

ANHEDONIA AND DELAY DISCOUNTING IN PROBLEMATIC CANNABIS USERS

by

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Abstract

Depressive symptoms (e.g., anhedonia) have been observed in cannabis users. Alterations in delay discounting have been observed in depressed individuals. Steep discounting (i.e., impulsive choice) has been associated with tobacco, alcohol, and cocaine abuse, but not cannabis abuse. This study evaluated the association between anhedonia, cannabis use, and delay discounting. Participants (329 undergraduates) were assessed for marijuana use patterns (age of first use, weekly dose, MPS, DSM-V CUD), anhedonia (SHAPS), and delay discounting (impulsivity) using an online Qualtrics survey to determine the covariation among these variables. Anhedonia and measures of marijuana use were not significantly associated and neither measure was significantly associated with delay discounting. Significant correlations were observed primarily among marijuana use measures. In multiple regression analysis, neither anhedonia nor marijuana use amount was a significant predictor of delay discounting. A significant quadratic trend was observed for marijuana use amount on discounting, suggesting a dose-dependent relationship.

Table of Contents

Introduction..... 4

Cannabis Use, Abuse, and Dependence.....5

 Assessment Surveys.....5

 Prevalence.....5

Mechanism of Action.....6

 Neurochemistry.....6

 Mesolimbic Dopamine System.....7

 Abuse Potential.....8

 Dependence..... 9

 Withdrawal.....12

Psychological Impact.....13

 Attention.....13

 Working Memory.....14

 Decision-Making.....14

 Summary.....15

Behavioral Economics.....16

 Delay Discounting.....16

 Delay Discounting and Cannabis Dependence.....18

Cannabis Dependence and Mental Illness Comorbidity.....19

 Depression.....19

Depression and Delay Discounting.....22

The Present Study.....24

Method.....25

 Participants.....25

 Design.....25

 Measures and Procedure.....25

Results.....27

 Participant Demographics.....27

 Marijuana Use Frequency.....28

 Data Analysis.....32

Discussion.....35

 Anhedonia and Delay Discounting.....35

 Cannabis Use and Delay Discounting.....36

 Anhedonia and Cannabis Use.....36

 Marijuana Use Measures.....37

 Study Limitations.....38

 Conclusions.....39

References.....42

Introduction

Marijuana is the most commonly used illicit drug not only in the United States, but also worldwide (Cooper & Haney, 2008). As prevalence of use has increased in recent years, so too has the prevalence of cannabis use disorder (Hasin et al., 2015). According to the DSM-IV, cannabis dependence is characterized by psychosocial interferences including using cannabis in larger amounts or over a longer period than intended, the inability to reduce cannabis use, and neglecting important social or occupational obligations in favor of using cannabis (Blanco et al., 2008). Cannabis use has been associated with psychological impairments related to attention, working memory, and decision-making (Heishman et al., 1997; Miller et al., 1977; Ramaekers et al., 2006; Morrison et al., 2009). Furthermore, there is an extensive literature suggesting that symptoms of major depressive disorder are prevalent among cannabis users (Grant et al., 1995; Repetto et al., 2008; Horwood et al., 2012).

The discounting of delayed rewards is often studied in depressed populations (Beck, 1979; Pulcu et al., 2014). Depressed individuals tend to discount the value of delayed rewards differently than that of healthy controls, perhaps due to characteristic depressive symptoms including hopelessness and loss of pleasure (Beck, 1979; Berenbaum & Oltmanns, 1992; Wacker et al., 2009; Lempert & Pizzagalli, 2010; Pulcu et al., 2014). Furthermore, there is extensive evidence concluding that steeper discounting of delayed rewards is observed among individuals with dependence on substances including tobacco, alcohol, and cocaine (Yi, Mitchell, & Bickel, 2010). The limited literature regarding delay discounting among cannabis-dependent individuals suggests that there may be a modest association, perhaps not as strong as the association among discounting and substances with greater abuse-related properties (Johnson et al., 2010; Peters et al., 2013).

Cannabis Use, Abuse, and Dependence

Assessment Surveys

There are a variety of instruments available to assess factors related to marijuana use. The Marijuana Use Form (MUF) inquires whether participants have ever used marijuana, date of most recent marijuana use, and use frequency within the past month as well as over the lifetime (Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007). While the MUF only measures use patterns, other instruments have been developed to assess potentially adverse consequences of long-term marijuana use. The Marijuana Problems Scale (MPS) is a nineteen-item survey that assesses the social, occupational, physical, and personal consequences related to marijuana use within the last ninety days (Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007). Even further than measuring negative consequences associated with marijuana use, the Marijuana Motives Measure (MMM) aims to determine the individual's reasons for choosing to use marijuana; participants use a five-point Likert-type scale to indicate the degree to which they have used marijuana for reasons including coping, social connection, conformity, cognitive enhancement, and awareness expansion (Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007).

Need a short summary paragraph here on these scales – is there any consensus on one being 'best' or most sensitive, etc.

Prevalence

Cannabis is the most frequently used illicit drug not only in the United States, but globally as well (Cooper & Haney, 2008). In recent years, twenty-three states have established medical marijuana protocols, four states have legalized cannabis for recreational use, and overall support for legalization has increased (Hasin et al., 2015). Marijuana use in the United States increased from 4.1 percent of the population in 2002 to 9.5 percent of the population in 2013

(Hasin et al., 2015). Accordingly, the prevalence of DSM-IV cannabis use disorder increased from 1.5 percent in 2002 to 2.9 percent in 2013, reflecting a statistically significant increase across all demographic subgroups (Hasin et al., 2015). However, the prevalence of cannabis use disorder among regular marijuana users decreased significantly from 2002 (35.6 percent) to 2013 (30.6 percent) (Hasin et al., 2015).

Mechanism of Action

Neurochemistry

Among the hundreds of chemical compounds found in cannabis, tetrahydrocannabinol (THC) is regarded as the active ingredient for its psychoactive properties (Williamson, Buckland, & Cunningham, 2013). Common psychoactive effects include euphoria, depersonalization, altered sense of time, and intensification of sensory experiences (Anderson, Rizzo, Block, Pearlson, & O'Leary, 2010). THC produces these psychoactive effects by binding to cannabinoid receptors within the endocannabinoid system known as CB₁ and CB₂ (Solinas, Goldberg, & Piomelli, 2008). Binding to these receptors allows THC to mimic the effects of anandamide, an endogenous neurotransmitter (Schwarz, Blanco, & Lotz, 1994). CB₁ receptors are abundant in areas of the brain responsible for memory, motor coordination, and emotionality (Solinas, Goldberg, & Piomelli, 2008). These receptors are located at presynaptic terminals within areas including the hippocampus, cerebellum, and prefrontal cortex, as well as regions of the mesolimbic dopamine system (Solinas, Goldberg, & Piomelli, 2008). While the large quantity of CB₁ receptors deems them primarily responsible for the psychoactive effects of THC, CB₂ receptors also play an important role (Solinas, Goldberg, & Piomelli, 2008). CB₂ receptors are primarily found in peripheral tissues and are sparsely dispersed throughout the brain and the

central nervous system (Bab et al., 2009).

Mesolimbic Dopamine System

Dopamine is a largely influential neurotransmitter that travels over many different pathways throughout the brain for a wide range of purposes (Puri, Hall, & Ho, 2013). Among the four major dopamine pathways are the nigrostriatal pathway, which moderates motor function and movement, the mesocortical pathway, which influences cognitive control and emotional response, and the tuberoinfundibular pathway, which is involved in hormone secretion (Puri, Hall, & Ho, 2013). This section will focus on the mesolimbic dopamine pathway, which is involved in regulating the reinforcing properties of pleasant stimuli (Puri, Hall, & Ho, 2013).

Activity of the mesolimbic dopamine system is associated with unconditioned reinforcers for numerous adaptive activities including eating, drinking, mating, and social bonding (Pitchers et al., 2010). Beyond regulating the rewarding properties of natural reinforcers, dopaminergic cells in the ventral-tegmental area are also highly responsive to conditioned reinforcement (Cassidy & Shaver, 2016). In response to positive reinforcing stimuli, whether natural or conditioned, dopamine is transported from the ventral tegmental area to the nucleus accumbens and limbic regions of the amygdala, hippocampus, and medial prefrontal cortex (Pierce & Kumaresan, 2006).

There is conclusive evidence that the mesolimbic dopamine system has a critical role in conditioning and regulating the rewarding effects of drugs of abuse in substance-dependent individuals (Levrin et al., 2015). For instance, acute cocaine administration inhibits dopamine transporter proteins from removing dopamine neurotransmitters from the synaptic cleft (Hope, 1997). As a result, the dopamine concentration within the synaptic cleft is drastically increased and in turn, dopaminergic receptors are rapidly activated (Hope, 1997). Repeated exposure to

substances with high abuse potential alters the neuronal composition and synaptic strength within the mesolimbic dopamine system, ultimately motivating the individual to continue using the substance (Pitchers et al., 2010).

Following cocaine administration, its effects are experienced almost immediately and last only a short duration of time (Pierce & Kumaresan, 2006). These properties are conducive to the rapid formation of association between the reinforcer and its reinforcing effects across a variety of species, deeming cocaine a substance of high abuse potential (Pierce & Kumaresan, 2006). Conversely, the onset of cannabis effects is more drawn out and its effects tend to last longer, deeming cannabis a substance of lower abuse potential (Pierce & Kumaresan, 2006). Unlike cocaine and other drugs of higher abuse potential, mild to moderate cannabis use does not alter the composition of the mesolimbic dopamine system (Urban et al., 2012). However, decreased dopamine release has been observed in chronic cannabis users as well as those who began using during adolescence (Urban et al., 2012).

Abuse Potential

Abuse potential refers to the level at which a drug produces positive reinforcing effects and therefore motivates the user to continue using (Markgraf, Hudzik, & Compton, 2015). Virtually every drug abused by humans is also self-administered by nonhuman animals in a variety of laboratory models (Miller & Carroll, 2012). Animal models have high predictive validity, meaning that if laboratory animals repeatedly self-administer the drug then it will also have a high abuse liability in humans (Miller & Carroll, 2012).

Regarding the abuse potential of cannabis, there is a discrepancy in the literature and therefore an animal model has not yet been established. One early study found that rhesus monkeys would not consistently self-administer various doses of THC, even though they had

previously been trained to self-administer cocaine as well as cocaine-THC mixtures (Harris, Waters, & McLendon, 1974). While a later study found that non-human animals would self-administer THC, it is important to note that the animals were deprived of basic needs such as food and water; only under these deprived conditions would the animals self-administer THC, which is a measure that does not need to be taken in order for animals to self-administer drugs with higher abuse potentials (Cooper & Haney, 2008). In human laboratory studies, subjects are more likely to self-administer active marijuana compared to placebos, and marijuana with high THC levels compared to lower THC levels (Cooper & Haney, 2008). Human preference to administer marijuana with increasing THC levels supports the hypothesis that THC is the primary reinforcing agent in marijuana (Cooper & Haney, 2008).

Dependence

The DSM-IV identifies cannabis abuse by continued failure to fulfill daily obligations, persistent substance-related legal problems, recurrent use at inappropriate times, and failure to stop using despite substance-related interpersonal problems (Thake & Davis, 2011). While cannabis abuse is characterized by psychological and social consequences of use, cannabis dependence also takes the biological features of substance use into account (Thake & Davis, 2011). The DSM-IV recognizes cannabis dependence (CD) as fulfillment of at least three of the following six criteria at any time over a twelve-month period: “(1) development of tolerance; (2) using cannabis in larger amounts or over a longer period than intended; (3) inability to cut down or reduce cannabis use; (4) spending large amounts of time to obtain, use, or recover from the effects of cannabis; (5) giving up important social, occupational, or recreational activities in favor of using cannabis; (6) continued use of cannabis despite its adverse consequences” (Blanco et al., 2008).

It is estimated that only 9.1 percent of individuals who ever use cannabis in their lifetime develop dependence (Looby & Earleywine, 2007). While daily cannabis use increases the user's risk of developing dependence, research indicates that a minority of daily users (20 to 50 percent) are cannabis-dependent (Coffey et al., 2002; EMCDDA, 2009). Other conditions that may predict the development of cannabis dependence include early onset of use, dependence upon other substances such as nicotine, alcohol, and cocaine, family history of substance use disorders, and personality traits including impulsivity and aggression (Chen et al., 2005; Lopez-Quintero et al., 2010; Von Sydow et al., 2002). These predictor variables are similar in that they are all stable vulnerability factors; however, conflicting research indicates that the development of cannabis dependence is attributable to current problematic circumstances rather than stable vulnerability conditions (Pol et al., 2013). Current circumstances that may predict cannabis dependence include living alone, using cannabis as a coping mechanism, and recent stressful life events, most often involving finances (Pol et al., 2013). While cannabis dependence is observed only in a small percentage of users (Looby & Earleywine, 2007; Coffey et al., 2002; EMCDDA, 2009), the literature has identified cannabis use patterns as well as negative life circumstances that may contribute to the development of cannabis dependence (Chen et al., 2005; Lopez-Quintero et al., 2010; Von Sydow et al., 2002; Pol et al., 2013).

Although research regarding the variables contributing to cannabis dependence is inconclusive, it is important to recognize the distinction between dependent and non-dependent users. Non-dependent users are able to manage their use and experience little interference with other aspects of their lives, whereas dependent users experience significant psychosocial impairments as a result of their substance use (Looby & Earleywine, 2007). Common psychosocial problems experienced by dependent users include family problems, strained

romantic relationships, and increased absence at school or work (Looby & Earleywine, 2007). Overall, dependent users are characterized by uncontrolled use of the substance along with the psychosocial and motivational impairments that arise from frequent use (Coffey et al., 2002; Looby & Earleywine, 2007).

Beyond distinguishing between dependent and non-dependent users, a distinction should also be made between problematic and non-problematic users (Thake & Davis, 2011). Many individuals who do not meet criteria for abuse or dependence nonetheless experience problems and impairments indirectly resulting from frequent cannabis use (Caldeira et al., 2008; Davis et al., 2009). Beck and Legleye (2008) pioneered the development of a problematic cannabis use threshold, in which problematic use is characterized by negative health or social outcomes for the individual or the larger community. Similarly, Davis and colleagues (2009) define problematic cannabis use as a series of use patterns that is indirectly detrimental to the user socially, physically, financially, and occupationally. In their study, it was found that although weekly cannabis use increased the risk of experiencing use-related problems, only two-thirds of those who used at least weekly reported use-related problems (Davis, Thomas, Jesseman, & Mazan, 2009). In addition to higher use frequency, other characteristics that may predict problematic use are using in the morning, using as a coping mechanism, experiencing depression or guilt, and engaging in risky behaviors such as driving under the influence (Annaheim et al., 2008; Davis et al., 2009; Legleye et al., 2007). Conclusively, more frequent cannabis use increases the risk of experiencing use-related problems, but frequent cannabis use – even on a weekly basis – does not explicitly cause problematic use, abuse, or dependence (Thake & Davis, 2011).

Withdrawal

A consensus has not been reached regarding whether cessation of regular use produces a distinctive cannabis withdrawal syndrome (Milin, 2008). Although the DSM-IV does not currently acknowledge diagnostic criteria for cannabis withdrawal syndrome, there is preliminary evidence suggesting that abrupt cessation of cannabis use produces unpleasant psychological withdrawal symptoms (Milin, 2008). Reported withdrawal symptoms include mood changes, increased anxiety, irritability, aggressiveness, disturbed sleep, and more infrequently, physical symptoms such as headaches, upset stomach, nausea, and discomfort (Milin, 2008; Levin et al., 2010).

It is noteworthy that not all individuals who use cannabis experience withdrawal symptoms upon cessation; one study found that only 42.4 percent of participants reported incidence of cannabis withdrawal (Levin et al., 2010). Participants who used marijuana more frequently on a daily, weekly, and monthly basis reported more severe withdrawal symptoms, while no significant correlation was found between withdrawal symptoms and race, age, history of tobacco dependence, or other cannabis use variables (Levin et al., 2010). Furthermore, significant associations were found between high tolerance and instance of withdrawal symptoms (Levin et al., 2010). In instances where no withdrawal symptoms are reported, it is theorized that THC's properties of easily storing in fat tissue and releasing slowly prevent the user from experiencing withdrawal symptoms (Tanda & Goldberg, 2003).

Overall, some users have reported withdrawal symptoms following cessation of cannabis use (Milin, 2008; Levin et al., 2010). Additionally, instance of withdrawal symptoms seems to be associated with frequency of use and level of tolerance (Levin et al., 2010). However, not all cannabis users experience a withdrawal syndrome (Levin et al., 2010; Tanda & Goldberg, 2003)

and cannabis withdrawal syndrome has yet to be recognized by the DSM-IV (Milin, 2008).

Psychological Impact

Cannabis use has been shown to impair an array of executive functions, which include learning, memory, attention, and problem-solving (Crean, Crane, & Mason, 2011). The level of impairment differs depending on age at onset, frequency, quantity, and duration of marijuana use (Crean, Crane, & Mason, 2011). Certain executive functions may return to normal levels at cessation of marijuana use, while other impairments have more long-term impacts (Crean, Crane, & Mason, 2011). It has been found that after three weeks of abstinence, cannabis users exhibited enduring impairments in decision-making, concept formation, and planning, while basic attention and memory functions returned to normal (Crean, Crane, & Mason, 2011). The literature is inconclusive regarding whether low-to-moderate recreational marijuana users will experience long-term cognitive impacts (Jager et al., 2006). Furthermore, research indicates that heavy cannabis users often accumulate a high tolerance for THC, resulting in little to no impairment of executive functions (Ramaekers et al., 2011).

Attention

Attentional processing refers to the ability to focus on a target stimulus in both divided and sustained attention tasks (Grady, 1999). Research indicates that non-experienced cannabis users experience greater attentional impairment than individuals who use cannabis regularly (Morrison et al., 2009). Interestingly, regular cannabis users perform better in both sustained and divided attention tasks following THC administration rather than an abstinence period (Hart, van Gorp, Haney, Foltin, & Fischman, 2001).

Working Memory

The present literature is conclusive that acute cannabis use significantly impairs the ability to retain, manipulate and recall information after a short delay, even in regular cannabis users (Heishman et al., 1997; Miller et al., 1977). However, there seems to be no long-term impact on working memory; one study found no significant differences in working memory ability between non-users and cannabis users of low to high frequencies following an abstinence period of only 19 hours (Pope & Yurgelun-Todd, 1996).

Decision-Making

The current literature presents a discrepancy regarding whether acute cannabis use leads to disruptions in decision-making (Crean, Crane, & Mason, 2011). Ramaekers et al. (2006) conducted a study in which regular cannabis users were asked to perform a decision-making task called the Tower of London. In this task, participants viewed computer-generated images of three differently colored balls each on a stick. They were presented with a before image as well as an after image in which the balls were arranged in a different order. Participants were asked to determine the least number of times that the balls needed to be switched in the before image to achieve the after image. It was found that although the response time was consistent across all groups, subjects who were administered THC made more incorrect responses than control subjects up to five and a half hours after administration (Ramaekers et al., 2006). The findings were dose-dependent, meaning that participants who were administered higher doses of THC made more numerous incorrect decisions and answered incorrectly for a longer period of time following administration than those who were administered lower doses of THC (Ramaekers et al., 2006). These results are in stark contrast to another study which found that marijuana users were not impaired in the Tower of London task following THC administration (Hart, van Gorp,

Haney, Foltin, & Fischman, 2001).

Vadhan and colleagues (2007) conducted a study in which decision-making ability in marijuana users was assessed using the Iowa Gambling Task. In this task, participants were asked to repeatedly select cards from four different decks to potentially win hypothetical amounts of money. Two decks consistently yielded smaller gains with occasional smaller losses, while the other two decks consistently yielded larger gains with occasional larger losses. Overall, it would be more advantageous to select from the first two decks in terms of monetary gains. It was found that although subjects who were administered varying levels of THC exhibited prolonged response times, they did not make significantly more incorrect (disadvantageous) decisions than control subjects (Vadhan et al., 2007).

Summary

While the literature is inconclusive regarding the effect size of impaired psychological impact in cannabis users, age at onset, frequency, quantity, and duration of use have been identified as potential predictors of cognitive disruption (Crean, Crane, & Mason, 2011). For instance, inexperienced users performed more poorly on attention tasks following THC administration than did frequent users, likely due to acquired THC tolerance in those who use regularly (Hart et al., 2001; Morrison et al., 2009). While working memory is similarly impaired in experienced and non-experienced users following THC administration, there seems to be no long-term effect of cannabis on working memory (Heishman et al., 1997; Miller et al., 1977; Pope & Yurgelun-Todd, 1996). Regarding impairment of decision-making, the literature suggests that regular cannabis users tend to have prolonged response times, but do not show a significant trend towards choosing incorrectly (Hart et al., 2001; Vadhan et al., 2007). In instances where cannabis users do make significantly more incorrect choices, it is hypothesized

that this impairment is dose-dependent (Ramaekers et al., 2006).

Behavioral Economics

Behavioral economics is an interdisciplinary field of research that applies key principles of economics to the study of behavior in an economic setting (Madden, 2000). Key principles of economics such as price, demand, alternative sources of reinforcement, and decreased valuation of delayed rewards are used to better understand decision-making (Madden, 2000). In behavioral economics, the standard economic model is applied in consideration with human beings' natural tendency to make economically irrational decisions (Thorgeirsson & Kawachi, 2013).

Psychological variables that may impede economically sound decision-making in humans include bounded rationality and bounded willpower (Thorgeirsson & Kawachi, 2013). When making decisions, humans are bound to their existing level of rationality in that economically irrelevant contextual influences inhibit the ability to view the situation with perfect clarity and consideration of the future (Thorgeirsson & Kawachi, 2013). Humans are also bound to their level of willpower in that they may succumb to immediate rewards in exchange for later consequences (Thorgeirsson & Kawachi, 2013). Overall, the discipline of behavioral economics takes human error into account when assessing decision-making behaviors in an economic setting.

Delay Discounting

One branch of behavioral economic research attempts to quantify impulsive decision-making by studying delay discounting, or the preference for smaller, immediate rewards over larger, later rewards (Madden & Johnson, 2010). In this decision-making scenario, preference for the immediate reward is more impulsive because this choice pattern decreases the long-term rate of reward (Madden & Johnson, 2010). Rachlin and colleagues (1991) pioneered delay-

discounting research in humans, presenting participants with the choice of receiving hypothetical amounts of money immediately or after specified delays ranging from one month to fifty years. While most participants chose the immediate reward when both the immediate and the delayed rewards were \$1,000, responses began to differ as the immediate reward became smaller (Rachlin, Raineri, & Cross, 1991). As the survey proceeded, the immediate reward systematically decreased (e.g. \$990 now vs. \$1,000 in one month) until participants were eventually choosing between \$1 now and \$1,000 sometime in the future (Rachlin, Raineri, & Cross, 1991). The point at which the participant switches from selecting the full, delayed reward to the smaller, immediate reward is referred to as the indifference point (Rachlin, Raineri, & Cross, 1991). The amount of the offer at the indifference point is the discounted value of the delayed reward, indicating that the subject would reject any smaller reward amount and accept any larger reward amount (Madden & Bickel, 2010). According to the economic analysis of choices made in this scenario, a comparatively high indifference point indicates steeper discounting of rewards and serves as a measure of increased impulsivity (Rachlin, Raineri, & Cross, 1991).

In order to predict discounting rates over time, researchers have attempted to describe how the value of a reward declines as the delay to its delivery increases through fitting exponential and hyperbolic curves to empirical delay discounting functions (Madden & Johnson, 2010). Classic economists devised the exponential equation of delay discounting, in which the value of a delayed reward should be discounted in a compounding fashion with each additional unit of delay (Madden & Johnson, 2010). While the exponential equation reflects the most economically rational discounting patterns, the hyperbolic discounting equation more accurately accounts for systematic deviations from rationality often observed in human participants

(Rachlin et al., 1991; Simpson & Vuchinich, 2000; Madden & Johnson, 2010), particularly in individuals with substance dependence (Bickel et al., 1999; Madden et al., 1999; Odum et al., 2002).

Delay Discounting and Cannabis Dependence

The literature regarding delay discounting is often targeted to substance-dependent populations, as these individuals frequently sacrifice later rewards such as improved health and decreased risk of legal repercussions for the immediate reward of a substance-induced high and prevention of withdrawal symptoms (Yi, Mitchell, & Bickel, 2010). As substance-dependent individuals repeatedly choose to consume the substance, it can be inferred that they value the immediate reinforcement of the substance more highly than the subjective value of abstinence (Yi, Mitchell, & Bickel, 2010). This decision-making behavior is indicative that substance-dependent individuals may discount the value of future rewards more highly in other aspects of their lives as well (Yi, Mitchell, & Bickel, 2010).

While there is strong evidence for higher rates of discounting among tobacco, alcohol, cocaine, and other types of drug users (Yi, Mitchell, & Bickel, 2010), the literature is less extensive regarding discounting in cannabis users (Peters et al., 2013). One study involving adults with current marijuana dependence, former marijuana dependence, and no history of regular marijuana use found that individuals with current marijuana use showed a nonsignificant trend towards steeper discounting than the other two groups, indicating that marijuana-dependent individuals may show a more modest increase in discounting than users dependent on other drugs (Johnson et al., 2010). In a subsequent study, although delay discounting was not correlated with marijuana use, increased discounting was associated with decreased readiness to change problematic marijuana use patterns (Peters et al., 2013). Overall, the current literature

suggests that marijuana dependence may be weakly associated with delay discounting, and this association is not as strong as that observed with other drugs with higher abuse-related properties (Johnson et al., 2010).

Cannabis Dependence and Mental Illness Comorbidity

Individuals diagnosed with substance use disorder are about twice as likely to suffer from a comorbid mental illness compared to general respondents (National Institute on Drug Abuse [NIDA], 2010). In 2010, NIDA reported that roughly seventeen percent of respondents with cannabis use disorder also suffered from any mood disorder, while about fifteen percent also suffered from any anxiety disorder. While the correlation between cannabis use disorder and comorbid mental illness is clear, their temporal relationship is a subject of controversy. In some cases, individuals may use cannabis as a coping mechanism for mental illness, whereas other individuals may experience the incidence of adverse psychological symptoms resulting from cannabis use (Dakwar et al., 2011).

Depression

In 2015, nearly seven percent of adults in the United States reported experiencing at least one major depressive episode (NIDA, 2015). According to the Diagnostic and Statistical Manual of Mental Disorders V, major depression is a mood disorder often characterized by feelings of sadness, hopelessness, or worthlessness, decreased ability to focus and make decisions, disrupted sleeping patterns, change in weight or appetite, and fatigue or loss of energy (Uher, Payne, Pavlova, & Perlis, 2014). Perhaps among the most characteristic symptoms of depression is loss of pleasure and interest in most activities, also referred to as anhedonia (Pizzagalli, 2014). There is evidence suggesting that major depressive disorder is marked by weakened dopamine

transmission, which may account for the reduced response to pleasurable stimuli in anhedonic individuals (Pizzagalli, 2014). Furthermore, this neurobiological imbalance is thought to contribute not only to the anhedonic states of depressed individuals, but also to the drug abuse patterns of substance-dependent individuals (Lazenka & Hutsell, 2017).

The literature regarding depression among marijuana users remains inconclusive in terms of prevalence as well as order of occurrence (Grant et al., 1995; Brook et al., 1998; Harder et al., 2006; Repetto et al., 2008; Johnson et al., 2009; Horwood et al., 2012). For instance, Johnson and colleagues found no evidence of correlation between marijuana use and depressive symptoms (2009), whereas Grant and colleagues found that those meeting criteria for cannabis abuse or dependence were over six times more likely to also meet criteria for major depressive disorder (1995). Similarly, a ten-year longitudinal study found that early depressive symptoms did not predict subsequent marijuana use (Brook, Cohen, & Brook, 1998), while another prospective study found that depressive symptoms in adolescent males predicted marijuana use later in life (Repetto, Zimmerman, & Caldwell, 2008). The last two studies referenced examined depressive symptoms as the causal variable for marijuana use, whereas other researchers have conversely examined marijuana use as a potential predictor of depression (Harder, Morral, & Arkes, 2006). In one study, it was found that marijuana use did not significantly predict the development of depressive symptoms (Harder, Morral, & Arkes, 2006). A later study supported these results, concluding that early-onset problematic cannabis use in adolescents did not predict the onset of depression in young adulthood (Harder, Stuart, & Anthony, 2008). Conversely, a fifteen-year longitudinal study found evidence of a causal relationship between frequent adolescent cannabis use and development of depression in adulthood (Horwood et al., 2012). Evidence of co-occurring marijuana use and depressive symptoms has been documented, but

whether there is a reliable association between the two remains unclear. Additionally, evidence of a temporal relationship is inconclusive; it is unknown whether marijuana use may produce or exacerbate depressive symptoms, or if depressed individuals may be using marijuana as a coping mechanism (Bovasso, 2001).

While the temporal relationship between depression and cannabis use is unclear, there is evidence in support of the theory that high prevalence of use among depressed individuals is best explained by a self-medication motivating factor (Denson & Earleywine, 2006; Walsh et al., 2013). A study of over six hundred Canadian adults who used cannabis for therapeutic purposes found that sixty-seven percent of all participants reported using cannabis to relieve symptoms of depression (Walsh et al., 2013). Furthermore, Denson and Earleywine employed the largest known survey of marijuana and depression with over 4,400 participants and found that marijuana use may alleviate depressive symptoms (2006). Despite similar score ranges on all depression subscales, participants who used marijuana daily reported less depressed mood and more positive affect (positive moods such as joy, interest, and alertness) than those who did not use at all (Denson & Earleywine, 2006).

Overall, the literature regarding comorbid marijuana use and major depressive disorder is largely inconclusive. There is some research to support the hypothesis that marijuana use and depression are correlated, while other studies have found no correlation between the two. Additionally, researchers have yet to come to a consensus on the temporal relationship between marijuana use and depression in cases where associations have been observed. Some studies suggest that cannabis use may foster depressive symptoms, while other researchers adhere to the self-medication hypothesis in which depressed individuals use cannabis for therapeutic purposes.

Depression and Delay Discounting

Major depressive disorder is largely characterized by feelings of hopelessness, a negative view of the future, and impaired reward processing (Pulcu et al., 2014). Accordingly, delay discounting procedures are often employed to measure future-directed thinking in depressed individuals (Pulcu et al., 2014). An existing theory is that due to a hopelessness for the future, depressed individuals are more likely to discount the value of future rewards and consequently settle for smaller, more immediate rewards (Beck, 1979). One study involving participants with current depression, past depression, and no history of depression found that those with current depression discounted future rewards at significantly higher rates than those in the other two groups (Pulcu et al., 2014). An association was also observed between steep discounting and feelings of hopelessness within the currently depressed group, supporting the theory that depressed individuals may discount the value of future rewards due to a bleak outlook of the future (Pulcu et al., 2014).

Contrary to the theory that depressed individuals discount future rewards more steeply because of hopeless feelings, there is also evidence of an association between major depressive disorder and lower discounting of future rewards (Lempert & Pizzagalli, 2010). One study employed the Snaith-Hamilton Pleasure Scale to assess anhedonia levels in thirty-six undergraduate participants (Lempert & Pizzagalli, 2010). It was observed that increased anhedonia was significantly associated with lower levels of delay discounting, meaning that anhedonic individuals were more likely to prefer the larger, delayed reward rather than the smaller, immediate reward (Lempert & Pizzagalli, 2010). These findings support the existing theory that depressed individuals may discount less because of blunted responses to immediate rewards, a key characteristic of anhedonia (e.g. Berenbaum & Oltmanns, 1992; Wacker et al.,

2009; Lempert & Pizzagalli, 2010).

A later study assessed delay discounting behaviors in depressed individuals who also suffered from comorbid substance use disorder (Moody, Franck, & Bickel, 2016). As noted previously, substance-dependent individuals express a tendency to discount future rewards more steeply than healthy controls (Madden & Bickel, 2010). In this study, it was observed not only that those with substance use disorder discounted future rewards more than healthy controls, but also that those with comorbid depression and anti-social personality disorder discounted more steeply those with substance use disorder alone (Moody, Franck, & Bickel, 2016). Although substance use disorder combined with major depressive disorder alone was not significantly associated with steeper discounting, the finding that combined depression, anti-social personality disorder, and substance use disorder were highly correlated with steeper discounting suggests an additive effect of psychological illnesses (Moody, Franck, & Bickel, 2016).

Although the literature remains inconclusive regarding the direction of association between major depressive disorder and discounting, there is clear evidence that depressed individuals tend to discount the value of future rewards at a systematically different rate than that of healthy controls (Lempert & Pizzagalli, 2010; Pulcu et al., 2014). One theory views the depressive symptom of hopelessness for the future as the explanatory variable for depressed individuals' tendency to discount the value of future rewards (Pulcu et al., 2014). Conversely, an opposing theory states that anhedonia, or general lack of response to immediate, rewarding stimuli, accounts for depressed individuals' preference for later rewards (Berenbaum & Oltmanns, 1992; Wacker, Dillon, & Pizzagalli, 2009; Lempert & Pizzagalli, 2010). Additionally, the literature suggests that psychological illnesses may exacerbate steeper discounting, namely in individuals with comorbid substance use disorder (Moody, Franck, & Bickel, 2016).

The Present Study

The existing literature suggests that there may be an independent association between problematic cannabis use and incidence of depressive symptoms (Grant et al., 1995; Repetto et al., 2008; Horwood et al., 2012). Furthermore, there is conclusive evidence that depressive symptoms, particularly hopelessness and anhedonia, are associated with delay discounting tendencies significantly differing from that of healthy controls (Lempert & Pizzagalli, 2010; Pulcu et al., 2014). Finally, there is strong evidence of steeper discounting of delayed rewards among tobacco, alcohol, and cocaine users (Yi, Mitchell, & Bickel, 2010), but the literature regarding discounting among cannabis users is less extensive (Peters et al., 2013). Considering these observations, the purpose of the present study is to determine the associations between problematic cannabis use, anhedonic symptoms, and impulsivity as measured by discounting of delayed rewards.

Method

Participants

Participants in this study included 329 undergraduate students at East Carolina University. Participants included 197 females, 131 males, and one unspecified between the ages of 18 and 30. Participants were recruited using the Department of Psychology's Experimentrak software, which invites all students currently enrolled in introductory psychology courses to participate in the study. Participants were informed that participation in the study was completely anonymous, voluntary, and had no bearing on their academic standing.

Design

The research design of this study was non-experimental and correlational, as it explored the relationships between problematic cannabis use, depressed mood, and impulsivity. Problematic cannabis use was studied as the predictor variable for potential anhedonic symptoms and impulsivity traits.

Measures and Procedure

All data were collected using a compilation of self-report surveys administered through Qualtrics, a web-based survey tool (Qualtrics, Provo, UT). The first section of the survey assessed marijuana use patterns by asking participants to indicate their age of first marijuana use and the amount of marijuana typically used per week in ounces. Participants who indicated no marijuana use were redirected to the next section of the survey. Participants who indicated any level of marijuana use were then assessed for cannabis dependence using the DSM-V Non-Alcohol Psychoactive Substance Use Disorders criteria. Participants selected yes or no to each of five items to indicate the presence or absence of various aspects of tolerance and withdrawal. Participants were then asked to complete the Marijuana Problems Scale (MPS), a 19-item questionnaire measuring the level of interpersonal, occupational, medical, legal, and personal

problems caused by marijuana use. Participants responded to each item by indicating that marijuana causes them to experience no problem (0), a minor problem (1), or a serious problem (2) in the given area.

The second section of the survey assessed the hedonic experience of each participant. Participants were first asked to indicate whether they have been clinically diagnosed with depression, and were then presented with the Snaith-Hamilton Pleasure Scale (SHAPS). The SHAPS is a 14-item questionnaire measuring the level of pleasure experienced over four hedonic domains: interest/pastimes, social interaction, sensory experience, and food/drink (Snaith et al., 1995). Each item describes a scenario that hedonic individuals would likely find enjoyable. Participants were asked to indicate the degree to which they agreed that they would find pleasure in each experience using a four-point Likert-type scale ranging from strongly disagree to strongly agree. Since the SHAPS is intended to measure pleasure, the present study used a reverse-scoring technique so that responses would reflect anhedonia rather than pleasure. Specifically, strongly disagree was scored as a four (low pleasure, high anhedonia) while strongly agree was scored as a one (high pleasure, no anhedonia).

The third section of the survey assessed choice impulsivity of each participant using a series of delay discounting tasks. Participants were asked to indicate whether they would prefer to receive a smaller amount of money immediately or a larger amount of money after a specified delay. The maximum hypothetical amount offered was \$300, and delays used were one week, 3 weeks, 10 weeks, 30 weeks, 100 weeks, and 300 weeks. Indifference points were identified by the point at which each participant switched from selecting the delayed reward to the immediate reward or vice versa, indicating that the immediate and delayed amounts are perceived to be of the same value due to the delay. Indifference points were then used to estimate the extent to

which the reward was discounted in a least squares nonlinear regression. The delay discounting portion of the survey served as an integrated attention-check mechanism; subjects who indicated only one indifference point were considered to be paying attention and therefore providing accurate feedback, whereas subjects who switched from choosing the immediate reward to the delayed reward multiple times were thought to be providing inauthentic feedback and were therefore excluded from the data set.

Finally, participants were asked to provide demographic data including date of birth, biological sex, racial/ethnic background, current cumulative grade point average, and number of undergraduate credit hours currently completed. After completing the survey, participants were informed of the purpose of the study and thanked for their contributions.

Results

Participant Demographics

Table 1 (page 30) describes the survey sample based on gender, ethnicity, age, and marijuana ounces used per week. 60 percent of participants (n=197) were female and 40 percent (n=131) male. Twenty-four percent of participants (n=78) were non-white (Native American, Asian American, African American, Latino, and Pacific Islander), while 76 percent (n=251) were white. The mean age of all participants was 18.69 years. Table 1 also categorizes participants according to ounces of marijuana used per week, which is discussed further below.

Additional participant demographics are depicted in Figure 1 (page 31); the left graph indicates the number of participants who fell into each age range. The majority of participants were between the ages of 18 and 20. The middle graph indicates the number of participants who reported currently having each approximate GPA. Nearly half of all participants indicated having

an approximate GPA of 3.5. The right graph depicts the number of participants who have completed within each range of credit hours. The majority of participants (74%) had completed between 0 and 15 credit hours, meaning that most participants were first-semester freshmen.

Marijuana Use Frequency

Seventy percent of participants (n=232) indicated having used marijuana at any point during their lives, while just over 30 percent (n=111) indicated current, regular marijuana use. Of the participants who indicated current marijuana use, 66 percent (n=74) use one-sixteenth of an ounce or less per week and 25 percent (n=28) use about one-eighth of an ounce per week. Only 4 percent (n=4) use one-quarter of an ounce per week and only 5 percent (n=5) use one-half of an ounce or more per week.

The graphs shown in Figure 2 (page 32) depict the relationships between amount of marijuana used per week and other use-related variables. The upper left graph illustrates the age of first marijuana use for participants in each weekly use category. The mean age of first use for participants who use one-quarter of an ounce per week was 16.5, while the mean age of first use for all other weekly use categories is approximately 15. The upper right graph depicts the DSM-V Cannabis Use Disorder criteria met for participants in each weekly use category. A positive trend was observed between the two variables, suggesting that increased marijuana use per week was associated with more dependence characteristics. The lower left graph displays scores on the MPS for participants in each weekly use category. There was a modest positive association, suggesting that increased marijuana use per week may result in a higher incidence of marijuana-related problems. Finally, the lower right graph illustrates scores on the SHAPS for participants in each weekly use category. A modest negative relationship was observed, indicating that increased marijuana use per week was associated with blunted responses to pleasurable stimuli.

Variable	n (%)
Gender	
Female	197 (60)
Ethnicity (Non-White)	78 (24)
Age	18.69
Marijuana ounces used per week	
Never	97 (29)
Not Current	121 (37)
1/16 th	74 (22)
1/8 th	28 (9)
1/4 th	4 (1)
> 1/4 th	5 (2)

Table 1. The number and percent of participants by gender, ethnicity, mean age, and marijuana ounces used per week.

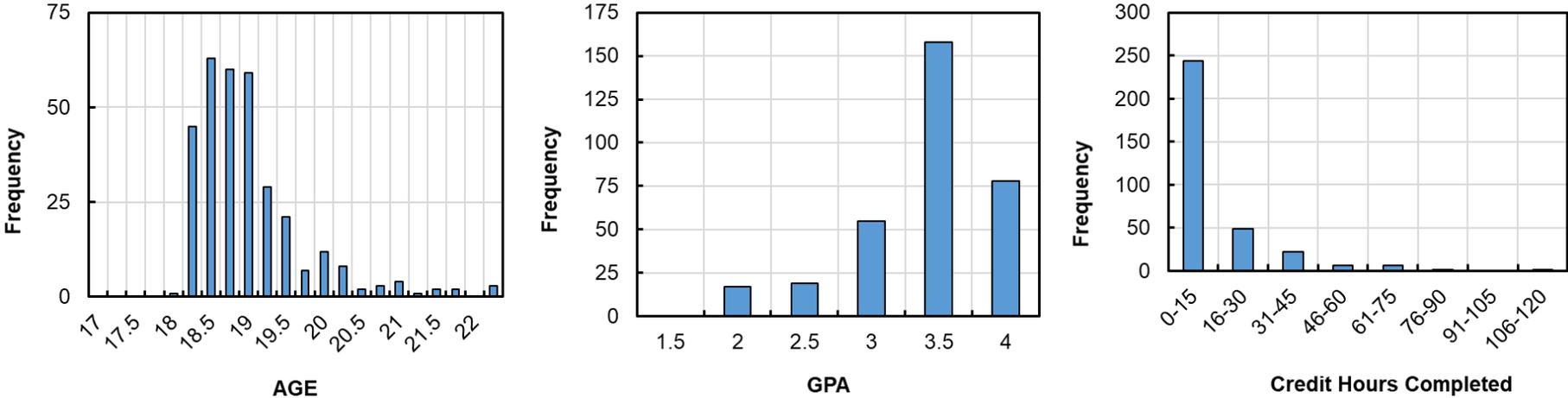


Figure 1. Left: the number of participants in each age range. Middle: the number of participants who reported each approximate GPA. Right: the number of participants who fell into each range of credit hours completed.

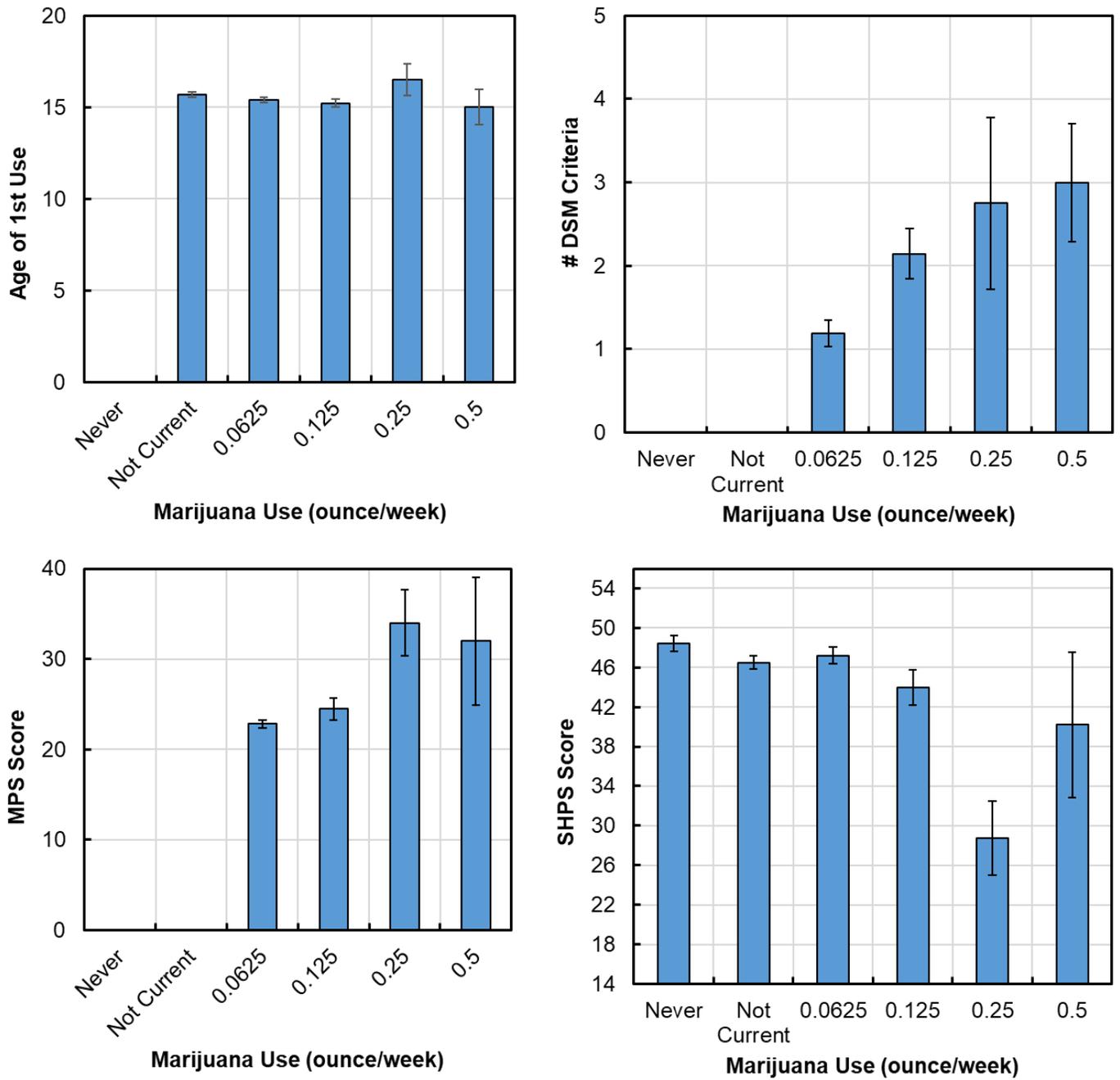


Figure 2. Upper left: approximate amount of marijuana used per week and age of first marijuana use. Upper right: approximate amount of marijuana used per week and DSM-V CUD criteria. Lower left: approximate amount of marijuana used per week and MPS score. Lower right: approximate amount of marijuana used per week and anhedonia score.

Data Analysis

Participants who indicated using one quarter of an ounce of marijuana per week and one half an ounce or more per week were excluded from data analysis due to few participants in each group. A series of bivariate correlations were calculated to determine the correlations among all variables, summarized in Table 2 (page 34). The correlation between age of first marijuana use and DSM-V CUD criteria was $r(262) = 0.27, p < 0.05$. The correlation between age of first marijuana use and MPS score was $r(262) = 0.41, p < 0.05$. The correlation between DSM-V CUD criteria and MPS score was $r(262) = 0.73, p < 0.05$. The correlation between DSM-V CUD criteria and ounces of marijuana used per week was $r(262) = 0.67, p < 0.05$. The correlation between ounces of marijuana used per week and age of first marijuana use was $r(262) = 0.54, p < 0.05$. The correlation between ounces of marijuana used per week and MPS score was $r(262) = 0.88, p < 0.05$. Insignificant correlations were observed among all remaining intercorrelations.

A multiple regression analysis, summarized in Table 3 (page 35), was conducted to determine if marijuana ounces used per week or anhedonia scores significantly predicted delay discounting scores. Neither marijuana use amount nor anhedonia were significant predictors of discounting. However, a significant quadratic trend was observed for marijuana use amount on delay discounting ($\beta = 61.29, p < 0.04$). The multiple regression models are displayed in Figure 3 (page 35).

<i>Variable</i>	1.	2.	3.	4.	5.	6.
	1 st Use	DSM	MPS	AMT	SHPS	DD
1. Age 1 st Use	--					
2. DSM CUD	0.27*	--				
3. Marijuana Problem Scale	0.41*	0.73*	--			
4. Use Amount (ounces/week)	0.54*	0.67*	0.88*	--		
5. Anhedonia Score (SHPS)	0.10	0.09	0.04	0.08	--	
6. Delay Discounting	-0.07	-0.03	-0.03	0.01	0.02	--

Table 2. Summary of correlations for age of first marijuana use, DSM-V criteria for Cannabis Use Disorder, Marijuana Problems Scale scores, ounces of marijuana used per week, anhedonia scores, and delay discounting.

<i>Predictor</i>	β	<i>t</i>	<i>p</i>
Model 1			
Marijuana Use Amount	0.03	0.03	0.97
Anhedonia Score	0.002	0.32	0.75
MJ*Anhedonia Interaction	0.07	0.13	0.57
Model 2			
Marijuana Use Amount	-6.66	-1.9	0.056
(MJ Use Amt) ²	61.29	2.05	0.04

Table 3. Multiple regression analysis

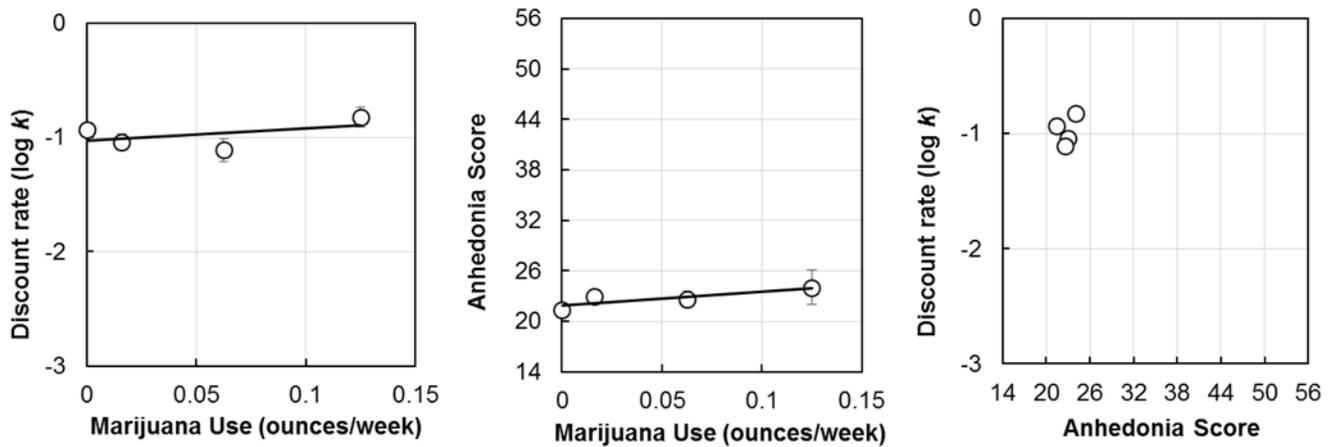


Figure 3. Multiple regression models

Discussion

The current literature indicates that depressive symptoms, namely anhedonia, may be more prevalent among cannabis-dependent populations (Bovasso, 2001). Major depressive disorder has also been associated with some measures of impulsivity (Beck, 1979; Lempert & Pizzagalli, 2010; Pulcu et al., 2014). Furthermore, the literature is conclusive in that individuals dependent upon substances including tobacco, nicotine, and cocaine score higher on measures of impulsivity, but the research is less extensive regarding impulsivity among cannabis-dependent individuals (Yi et al., 2010; Peters et al., 2013). Accordingly, the present study employed a delay discounting task to assess impulsivity in cannabis users and determine the association between cannabis use, anhedonia, and discounting.

Overall, no statistically-significant correlations were observed between anhedonia and problematic marijuana use, delay discounting and problematic marijuana use, or anhedonia and delay discounting. However, multiple statistically-significant correlations were observed particularly among marijuana use measures. The following sections compare these findings to the existing literature and outline potential explanations for discrepancies.

Anhedonia and Delay Discounting

The existing literature indicates that depressed individuals tend to discount at systematically different rates compared to healthy controls. Depressed individuals have been shown to discount the value of future rewards more steeply, perhaps due to a sense of hopelessness for the future (Beck, 1979; Pulcu et al., 2014), as well as less steeply, likely due to a lack of pleasure in response to immediate rewards (Berenbaum & Oltmanns, 1992; Wacker et al., 2009; Lempert & Pizzagalli, 2010). The present study sought to explore the steeper discounting theory, as it assessed the anhedonia (lack of pleasure) aspect of depression. The

present findings are neither consistent nor inconsistent with the existing literature, as depressed individuals were not present in the sample. The present study assessed a general sample of college students lacking in high anhedonia scores, while past research involved participants from clinically depressed populations.

Cannabis Use and Delay Discounting

The present study observed no significant association between problematic marijuana use and delay discounting, although it is important to note that participants who indicated using the greatest amounts of marijuana per week were excluded due to a low number of participants in these groups. Nonetheless, this lack of association is consistent with the limited literature on discounting in marijuana users, which indicates that there is little to no association (Johnson et al., 2010; Peters et al., 2013). Cannabis differs from other drugs of abuse in that individuals dependent on substances including tobacco, alcohol, and cocaine have been shown to discount the value of future rewards more steeply (Yi, Mitchell, & Bickel, 2010). The present findings suggest that cannabis-dependent individuals may be less impulsive than individuals dependent on substances with higher abuse potential.

Anhedonia and Cannabis Use

Previous findings have also indicated that depressive symptoms are more prevalent within cannabis-dependent populations (Grant et al., 1995; Repetto et al., 2008; Horwood et al., 2012). The present study failed to observe this association, likely due to the low number of participants in high marijuana use groups as well as high anhedonia groups. Conversely, other studies have also found no correlation between cannabis use and depressive symptoms (Brook et al., 1998; Harder et al., 2006; Harder et al., 2008; Johnson et al., 2009).

One explanation for the lack of association between cannabis use and depression may be

related to the use motives of cannabis-dependent populations; it has been theorized that depressed individuals use cannabis as a form of self-medication (Bovasso, 2001; Denson & Earleywine, 2006; Wash et al., 2013). In this case, marijuana users would exhibit fewer depressive symptoms because of marijuana use rather than exacerbated depressive symptoms (Denson & Earleywine, 2006). In the present study, assessing participants for marijuana use motives would have helped to determine if self-medication motives influenced the lack of association between cannabis use and anhedonia.

While the multiple regression analysis revealed that neither marijuana use amount nor anhedonia were significant predictors of delay discounting, a significant quadratic trend was observed for weekly marijuana use amount on discounting. Although the present sample is lacking participants in higher use groups, evidence of a dose-dependent relationship between use amount and discounting can be observed in Figure 3 (page 35). This is an important observation because traditional behavioral pharmacology studies the dose of any substance as the primary variable for determining behavioral outcomes (Byrne & Poling, 2000). The quadratic trend observed in the present sample indicates that a dose-dependent effect may be present in a sample with a wider range of weekly use amounts, overall suggesting that marijuana use amount (dose) could serve as a predictor for discounting.

Marijuana Use Measures

The correlational analysis among all variables revealed that statistically-significant correlations were present primarily among marijuana use measures. Specifically, weekly marijuana use amount was significantly correlated with age of first marijuana use, DSM-V criteria for cannabis use disorder, and MPS score. MPS score was also significantly correlated with age of first marijuana use and DSM-V CUD criteria. Finally, DSM-V CUD was

significantly correlated with age of first marijuana use.

The fact that weekly marijuana use amount was significantly associated with three of the other marijuana use measures is an important finding because it serves as further support for the dose-dependent effect. In other words, the more marijuana an individual uses per week, the more likely they are to fulfill more criteria for cannabis use disorder and experience more marijuana-related problems. This finding could be useful for future cannabis research because studying dose as the predictor variable could lead to discoveries regarding behavioral effects of cannabis over a range of dose amounts.

Study Limitations

Limitations of the present study include expectancy theory, which refers to the fact that measures of marijuana use were presented to participants before completing the delay discounting tasks. Research has shown that participants who are administered a THC placebo discount less as a means of compensating for the expected effects of THC (Metrik et al., 2012). Expectancy theory may have had a similar effect in the present study, motivating participants to make less impulsive choices following disclosure of their marijuana use patterns. Further, the discounting task was not self-adjusting according to choices made, which is a feature that is typically used in modern discounting research. Finally, the nature of the study did not allow for a high degree of environmental control. The researchers were unable to control the setting in which the participants chose to complete the survey, nor the sobriety status of participants at the time of completion; in other words, participants may have completed the survey in a distracted environment, and it is possible that current marijuana users may have been under the influence at the time of participation.

Conclusion

Although no statistically-significant associations were observed among anhedonia and cannabis use, discounting and cannabis use, or anhedonia and discounting, the present study nonetheless made valuable contributions to the cannabis research literature. The data analysis revealed the importance of marijuana use amount as a predictor variable for behavioral outcomes. The present literature tends to overlook the importance of cannabis dose although traditional behavioral pharmacology has recognized dose amount as a critical component of drug research (Byrne & Poling, 2000). Future cannabis research should study marijuana use amount as the predictor variable in order to better understand the behavioral outcomes for users across a range of use amounts.

The present findings regarding discounting among cannabis users support the existing literature, which indicates that little to no association exists. Since delay discounting tasks serve as a measure of impulsivity, the overall implication is that cannabis users are not more impulsive than non-drug users. Cannabis seems to differ from other drugs of higher abuse potential including nicotine, tobacco, and cocaine, which have been associated with more impulsive users (Yi, Mitchell, & Bickel, 2010). Additionally, since cannabis was not associated with anhedonia, the present study also found preliminary evidence to support the existing theory that cannabis users may be self-medicating for depressive symptoms (Bovasso, 2001; Denson & Earleywine, 2006; Wash et al., 2013).

Although further research is needed to support these findings, the implication that cannabis users are not as impulsive as users of drugs with higher abuse potential along with the preliminary evidence that individuals may be relieving depressive symptoms through cannabis use serve to support the broad argument that the status of cannabis as a Schedule I drug should

be reconsidered (DEA). The DEA classifies Schedule I drugs as those that have high abuse potential and do not provide any approved medical benefits. However, there is expanding evidence that cannabis differs from drugs of higher abuse potential in terms of behavioral outcomes. In addition, there is expanding support for the theory that cannabis use could serve to relieve depressive symptoms. Future research should examine the use motives of cannabis-dependent individuals in order to identify instances of self-medication and potentially provide support for the rescheduling of cannabis.

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