychosocial interventions. Cognitive behavioral therapy (CBT) and relapse prevention (RP) programs emphasize the identification of beliefs and behaviors that trigger and maintain cannabis use (Aklin & Bedard-Gilligan, 2019). Coping and problem-solving skills are taught to reduce cannabis use and promote more adaptive responses to internal and external triggers. Motivational interviewing (MI) and motivation enhancement therapies (MET) focus on identifying problem behaviors and ambivalence regarding substance use and use this ambivalence to motivate change in an empathic, non-judgmental, and collaborative manner (Aklin & Bedard-Gilligan, 2019). Sessions include structured and personalized feedback regarding personal use patterns and norms / risks seen in reference groups (predominantly peers). A qualitative analysis of drinking motives discussed during MI sessions with young adult alcohol users found that positive and negative intra- and interpersonal motives related to social interaction, pressure, and rejection were most salient (Dupree, Magill & Apodaca, 2016). The authors highlighted the importance of RS in relation to alcohol motives for and against alcohol use. These findings could also be pertinent to cannabis users, particularly those high in RS.

Using multiple intervention approaches appear to result in robust positive outcomes (i.e., reduced use, problems, and greater abstinence) in randomized clinical trials with cannabis users (Aklin & Bedard-Gilligan, 2019). A recently published study assessed the utility of combined MET and CBT to reduce both cannabis use and anxiety (Buckner et al., 2019). The authors posited that individuals with anxiety are prone to engage in false safety behaviors in response to phobic stimuli; these behaviors were also found to be associated with more frequent cannabis use. Their intervention, integrated cannabis and anxiety reduction treatment (ICART), was found to result in reduced cannabis use and associated problems as well as greater abstinence from
cannabis (Buckner et al., 2019). This intervention and finding could be replicated in cannabis users high in RS with some potential success, as learning coping skills to address perceived rejection threats and cues may prove beneficial. A planned systematic review and meta-analysis is underway to explore the efficacy of brief interventions in adolescent and young adult cannabis users that aim to motivate individuals to change their behavior, teach behavioral change skills, and connect them to services in 1-2 sessions (Halladay, Petker, Fein, Munn & MacKillop, 2018). A 75-minute single-session brief intervention, PAUSE, was developed to target college alcohol and cannabis users (Halladay, Fein, MacKillop & Munn, 2018). Found to be an acceptable, feasible, and efficient method of intervening with this population, PAUSE incorporates a mental health screening, motivation interviewing techniques assessing pros and cons of use, personalized feedback, an identification of values and how changing substance use behaviors can assist in achieving those values, and referrals. Brief interventions, such as PAUSE, may benefit young adult cannabis users such as those in the present study’s sample given the high rates of craving and use, particularly those experiencing social stress in college.

Research has begun to employ novel methods to treat cannabis use. Ecological momentary interventions (EMI; Heron & Smyth, 2010) aim to influence behaviors in the real-world, in real time and have been used to address cannabis use in adolescents and young adults. The Momentary Self-Monitoring and Feedback + Motivational Enhancement Therapy (MOMENT) intervention combines two 1-hour MET sessions provided in primary care clinics followed by an EMI protocol that allows participants to identify and self-monitor cannabis context and behaviors via cell phone and receive supportive messages when they encounter salient factors related to triggers (Kells & Shrier, 2017; Shrier et al., 2018; Shrier, Rhoads, Burke, Walls & Blood, 2014). Mason and colleagues (2018) found that Peer Network
Counseling (PNC-text), a brief, text-delivered intervention for young adults with CUD that focuses on peer and social relations, was feasible and resulted in reduced number of use days and relationship problems in participants with less severe CUD. Interestingly, they also found that the control group of cannabis users who did not receive PNC-text also reported decreased cannabis urges and increased their peer support network, potentially indicating that simply reflecting on their cannabis use and ways to increase peer support to reduce use had a therapeutic effect (Mason et al., 2018). To develop treatments for heavy using young adults, Riggs and colleagues (2018) adapted Marijuana eCHECKUP TO GO, a web-based cannabis use intervention that provides university-specific personalized feedback with normative information about cannabis use rates as well as protective behavioral strategies that reduce use. They found preliminary evidence that Marijuana eCHECKUP TO GO was feasible and demonstrated reductions in perceived use prevalence and being high fewer hours per week, days and periods per week, and weeks per month (Riggs et al., 2018). Together, these findings suggest interventions that use methods more practical for young adult cannabis users, such as cell phone or online treatment, are feasible and effective at reducing cannabis use and could be implemented on college campuses, such as CCNY.

Given the low rates of traditional treatment engagement for cannabis users, these interventions may provide another avenue to seek treatment. This is particularly important for users who are sensitive to the stigma associated with substance abuse and treatment-seeking as well as for individuals who are rejection sensitive and may be less likely to meaningfully engage in traditional psychosocial treatments or readily explore the intra- and interpersonal factors related to their cannabis use. Extending EMI’s to target psychological symptoms and traits, such as rejection sensitivity and interpersonal dysfunctions, can provide immediate therapeutic
interventions to individuals as they encounter social stressors in real-time and reduce factors related to poor treatment adherence (Wenze & Miller, 2010).

**Study Strengths**

The present study has several strengths. First, we aimed to establish convergence between experimental and ecological methodologies assessing social rejection. The present study is longitudinal in design and provides evidence that experimentally induced rejection distress influences and is prospectively predictive of reduced real-world cannabis craving. Cyberball+ was found to be an ecologically valid paradigm that is effective at investigating experiences of exclusion in cannabis user and parameter estimates of distress. Another strength of this study is the inclusion of moderate and heavy use cannabis groups, as cannabis users are not a homogenous group and the type, quantity, and pattern of use may have a different impact on use behaviors, motivations for use, and the sequelae of biological, cognitive, psychological, and interpersonal effects associated with use. Additionally, this study addressed an important component of substance use research: measuring and confirming cannabis use via a biological measure (i.e., urine drug test). Furthermore, this study adds to evidence demonstrating text messaging as an effective variation of EMA. In this study, the diary was a brief, smartphone compatible survey linked to text message signals. Given the high rates of mobile phone usage in young adults, employing this tool as a research methodology and clinical intervention is critical for this population. Limitations noted in prior EMA studies (Phillips et al., 2014) were addressed in the present study: the diary was programmed to be completed within 30-minutes of the initial prompt and cut off thereafter so that data could be considered as “in the moment”. Reminders to increase response and compliance rates were sent in the form of follow-up texts 15-minutes after
the initial prompt, which gave participants an additional 15-minutes to complete each assessment within the allotted time frame. As can be seen, completion rates were high (97%) for individuals who responded, which indicates that participants did not find the assessment burdensome. Lastly, our sample consisted of racially diverse, non-traditional young adults studying at an urban college.

**Study Limitations**

The present study has several limitations. First, the sample size was small and additional data were excluded in certain analyses. Replication of these findings in a larger sample may reveal important differences in the influence of cannabis use frequency and severity on rejection sensitivity. Second, due to the small sample size, the median was used to identify low and high trait rejection sensitivity groups in this study. Studies assessing trait RS typically use scores +1 / -1 standard deviation around the mean or in the top and bottom 25 to 30th percentile to better capture individuals low and high in this interpersonal trait (Leng, Qian & Zhu, 2018). Third, experiences of real-world rejection were assessed in a limited fashion (i.e., yes or no). Additionally, cannabis-related consequences were not assessed in this study via self-report or during the EMA period. Problems associated with cannabis use have been shown to be related to severity of use and could further elucidate interpersonal dysfunctions as a result of cannabis use. Furthermore, there were several methodological limitations related to the EMA data collection in this pilot study. One such limitation is the one-week EMA period design; studies have shown that a minimum of 2-week long EMA periods are better suited to assessing substance use and changes in behavior over time. EMA compliance rates in this sample were much lower than published studies, potentially due to a limited budget for participant incentives ($25.00).
Receiving payment was not tied to completing a minimum number of EMA assessments. Due to the small sample size and use of statistical procedures that account for missing data, such as multilevel modeling, individuals with low compliance were not excluded from analyses. An 80% compliance rate in EMA studies is recommended while published studies typically exclude those with less than 20% compliance (Jones et al., 2019). Lastly, Buckner and colleagues (2012) have shown that providing participants with a brief practice period, feedback prior to the data collection, and consistent monitoring and outreach during the EMA assessment period resulted in increased compliance than is typically reported in published EMA studies assessing cannabis use.

**Future Directions**

A replication of the present study that addresses the stated limitations with a larger sample is warranted. An important area of future research is to accurately assess and capture responses to social rejection via laboratory-based and ecological measurements. Research has noted that Cyberball is a task measuring social exclusion and does not explicitly elicit feelings of rejection (Beekman et al., 2016; Leng, Qian & Zhu, 2018). One paradigm, the Chatroom task, simulates online social interactions by first asking participants to rate photographs of peers based on their interest of chatting with them then obtaining the participant’s photograph to elicit concerns about being evaluated and rated in return to assess the cognitive-emotional responses to social evaluation and personal self-esteem (Guyer et al., 2008) The Chatroom Task has been identified as a more ecologically valid assessment of social rejection. Leng and colleagues (2018) employed the Chatroom task with college students and found that individuals high in RS displayed greater attentional bias, more anger, and lowered emotion regulation after rejection.
Future studies can conduct a deeper analysis of quantitative and qualitative data on rejection in naturalistic settings to better inform experimental paradigms and identify relevant factors for specific groups of individuals. For example, Meehan and colleagues (2019) employed EMA in a single case study of a 19-year old undergraduate woman with high trait RS to better understand its relation to her interpersonal style in the context of daily interpersonal situations. Several studies have investigated RS in populations at-risk of experiencing status-based rejection, such as women and ethnic/racial minorities in academic settings (London, Downey, Romero-Canyas, Rattan & Tyson, 2012; Mendoza-Denton, Downey, Purdie, Davis & Pietrzak, 2002) and LBGTQ individuals (Dyar, Feinstein, Eaton & London, 2016; Hatzenbuehler, 2009; Pachankis, Goldfried & Ramrattan, 2008). Given that these very individuals are also at risk for increased substance use, few studies have investigated the influence of RS (Kopetz et al., 2014; Pachankis, Hatzenbuehler & Starks, 2014). Researchers and clinicians may also want to investigate whether psychosocial or pharmacological treatments used in clinical populations noted to be correlated with high RS are also associated with reductions in cannabis use, problems and CUD, such as individuals with a primary social anxiety, major depression, or borderline personality diagnoses.

For young adult users, particularly those of college age or in academic settings, assessing the consequences and problems associated with cannabis use is valuable and can assist in developing targeted interventions, particularly for interpersonal dysfunctions. Future research may investigate how cannabis-related problems manifest in daily life via EMA and provide additional information for research and intervention, particularly when discussing potential motivations for decreased cannabis use in clinical populations. A recently published EMA study assessed negative affect and the dose of THC and CBD, the psychoactive and therapeutic chemical properties, respectively, in a medical cannabis sample (Cuttler, Spradlin, &
McLaughlin, 2018). They found that users perceived a 50% reduction in depression symptoms and a 58% reduction in anxiety and stress symptoms after cannabis use in naturalistic settings. Dosage appeared to be an influential factor in these findings, as cannabis high in CBD and low in THC was largely associated with alleviating depression while high concentrations of both components resulted in perceived changes in stress. Along with the changing sociopolitical landscape regarding legalization and decriminalization of cannabis, the conflicting notion that substances can be both therapeutic and addictive plays an important role in the perception, use, and misuse of cannabis (Budney et al., 2019).

Lastly, multilevel modeling allows insight into the complex nature of substance use. EMA studies can employ cross lagged models to assess the influence of one factor one another at sequential points in time. Thus, we may be able to identify how craving, experiences of rejection, and social context at a current point in time may influence use at a future time.

**Conclusion**

The present study aimed to assess the influence of rejection sensitivity and experiences of rejection in cannabis using young adults. Assessing rejection and social stress in relation to cannabis use can reveal insights into intra- and interpersonal dysfunctions that maintain substance use as a maladaptive coping strategy. The study’s findings from experimental and ecological settings can inform factors related to cannabis craving and use to better target and intervene in problematic cannabis use in young adults.
Telephone Screening
Interested = 365
Screened = 149

Ineligible = 43
Interested but not screened = 49
No response / no longer interested = 167

Phase I
Eligible = 106
Completed, N = 70

No Show / Cancellations = 23
Cancelled due to project difficulties = 13

Phase II
Eligible, N = 46
Completed, N = 46

HC
n = 24

CB-Moderate
n = 21

CB-Heavy
n = 25

Cyberball+ Analyses
Completed, n = 69
Excluded from analyses n = 14
n = 55

EMA Analyses
Excluded from analyses, n = 2
n = 44

Note: CB = Cannabis. EMA = Ecological Momentary Assessment. HC = Healthy controls.

Figure 1. Study Enrollment and Procedures
Table 1.

Differences among Cannabis Use Groups on Demographic Characteristics (N = 70)

<table>
<thead>
<tr>
<th>Variables</th>
<th>HC (n = 24)</th>
<th>CB-Mod (n = 21)</th>
<th>CB-Heavy (n = 25)</th>
<th>Test Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>21.50 (3.43)</td>
<td>19.14 (1.24)</td>
<td>20.84 (3.59)</td>
<td>χ² = 1.60</td>
<td>p = .45</td>
</tr>
<tr>
<td>Sex (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>13 (54.17)</td>
<td>12 (57.14)</td>
<td>10 (40.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11 (45.83)</td>
<td>9 (42.86)</td>
<td>15 (60.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>7 (29.17)</td>
<td>10 (47.62)</td>
<td>10 (40.0)</td>
<td>χ² = 1.64</td>
<td>p = .44</td>
</tr>
<tr>
<td>Non-Hispanic/Latino</td>
<td>17 (70.83)</td>
<td>11 (52.38)</td>
<td>15 (60.40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>4 (16.67)</td>
<td>7 (33.33)</td>
<td>9 (36.0)</td>
<td>χ² = 10.37</td>
<td>p = .21</td>
</tr>
<tr>
<td>Black/ African American</td>
<td>9 (37.50)</td>
<td>9 (42.86)</td>
<td>5 (20.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>8 (33.33)</td>
<td>2 (9.52)</td>
<td>6 (24.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-racial</td>
<td>3 (12.50)</td>
<td>1 (4.76)</td>
<td>4 (16.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other a</td>
<td>0 (0)</td>
<td>2 (9.52)</td>
<td>1 (4.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Status (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First-Year</td>
<td>10 (41.67)</td>
<td>7 (33.33)</td>
<td>9 (36.0)</td>
<td>χ² = 3.38</td>
<td>p = .75</td>
</tr>
<tr>
<td>Second-Year</td>
<td>4 (16.67)</td>
<td>8 (38.10)</td>
<td>9 (36.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third-Year</td>
<td>6 (25.0)</td>
<td>4 (19.05)</td>
<td>4 (16.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth-Year</td>
<td>4 (16.67)</td>
<td>2 (9.52)</td>
<td>3 (12.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single/Never Married (%)</td>
<td>24 (100.0)</td>
<td>21 (100.0)</td>
<td>24 (96.0)</td>
<td>χ² = 1.83</td>
<td>p = 1.0b</td>
</tr>
<tr>
<td>Divorced</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (4.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any Children (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1 (4.17)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>χ² = 1.94</td>
<td>p = .64b</td>
</tr>
<tr>
<td>No</td>
<td>23 (95.83)</td>
<td>21 (100.0)</td>
<td>25 (100.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Religion (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Christian</td>
<td>8 (33.33)</td>
<td>12 (57.14)</td>
<td>2 (8.0)</td>
<td>χ² = 17.77</td>
<td>p = .006b</td>
</tr>
<tr>
<td>Jewish</td>
<td>1 (4.17)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Islamic</td>
<td>3 (12.50)</td>
<td>2 (9.52)</td>
<td>4 (16.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>5 (20.83)</td>
<td>0 (0)</td>
<td>6 (24.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>7 (29.17)</td>
<td>7 (33.33)</td>
<td>13 (52.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Employment (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>15 (62.50)</td>
<td>13 (61.90)</td>
<td>14 (56.0)</td>
<td>χ² = 0.26</td>
<td>p = .88</td>
</tr>
<tr>
<td>No</td>
<td>9 (37.50)</td>
<td>8 (38.10)</td>
<td>11 (44.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment Status (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>4 (16.67)</td>
<td>2 (9.52)</td>
<td>1 (4.0)</td>
<td>χ² = 5.71</td>
<td>p = .63b</td>
</tr>
<tr>
<td>Part-time</td>
<td>11 (45.83)</td>
<td>11 (52.38)</td>
<td>13 (52.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student</td>
<td>9 (37.50)</td>
<td>8 (38.10)</td>
<td>9 (36.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployed/Other c</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (8.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Income (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $25,000</td>
<td>4 (16.67)</td>
<td>7 (33.33)</td>
<td>9 (36.0)</td>
<td>χ² = 6.63</td>
<td>p = .37b</td>
</tr>
<tr>
<td>$25,000 – $49,999</td>
<td>12 (50.0)</td>
<td>7 (33.33)</td>
<td>5 (20.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source of Income (%)</td>
<td>$50,000 – $74,999</td>
<td>More than $75,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>2 (8.33)</td>
<td>6 (25.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent Income</td>
<td>2 (9.52)</td>
<td>5 (23.81)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Financial Means</td>
<td>5 (20.0)</td>
<td>6 (24.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2 (9.52)</td>
<td>5 (23.81)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$50,000 – $74,999 | More than $75,000 |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment</td>
<td>2 (8.33)</td>
</tr>
<tr>
<td>Parent Income</td>
<td>2 (9.52)</td>
</tr>
<tr>
<td>Other Financial Means</td>
<td>5 (20.0)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (9.52)</td>
</tr>
</tbody>
</table>

Note: CB-Heavy = Heavy cannabis users. CB-Mod = Moderate cannabis users. HC = Healthy controls. 

* p < .01.

a Other Race includes Native Hawaiian or Other Pacific Island (n = 2) and American Indian or Alaska Native (n = 1).

b Fischer’s exact p-value. All other p-values are from Chi-Square statistic.

c Other employment status includes disabled / retired (n =1).

d Other financial means for income source includes student loans / fellowships (n =1), public benefits (n =1), and investments (n =1).
Table 2.
Baseline and Post-Cyberball+ Cannabis Craving Scores

<table>
<thead>
<tr>
<th>MCQ subscale</th>
<th>Baseline MCQ Scores</th>
<th>Post Cyberball+ MCQ Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CB-Mod</td>
<td>CB-H</td>
</tr>
<tr>
<td></td>
<td>n = 19</td>
<td>n = 25</td>
</tr>
<tr>
<td>Compulsivity</td>
<td>5.37 (2.43)</td>
<td>6.04 (2.61)</td>
</tr>
<tr>
<td>Emotionality</td>
<td>10.47 (3.63)</td>
<td>11.24 (4.50)</td>
</tr>
<tr>
<td>Expectancy</td>
<td>12.63 (2.95)</td>
<td>14.8 (3.67)</td>
</tr>
<tr>
<td>Purposefulness</td>
<td>14.26 (2.30)</td>
<td>14.72 (4.89)</td>
</tr>
</tbody>
</table>

Note. Significant findings are in the difference between pre- and post- MCQ scores. CB-Mod = Moderate cannabis users. CB-H = Heavy cannabis users. MCQ = Marijuana Craving Questionnaire – Short Form. *p < .05.
Table 3.

Motivations for Cannabis Use in a Young Adult Sample

<table>
<thead>
<tr>
<th>MMM subscale</th>
<th>CB-Mod n = 21 Mean (SD)</th>
<th>CB-Heavy n = 25 Mean (SD)</th>
<th>Total N = 46 Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhancement*</td>
<td>16.48 (2.48)</td>
<td>16.20 (3.60)</td>
<td>16.33 (3.11)</td>
</tr>
<tr>
<td>Social*</td>
<td>12.19 (3.71)</td>
<td>11.40 (4.07)</td>
<td>11.76 (3.89)</td>
</tr>
<tr>
<td>Coping**</td>
<td>9.43 (3.47)</td>
<td>9.88 (3.39)</td>
<td>9.67 (3.40)</td>
</tr>
<tr>
<td>Expansion*</td>
<td>11.09 (4.83)</td>
<td>14.32 (5.01)</td>
<td>12.85 (5.14)</td>
</tr>
<tr>
<td>Conformity*</td>
<td>5.57 (1.03)</td>
<td>5.96 (2.60)</td>
<td>5.78 (2.03)</td>
</tr>
</tbody>
</table>

Note: CB-Heavy = Heavy cannabis users. CB-Mod = Moderate cannabis users. MMM = Marijuana Motives Measure.

*Subscale score ranges from 0 – 20.

**Subscale score ranges from 0 – 16.
Table 4.
Descriptives of Coping Styles Used for Social Situations in a Cannabis Use Sample

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>CSQSS Monitoring Mean (SD)</th>
<th>CSQSS Blunting Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC</td>
<td>24</td>
<td>46.71 (10.18)</td>
<td>23.54 (12.23)</td>
</tr>
<tr>
<td>CB-Mod</td>
<td>21</td>
<td>46.00 (9.14)</td>
<td>22.52 (7.74)</td>
</tr>
<tr>
<td>CB-Heavy</td>
<td>25</td>
<td>41.28 (11.11)</td>
<td>20.40 (8.87)</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>44.56 (10.38)</td>
<td>22.11 (9.82)</td>
</tr>
</tbody>
</table>

Note: CB-Heavy = Heavy cannabis users. CB-Mod = Moderate cannabis users. CSQSS = Coping Styles Questionnaire for Social Situations. HC = Healthy controls.
Table 5.

Trait Rejection Sensitivity in a Cannabis Using Young Adult Sample

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>A-RSQ Total Mean (SD)</th>
<th>A-RSQ Anxiety Mean (SD)</th>
<th>A-RSQ Expectancy Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC</td>
<td>24</td>
<td>9.37 (3.44)</td>
<td>30.21 (9.93)</td>
<td>24.92 (6.19)*</td>
</tr>
<tr>
<td>CB-Mod</td>
<td>21</td>
<td>7.75 (2.98)</td>
<td>28.14 (7.95)</td>
<td>20.05 (4.33)</td>
</tr>
<tr>
<td>CB-Heavy</td>
<td>25</td>
<td>8.40 (3.80)</td>
<td>29.56 (10.97)</td>
<td>22.12 (7.88)</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>8.54 (3.46)</td>
<td>29.36 (9.68)</td>
<td>22.46 (6.61)</td>
</tr>
</tbody>
</table>

Note: A-RSQ = Adult Rejection Sensitivity Questionnaire. CB-Heavy = Heavy cannabis users. CB-Mod = Moderate cannabis users. HC = Healthy controls. $p < .05$
Figure 2. Effect of Social Inclusion on Threatened Needs by Cannabis Use Frequency
Figure 3. Group Differences in Cannabis Use Frequency and Trait Rejection Sensitivity on Rejection Distress Ratings to Social Inclusion
Table 6.  
*Cannabis Users Demographics and Diary Responses over EMA Period*

<table>
<thead>
<tr>
<th>Variables</th>
<th>n</th>
<th>CB-Mod</th>
<th>CB-Heavy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD) or n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (% female)</td>
<td>43</td>
<td>9 (52.94)</td>
<td>11 (42.31)</td>
<td>20 (46.51)</td>
</tr>
<tr>
<td>CB Craving (% yes)</td>
<td>244</td>
<td>68 (26.56)</td>
<td>176 (43.67)</td>
<td>244 (37.03)</td>
</tr>
<tr>
<td>CB Use since last prompt (% yes)</td>
<td>658</td>
<td>53 (20.70)</td>
<td>194 (48.26)</td>
<td>247 (37.54)</td>
</tr>
<tr>
<td>CB Use Right Now (% yes)</td>
<td>655</td>
<td>9 (3.53)</td>
<td>56 (14.0)</td>
<td>65 (9.92)</td>
</tr>
<tr>
<td>Daily Users (% yes)</td>
<td>42</td>
<td>0 (0.0)</td>
<td>4 (15.38)</td>
<td>4 (9.52)</td>
</tr>
<tr>
<td>Experienced Rejection (% yes)</td>
<td>646</td>
<td>18 (7.09)</td>
<td>42 (10.71)</td>
<td>60 (9.29)</td>
</tr>
<tr>
<td>Total Positive Life Events (0-2)</td>
<td>646</td>
<td>118 (46.46)</td>
<td>184 (46.94)</td>
<td>302 (46.75)</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>136 (53.54)</td>
<td>208 (53.06)</td>
<td>344 (53.25)</td>
</tr>
<tr>
<td>1 - 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Negative Life Events (0-7)</td>
<td>646</td>
<td>157 (61.81)</td>
<td>195 (49.74)</td>
<td>352 (54.49)</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>62 (24.41)</td>
<td>116 (29.59)</td>
<td>178 (27.56)</td>
</tr>
<tr>
<td>1 - 2</td>
<td></td>
<td>35 (13.78)</td>
<td>81 (20.66)</td>
<td>116 (17.96)</td>
</tr>
<tr>
<td>3 or more</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Context of CB Use (%)</td>
<td>236</td>
<td>19 (41.30)</td>
<td>69 (36.32)</td>
<td>88 (37.29)</td>
</tr>
<tr>
<td>Alone</td>
<td></td>
<td>27 (58.70)</td>
<td>121 (63.68)</td>
<td>148 (62.71)</td>
</tr>
<tr>
<td>With Other People</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer CB Use at Time of Craving or Use (% yes)</td>
<td>183</td>
<td>33 (75.0)</td>
<td>102 (73.38)</td>
<td>135 (73.77)</td>
</tr>
<tr>
<td>PANAS Positive Affect (6-30)</td>
<td>650</td>
<td>14.60 (5.16)</td>
<td>15.26 (5.46)</td>
<td>15.0 (5.35)</td>
</tr>
<tr>
<td>PANAS Negative Affect (6-30)</td>
<td>650</td>
<td>8.86 (3.68)</td>
<td>9.13 (3.52)</td>
<td>9.02 (3.58)</td>
</tr>
</tbody>
</table>

Note: N = 664 occasions. CB = Cannabis. CB-Heavy = Heavy cannabis users. CB-Mod = Moderate cannabis users. EMA = Ecological Momentary Assessment. PANAS = Positive and Negative Affect Scale.  
\(^a\) Demographic information is presented by number of participants (N = 43).  
\(^b\) EMA diary responses is presented by number of occasions.  
\(^c\) For PANAS positive and negative affect: CB-Mod, n = 254; CB-H, n = 396.
Table 7.

Mixed Effects Logistic Regression Odds Ratios for Models Examining Predictors of Real-World Cannabis Craving

<table>
<thead>
<tr>
<th></th>
<th>Unconditional Growth Model</th>
<th>Model with EMA Predictors</th>
<th>Model with Cyberball+ Predictors</th>
<th>Final, Adjusted Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Status:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>NS</td>
<td>0.40*</td>
<td>0.40*</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Rate of Change:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (Linear)</td>
<td>0.97*</td>
<td>0.97*</td>
<td>0.97*</td>
<td>0.97*</td>
</tr>
<tr>
<td><strong>Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannabis Use Frequency (Heavy)</td>
<td>--</td>
<td>NS</td>
<td>3.86**</td>
<td>3.67*</td>
</tr>
<tr>
<td>Experiences of Rejection (Yes)</td>
<td>--</td>
<td>2.16*</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Cyberball+ Rejection Distress</td>
<td>--</td>
<td>--</td>
<td>0.52**</td>
<td>0.55*</td>
</tr>
<tr>
<td><strong>Covariates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>NS</td>
</tr>
<tr>
<td>Sex (Female)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Fit Statistics:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Likelihood (-2LL)</td>
<td>-362.49</td>
<td>-350.41</td>
<td>-303.82</td>
<td>-303.72</td>
</tr>
<tr>
<td>AIC</td>
<td>730.97</td>
<td>710.82</td>
<td>619.65</td>
<td>623.43</td>
</tr>
<tr>
<td>BIC</td>
<td>744.44</td>
<td>733.17</td>
<td>645.30</td>
<td>657.63</td>
</tr>
</tbody>
</table>

Note. All logistical regression coefficients presented here are exponentiated log-odds. When exponentiated, the intercept represents the conditional probability that the outcome variable equals one and the slope represents an odds ratio. Age was mean centered. All dichotomous and categorical variables were dummy coded. Cyberball+ Rejection Distress results are regression slopes measuring the level of rejection distress as a function of inclusion probability. This variable was standardized and mean centered, so that one standard deviation change in rejection distress is associated with a change in cannabis craving. AIC = Akaike’s information criterion, BIC = Bayesian information criterion, EMA = Ecological momentary assessment. *p < .05. **p < .01. *** p < .001.
Table 8.

Mixed Effect Logistic Regression Odds Ratio for Models Examining Predictors of Real-World Cannabis Use

<table>
<thead>
<tr>
<th></th>
<th>Unconditional Growth Model</th>
<th>Model with EMA Predictors</th>
<th>Model with Cyberball+ Predictors</th>
<th>Final, Adjusted Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Status:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>NS</td>
<td>0.18***</td>
<td>0.19***</td>
<td>0.20***</td>
</tr>
<tr>
<td><strong>Rate of Change:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time (Linear)</td>
<td>0.97*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannabis Use Frequency (Heavy)</td>
<td>--</td>
<td>3.28***</td>
<td>3.15***</td>
<td>3.04***</td>
</tr>
<tr>
<td>Craving (Yes)</td>
<td>--</td>
<td>5.78***</td>
<td>4.74***</td>
<td>4.72***</td>
</tr>
<tr>
<td>Experiences of Rejection (Yes)</td>
<td>--</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Cyberball+ Rejection Distress</td>
<td>--</td>
<td>--</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Covariates</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>NS</td>
</tr>
<tr>
<td>Sex (Female)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Fit Statistics:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Likelihood (-2LL)</td>
<td>-400.07</td>
<td>-350.64</td>
<td>-300.01</td>
<td>-299.92</td>
</tr>
<tr>
<td>AIC</td>
<td>806.13</td>
<td>713.29</td>
<td>614.03</td>
<td>617.85</td>
</tr>
<tr>
<td>BIC</td>
<td>819.60</td>
<td>740.11</td>
<td>643.95</td>
<td>656.32</td>
</tr>
</tbody>
</table>

Note. All logistical regression coefficients presented here are exponentiated log odds. When exponentiated, the intercept represents the conditional probability that the outcome variable equals one and the slope represents an odds ratio. Age was mean centered. All dichotomous and categorical variables were dummy coded. Cyberball+ Rejection Distress results are regression slopes measuring the level of rejection distress as a function of inclusion probability. This variable was standardized and mean centered, so that one standard deviation change in rejection distress is associated with a change in cannabis use. AIC = Akaike’s information criterion, BIC = Bayesian information criterion, EMA = Ecological momentary assessment. *p < .05. **p < .01. *** p < .001.
Appendix A. Drug Use History Questionnaire

These next questions will ask you about your drug use history. Please remember that your answers are confidential.

1. Do you or have you ever used marijuana?
   a. Yes
   b. No

2. How old were you when you first used / started using marijuana? _____ YEARS

3. How many times per week do you currently use marijuana? ______

4. How much marijuana do you use at any one time? ____ OUNCES

5. How much money do you spend on marijuana weekly? ______ DOLLARS

NORMATIVE BELIEFS/ PEER AND FAMILY INFLUENCES

6. Please think of your five closest friends that you spend time with on a regular basis. How many of them use marijuana? ______ (number up to 5)

7. Do any of your immediate family members (parents, brothers, sisters) use marijuana?
   a. Yes
   b. No

8. People who are important to you believe that you should not use marijuana.
   a. Strongly agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

RISK PERCEPTION / ATTITUDE

9. How harmful do you think marijuana is to health?
   a. Not at all harmful
   b. Slightly harmful
   c. Somewhat harmful
   d. Very harmful
   e. Extremely harmful
Appendix B. Need Threat Scale

**Need Threat Scale**

“For the following questions, please select the scale number that best represents the feelings you experienced during the game:”

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very Unconcerned</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Very Concerned</td>
</tr>
</tbody>
</table>

1. I felt rejected
2. I felt angry
3. I felt disconnected
4. I felt like an outsider
5. I felt invisible
6. I felt meaningless
7. I felt non-existent
8. I felt good about myself (R)
9. My self-esteem is high (R)
10. I felt liked (R)
11. I felt powerful (R)
12. I felt in control (R)
13. I felt superior (R)
14. I felt included (R)

R = Reversed scored.
Appendix C. Daily Mood and Social Diary

Section 1. Cravings
Prompt 1. Have you had a strong desire or urge to use marijuana since the last prompt?  Yes/No

Section 2. Use
Prompt 2. Did you use marijuana since the last prompt?  Yes/No
Prompt 2a (If yes). How much marijuana did you use since the last prompt?
Free Response: ________ Blunts
Free Response: ________ Grams

Prompt 3. Are you using marijuana right now?  Yes/No

Section 3. Social Situation
Prompt 4. When you used or had the urge to use marijuana, where you alone or with other people?
Choose one: Alone/In a Social Situation (with other people)

Prompt 4a (If “with other people”): Were other people using or about to use marijuana?  Yes/No

Section 4: Mood
Prompt 5: “Since the last prompt, how strongly have you felt the following:”

Ratings 1= Very Slightly or Not At All; 2= A Little; 3= Moderately; 4= Quite A Bit; 5= Extremely

1. Interested 1 2 3 4 5
2. Distressed 1 2 3 4 5
3. Strong 1 2 3 4 5
4. Upset 1 2 3 4 5
5. Guilty 1 2 3 4 5
6. Proud 1 2 3 4 5
7. Alert 1 2 3 4 5
8. Scared 1 2 3 4 5
9. Hostile 1 2 3 4 5
10. Inspired 1 2 3 4 5
11. Irritable 1 2 3 4 5
12. Determined 1 2 3 4 5
13. To what degree have you felt overwhelmed by any of these feelings? 1 2 3 4 5
14. To what degree have you felt like your emotions were out of control? 1 2 3 4 5
Appendix C. Daily Mood and Social Diary (continued)

Section 5: Life Events

Prompt 6. “Since the last prompt, have you:”

1. Had a disagreement with someone
2. Felt rejected by someone
3. Been complimented or praised by someone
4. Been disappointed by someone
5. Felt neglected by someone
6. Experienced a loss of some sort
7. Received good news
8. Received bad news
9. Been reminded of something painful from the past
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