Coping Motives Associated with Affect, Anxiety, and Depression After Cannabis Use in Young Adults: An Ecological Momentary Assessment Study

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Author's Declaration

I hereby declare that I am the sole author of this Dissertation. This is a true copy of the Dissertation, including any required final revisions, as accepted by my examiners.

I understand that my Dissertation may be made electronically available to the public.

Abstract

Background: Many young adults report engaging in cannabis use to manage their mood, or affect, and psychiatric symptoms of anxiety and depression. Previous research indicates that individuals may experience positive acute effects associated with cannabis use that obscure the long-term detrimental effects, although findings are mixed. This may be because the acute impacts of cannabis use are related to Cannabis Use Disorder (CUD), implying that changes are primarily related to the alleviation of withdrawal symptoms. Acute effects could also be related to coping motives, where individuals use cannabis in response to any distressing state, including but not limited to withdrawal symptoms. **Method:** The present study examined how symptoms of CUD and momentary coping motives are associated with acute changes in affect and symptoms of depression and anxiety (e.g., anhedonia, worry) through multiple, short assessments completed multiple times throughout the day (i.e., ecological momentary assessments; EMA) before and after engaging in cannabis use. **Results:** Individuals with CUD did not display significant increases in negative mood or symptoms of anxiety and depression before or after cannabis use. Those with momentary coping motives showed significant increases in negative affect and symptoms of anxiety and depression before use and decreases in negative affect and symptoms of anxiety and depression after use as compared to those with other motives. **Conclusion:** Results of the present study add to the body of evidence supporting that motives for cannabis use impact the acute effects. Further, that positive acute effects of cannabis use may not be solely related to alleviation of withdrawal symptoms seen in those with CUD, but rather, engaging in cannabis use to manage any distressing state more broadly (i.e., coping motives).

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List of Abbreviations

ANOVA: Analysis of Variance

APA: American Psychiatric Association

CBD: Cannabidiol

CI: Confidence Interval

CUD: Cannabis Use Disorder

CUDIT-R: Cannabis Use Disorder Identification Test – Revised

EMA: Ecological Momentary Assessment

GAD-2: Generalized Anxiety Disorder Screener-2

GLMM: Generalized Linear Mixed Model/Modeling

M: Mean

MMM: Marijuana Motives Measure

MPI: Marijuana Problem Index

PANAS: Positive and Negative Affect Schedule

PHQ-2: Patient Health Questionnaire-2

SD: Standard Deviation

SE: Standard Error

THC: Tetrahydrocannabinol

List of Symbols

p: Probability

F: Score on the F-distribution

β: Beta coefficient; Measure of effect size

α: Chronbach's alpha; measure of internal consistency

Ecological Momentary Assessment of Cannabis Use, Affect, and Psychiatric Symptoms in Young Adults

The use of cannabis to modify affect and psychiatric symptoms of anxiety and depression is commonplace (Bonn-Miller, Boden, Bucossi, & Babson, 2014), although a comprehensive understanding of the relationship between cannabis use, affect, depression, and anxiety remains elusive due to its complexity. The introduction of this paper provides a comprehensive examination of the research on the relationship between cannabis use, affect, and psychiatric symptoms which was used to inform the hypotheses and methodology of the present study. This includes a review of the following: 1) cannabis use among youth; 2) relevant contextual factors (i.e., legalization, COVID-19); 3) rates of cannabis use for symptom and mood management; 4) short- and long-term associations between cannabis, affect, and psychiatric symptoms of anxiety and depression; and 5) variables that impact these relationships (e.g., cannabis use disorder, motives).

Cannabis and Use Among Young Adults in Canada

Rates of cannabis use among young adults tend to be higher than in other age demographics. According to the 2021 *Canadian Cannabis Survey*, the mean age of initiating use of cannabis was 19.5 years old for males and 20.4 years old for females (Government of Canada, 2021). The same survey indicated cannabis use in the past year was more prevalent among youth aged 15 to 19 (37%) and young adults aged 20 to 24 (49%) as compared to adults aged 25 years and older (22%). Also, people who reported going to school as their main activity in the past week at some point during the past year (35%) used cannabis at a higher proportion than those who selected a different activity (25%; Government of Canada, 2021). This indicates that young adult students are among the most likely to be engaging in cannabis use.

Cannabis Use to Modify Affect or Psychiatric Symptoms

Based on the literature, adults often access medical cannabis with the expectation that it will lead to improvements in their psychiatric symptoms of anxiety and depression. Leung et al. (2022) analyzed data from the *2018 International Cannabis Policy Study* and found that among individuals who engaged in self-reported medicinal cannabis use in Canada and the United States, the most common mental health reasons for use were anxiety (52%) and depression (40%). A study conducted in Quebec, Canada surveyed individuals using cannabis purchased from a legal recreational store to self-medicate and found 70% reported use for anxiety and 37% for depression (Asselin et al., 2022). Among these individuals, most reported smoking cannabis (81%) rather than other modes of administration, and 38% reported using strains high in Tetrahydrocannabinol (THC; >20%; Asselin et al., 2022). Another Canadian study that examined authorized medicinal cannabis use (i.e., prescribed by a physician) between 2014 and 2019 found that 33% of those in Alberta and 39% of those in Ontario reported use for anxiety and/or depression (Lee et al., 2021). This indicates that not only cannabis users, but their prescribing physicians believe that cannabis use can be helpful for managing psychiatric symptoms of anxiety and depression, at least for some individuals. People also frequently decide to reduce or eliminate their psychiatric medications in favor of cannabis use, suggesting that cannabis is often seen as superior to prescribed medications for the purpose of anxiety and depressive symptom reduction (Corroon, Mischley, & Sexton, 2017; Lucas et al., 2016; Piper et al., 2017; Sexton, Cuttler, Finnell, & Mischley, 2016). These various sources highlight that cannabis is often being used and prescribed for anxiety and depressive symptom management.

The Impact of Legalization in Canada

Various contextual factors impact the present state of cannabis use among youth and for mood and symptom management. In Canada, this includes the legalization of cannabis at the federal level, initially for medicinal use in 2001, and subsequently for recreational use in 2018. The legalization of recreational cannabis use has been associated with reduced cost, increased availability, and increased potency (Hall & Lynskey, 2020). For example, in terms of availability, there are currently 13 stores authorized to sell recreational cannabis in Thunder Bay, Ontario, where this study took place (Ontario Cannabis Store, 2022). For comparison, there are only four Liquor Control Board of Ontario (LCBO) locations in the city (LCBO, 2022); the only stores in Ontario permitted to sell hard alcohol.

Legalization and regulation of cannabis is also associated with increased safety for users in some regards. Specifically, in Canada, those who engage in cannabis use no longer risk being charged with a criminal offense for possession of less than 30 grams. Additionally, the risk associated with potentially contaminated or "laced" cannabis is completely removed with the regulations associated with cannabis sales in Canada, greatly increasing safety associated with consumption. This means that the likelihood of individuals experiencing certain symptoms of Cannabis Use Disorder (CUD; i.e., spending a lot of time accessing cannabis use, experiencing negative consequences; American Psychiatric Association [APA], 2013) may be decreased for those accessing cannabis through the legal market.

At the same time, cannabis legalization has been associated with increasingly high levels of THC, as the consumer demands for such cannabis are high (Hall & Lynskey, 2020). Given that Canada's Lower-Risk Cannabis Use Guidelines recommend limiting the THC potency of the

cannabis consumed (Fischer et al., 2017), the increased availability of higher potency cannabis may increase the risk for those engaging in cannabis use.

At present it is unclear exactly what the impacts of legalization are in terms of rates of use, as there is limited research evidence to date. However, likely due to increased accessibility and the increased perception of safety, individuals who previously did not engage in cannabis use are feeling more able to do so. A study by Turna et al. (2021) examined the impact of legalization of cannabis in Canada on patterns of use and found that adults who previously were nonusers began engaging in cannabis use after cannabis became legal. Melchior et al. (2019) conducted a metanalysis and found that cannabis legalization was associated with a small increase in levels of cannabis use among youth. Additional studies also indicate adults, and not adolescents increased cannabis use after legalization (Hall & Lynskey, 2020; Smart & Pacula, 2019). However, findings are more mixed as to whether those who already engaged in cannabis use before legalization changed their consumption. The same study by Turna et al. (2021) found decreases in use after legalization among those who were already engaging in cannabis use pre-legalization. Such findings indicate that cannabis use may have increased as a results of legalization, but not universally.

In relation to how legalization and potential increases in use may be impacting mental health difficulties in those engaging in use, this has yet to be fully addressed in the literature. The only research available thus far provides some indication that legalization is associated with increased rates of CUD, although findings are mixed (Cerdá et al., 2020; Leung, Chiu, Stjepanović, & Hall, 2018; Smart & Pacula, 2019). This again highlights the potential risks for cannabis users associated with cannabis legalization.

The Impact of COVID-19 on Cannabis Use

An additional impact on cannabis use across the world has been the COVID-19 pandemic. Both its presence and associated mitigation measures has resulted in negative impacts on the mental health of many Canadians, with one study finding 31% met criteria for Generalized Anxiety Disorder (GAD), 29% for Major Depressive Disorder (MDD), and 63% reported significantly high levels of stress during this time (Turna et al., 2021). In Canadian young adults, 43% reported anxiety-related symptoms and 33% reported depression-related symptoms during the COVID-19 pandemic (Gill et al., 2022). Results from the *Canadian Perspective Survey Series* indicate that, among Canadians 15 and older, the number experiencing anxiety rated as high to extremely high quadrupled (from 5% to 20%) and the number reporting high levels of depression more than doubled since the onset of COVID-19 (from 4% to 10%; Rotermann, 2020). Increases in anxiety were often related to COVID-related fears and increases in depressive symptoms due to social isolation (Bartel, Sherry, & Stewart, 2020; Turna et al., 2021).

Canadian emerging adults also increased their cannabis consumption during the COVID-19 pandemic. Specifically, the *Canadian Perspective Survey Series* indicated that 11.6% of Canadians aged 15 to 34 increased their consumption of cannabis during the pandemic, and that this age group was more likely to have increased their consumption of cannabis than those aged 35 to 54 (Rotermann, 2020). This was particularly true for those with anxiety and depression (Dozois & Mental Health Research Canada, 2021). Canadians who rated their mental health status as fair or poor were about twice as likely to report cannabis use than those who rated their mental health as high (Rotermann, 2020). Also, cannabis use was significantly predicted by self-isolation and coping with depression motives for cannabis use during the pandemic (Bartel et al.,

2020). Overall, studies indicate that Canadian young adults were more likely to have increased their cannabis use during the pandemic, particularly among those with mental health difficulties.

While COVID is associated with an increase in cannabis use, increasing use during COVID could also be explained by the increased availability of cannabis in Canada resulting from legalization. While legalization officially occurred in late 2018, government-approved recreational cannabis stores were limited or not available for several months (Myran et al., 2021). For example, Toronto, Ontario, one of the largest Canadian cities, opened its first legal cannabis store in April 2019 (Toronto Star, 2019). Thunder Bay, Ontario, where the current study took place, did not open its first cannabis store until March 2020 (CBC News, 2020). There was also a 10-fold increase in the number of cannabis stores in Canada between November 2018 and April 2021, from 158 to 1,792 (Myran et al., 2021). These stores were also generally included in the list of essential services along with liquor stores; therefore, they were open throughout the pandemic. Increased availability occurring at the same time as the onset of the pandemic likely further explains reported increases in use among Canadian emerging adults during this period.

Misuse Liability

When considering use of cannabis for mood and symptom management it is important to also consider the misuse liability, more commonly referred to as abuse liability in the psychopharmacological literature, of cannabis. Misuse liability, or misuse potential, refers to the likelihood that an individual will use a given drug to achieve a desired psychological or physiological effect, potentially leading to chronic use despite negative consequences (i.e., substance use disorder; U.S. Department of Health and Human Services Food and Drug Administration Center for Drug Evaluation and Research, 2017). Cooper and Abrams (2019)

conducted a literature review on the misuse liability of cannabis and found that across several studies using varying methods of quantification (e.g., self-administration, visual analog scales) the subjective effects associated with intoxication and positive drug ratings were dose-dependent, indicating a high likelihood of misuse liability associated with cannabis use.

The mode of administration and the subcomponents of cannabis have different levels of misuse liability associated with them. Specifically, the misuse potential of smoked THC was found to be higher than orally administered synthetic THC (i.e., dronabinol), with the latter showing little evidence of misuse liability (Cooper & Abrams, 2019). Other orally administered synthetic THC products were also found to have low misuse potential (e.g., nabilone; Ware & St Arnaud-Trempe, 2010). Cannabidiol (CBD) is typically associated with low misuse potential, even lower than synthetic THC products like dronabinol (e.g., Epidiolex; Calhoun, Galloway, & Smith, 1998). CBD is also associated with low misuse liability in high-risk polysubstance using populations (Schoedel et al., 2018). In contrast, there is research that indicates that orally administered CBD results in dose-dependent effects on mood and subjective drug effects associated with misuse liability (Arout, Haney, Herrmann, Bedi, & Cooper, 2021). Given these findings, any benefits from cannabis in terms of mood and symptom management need to be balanced against the likelihood of developing CUD, particularly for those who smoke cannabis and/or use high THC cannabis products.

Cannabis Use, Anxiety, and Depression

Despite the number of individuals who use cannabis for the purpose of alleviating symptoms of anxiety and depression, and the medical professionals who prescribe cannabis for this purpose, research to date has found that cannabis use is associated with increased rates of psychiatric diagnoses and associated symptoms. In a cross-sectional study, Cheung and

colleagues (2010) found that cannabis use in the past 12 months was associated with increased levels of anxiety and depressive disorders in a representative sample of adults in Ontario. Dorard, Berthoz, Phan, Corcos, and Bungener (2008) found that cannabis misuse was associated with greater symptoms of depression and anxiety in adults as compared to healthy controls. There are some contradictory findings however, as a cross-sectional study by Denson and Earleywine (2006) found a different relationship, where weekly and daily cannabis users displayed lower level of depressed affect when compared to nonusers. These cross-sectional studies are limited in explaining the relationship between cannabis use, anxiety, and depression as they do not examine the relationship between these variables temporally. Also, findings among the studies are mixed.

Looking at the temporal relationship between cannabis use and depression, Womack, Shaw, Weaver, and Forbes (2016) used a longitudinal design and found that in a general sample of young adults with mild depression, cannabis use was associated with increased depression symptoms over time, and these individuals often increased their rate of use over time. In another longitudinal study by Bovasso (2001), individuals with no symptoms of depression who misused cannabis were four times more likely to report depressive symptoms approximately 15 years later as compared to those who did not misuse cannabis. Additionally, depressive symptoms did not predict cannabis misuse among individuals who did not misuse cannabis at baseline (Bovasso, 2001). This supports the premise that cannabis misuse may be a causal factor in the development of depressive symptoms, while depressive symptoms are not a causal factor in the development of cannabis misuse. This also suggests that individuals who have depressive symptoms and engage in cannabis use will not necessarily go on to misuse cannabis. In a three-year prospective study by Feingold, Weiser, Rehm, and Lev-Ran (2015) using data from the *National Epidemiologic Survey on Alcohol and Related Conditions*, baseline major depressive

disorder was associated with later cannabis use. Cannabis use was not significantly associated with increased incidence of major depressive disorder, contradicting previous longitudinal findings. As in the cross-sectional research, longitudinal studies generally indicate an adverse effect where cannabis use is uniquely associated with increased anxiety and depression years later. This is both in terms of severity or frequency of symptoms and diagnoses. The adverse relationship is not found uniformly across all studies though, as two studies found the opposite relationship, where anxiety and depression predicted subsequent cannabis use.

Evidence from reviews and metanalyses further show the adverse effects of cannabis use. In a review of both cross-sectional and longitudinal studies, Kedzior and Laeber (2014) examined the relationship between cannabis use and anxiety and found that anxiety, including the presence of the disorder and symptom severity, was positively associated with cannabis use and CUD. Cannabis use at baseline was also significantly associated with anxiety at follow-up. A review by Degenhardt, Hall, and Lynskey (2003) also found that across studies examining the relationship between cannabis use and depression, heavy cannabis use was associated with increased rates of depression, and early onset, regular cannabis use was associated with later depression, again supporting the hypothesis that cannabis use is associated with increases in symptoms. The review found little evidence that depression was associated with later cannabis use. A meta-analysis conducted by Lev-Ran et al. (2013), including only longitudinal studies, found that individuals engaging in heavy cannabis use (i.e., those with CUD or those who engage in cannabis use at least weekly) were at an increased likelihood of developing a depressive disorder compared to mild or nonusers. This study indicates that the amount of cannabis being used likely influences the risk of subsequent depression. Reviews and metanalyses of cross-sectional and longitudinal studies generally support an adverse effect of cannabis use on

depressive and anxiety symptoms and disorders. These stand as compelling evidence that cannabis use is detrimental to mental health over long periods of time.

Current research provides limited evidence for cannabis' utility in reducing psychiatric symptoms of anxiety and depression. Reviews of the literature on cannabis for therapeutic purposes provide no clear indication of its effectiveness for addressing symptoms of anxiety and depression (Walsh et al., 2017; Turna, Patterson, & VanAmeringen, 2017). Despite this, medicinal cannabis patients tend to report improvements. Webb and Webb (2014) found that 50% of individuals using medicinal cannabis reported a decrease in symptoms of anxiety. Swift, Gates, and Dillon (2005) also found 30% of individuals reported relief from depression and 30% reported relief from anxiety. This provides some evidence that there are changes in anxiety and depression not being captured in the correlational and longitudinal research, at least among medicinal cannabis users.

Studies of cannabis cessation provide further evidence that cannabis use leads to increases in psychiatric symptoms, specifically depressive symptoms. A study conducted by Hser et al. (2017) examined the impact of reductions in cannabis use on anxiety and depression among adults being treated for CUD and found that individuals who decreased their cannabis use across the 12 weeks of treatment displayed improvements in symptoms of anxiety and depression (Hser et al., 2017). The authors noted that while individuals frequently indicate cannabis use is helpful for managing psychiatric symptoms, their results indicate that reducing cannabis use would be the most effective way to improve symptoms. Another study, which included individuals accessing Cognitive Behavioural Therapy for depression and substance misuse, also indicated that reductions in cannabis use, and change in CUD diagnosis, resulted in improvements in depressive symptoms (Adamson et al., 2015). Moitra, Anderson, and Stein

(2016) found that cessation of cannabis use was associated with improved depressive symptoms in female young adults as well. Further, Dawes, Sitharthan, Conigrave, Phung, and Weltman (2011) also found that abstinence from cannabis in the context of inpatient treatment was associated with significant improvements in anhedonia from the first to fifth day of treatment. If cannabis use were to be associated with improvements in symptoms of depression, then cessation of cannabis use should result in increased symptomatology, like when an individual using psychopharmacological medication ceases use. This is not the case in the available literature on depression. It is noteworthy that these studies tend to focus on heavy cannabis use, rather than low to moderate use, which may influence the results. Studies also tend to involve treatment seeking individuals, who likely exhibit more substance-related difficulties than those not accessing treatment.

In the case of anxiety, individuals using medicinal cannabis who report improvements in their anxiety symptoms when engaging in cannabis use, report a return in symptoms after cessation of use (Swift et al., 2005). This is potential evidence for the utility of cannabis in improving anxiety, although the increase in symptoms could also be related to withdrawal, which is associated with increased anxiety (APA, 2013). At present, the research on cessation of cannabis use does not allow for clear conclusions about the influence of cannabis on anxiety symptoms.

The results presented indicate that long-term cannabis use is generally associated with increases in psychiatric symptoms of anxiety and depression, and cessation is associated with a reduction in psychiatric symptoms of depression, although the influence of cessation on anxiety is unclear. The findings appear to relate primarily to individuals engaging in heavy cannabis use (i.e., those with CUD or those who engage in cannabis use at least weekly), with one review

indicating low risk associated with infrequent cannabis use. However, some have concluded that any relationship between psychiatric disorders and cannabis use is generally an adverse relationship (Hanna, Perez, & Ghose, 2017). This statement seems to directly contradict individuals who report cannabis use to improve psychiatric symptoms.

Specific Symptoms of Anxiety and Depression

One potential explanation why individuals report coping motives despite research indicating substance use is associated with higher rates of anxiety and depressive symptoms is that individuals may experience changes in affect or mood, rather than overall symptomatology more broadly. Individuals with depression tend to show lower positive affect and increased negative affect compared to healthy controls, indicating a correlation between affect and a diagnosis of depression (Peeters, Berkhof, Delespaul, Rottenberg, & Nicolson, 2006). Although they are correlated, such affective symptoms need not be included in all presentations of the disorder. A diagnosis of major depressive disorder can be made with or without the presence of depressed mood if anhedonia is present (APA, 2013). The possibility exists that affect, or affective symptoms, can vary independently from behavioural or cognitive symptoms of depression as well, with cannabis differentially influencing affective symptoms compared to other symptoms.

In the same manner, individuals with anxiety disorders may present with increased negative affect, but this is not a required feature, as excessive, uncontrollable worry is the key criterion (APA, 2013). Research indicates that individuals with generalized anxiety disorder only show heightened anxious mood in response to stressful situations, with levels of anxiety comparable to healthy controls during non-stressful situations (Hoehn-Saric, McLeod, Funderburk, & Kowalski, 2004; Tan et al., 2012). It is possible that mood or affect and other

more essential features of anxiety, such as worry, may be differentially affected by cannabis use. If individuals experience an improvement in affect after substance use without an associated improvement in other symptoms (e.g., negative affect is decreased but worry and difficulty concentrating remains unchanged or worsens), this may explain why individuals report using cannabis to improve symptoms, despite an overall increases in depressive and anxiety symptoms.

Long-term Associations Between Cannabis Use and Specific Symptoms

Research on the relationship between affect specifically and substance use is mixed. The previously mentioned cross-sectional study by Denson and Earleywine (2006) found increased positive affect and decreased depressed affect among individuals who engage in cannabis use. Another cross-sectional study that examined affect and cannabis use in undergraduate students found no association between negative or positive affect and cannabis use overall (Allen & Holder, 2014). Due to the limited number of studies, the cross-sectional nature, and the mixed findings, it is difficult to determine if cannabis use is associated with overall decreased rates of negative affect or increased rates of positive affect when compared to nonusers.

The relationship between cannabis use and rumination has never been specifically examined in the literature. This contrasts the broader substance use literature, which includes multiple studies on overall substance use and its relationship with rumination. A cross-sectional study by Willem, Bijttebier, Claes, and Raes (2011) examined subtypes of rumination in adolescents and found that higher levels of the brooding subtype was associated with higher levels of alcohol use, whereas higher levels of the reflection subtype was associated lower levels of general drug use. In a study that examined the reciprocal relationship between drug use and rumination in 14- to 17-year-olds over the course of four years, rumination predicted future substance misuse, but substance misuse did not predict future rumination (Nolen-Hoeksema,

Stice, Wade, & Bohon, 2007). Expanding on this study, Skitch and Abella (2008) found that rumination predicted substance use among older adolescents following elevations in negative life events. Hopelessness showed a similar relationship to rumination, with levels of hopelessness predicting early onset and future cannabis use (Malmberg et al., 2010). Studies continue to point to substance use being associated with increased anhedonia, similar to symptoms of depression more broadly (Bovasso, 2001; Cano et al., 2017; Dorard et al., 2008). Research on cannabis use and anhedonia does include some mixed findings, as a study by Leventhal et al. (2017) found anhedonia in mid-adolescence was associated with future escalation in cannabis use, but cannabis use escalation was not associated with future anhedonia. Based on the available literature, rumination, hopelessness, and anhedonia generally worsens with cannabis use, although these findings are not universal.

In terms of the association between cannabis use with symptoms of anxiety, few studies that examined specific symptoms independently and longitudinally could be identified, as researchers almost universally opted to analyze overall severity of symptoms or anxiety disorder diagnosis. For example, research on worry has not occurred in relation to cannabis use. However, limited research has examined trait worry and cigarette use. Findings indicate a similar relationship to that of rumination, where tendency to worry is associated with increased likelihood of future nicotine use (Farris et al., 2016). Again, the available literature suggests that substance use is associated with a worsening of at least one specific symptom of anxiety (i.e., worry).

Regarding whether symptoms of anxiety and depression differ from one another in their relationship with cannabis use, Johnson, Bonn-Miller, Leyro, and Zvolensky (2009) found that anhedonic depression and anxious arousal symptoms show different relationships with cannabis

use frequency and coping motives cross-sectionally. In their study, anxious arousal symptoms, but not anhedonic depression symptoms, were significantly and uniquely associated with the frequency of cannabis use (Johnson et al., 2009). This study indicates that symptoms of anxiety and symptoms of depression may show different relationships with frequency of use and rates of coping motives for use.

The research reviewed indicates that different symptoms of anxiety and depression appear to show different relationships with cannabis use. Some symptoms increase the likelihood of future cannabis use (e.g., rumination, worry, hopelessness), while cannabis use is associated with increases in the severity of some symptoms (e.g., anhedonia). This research highlights the need to examine how cannabis use influences a variety of symptoms of anxiety and depression separately from each other, and mood more broadly. A summary of the literature on specific symptoms of anxiety and depression and their longitudinal relationship with cannabis use is displayed in Table 1.

Table 1

Literature on the Longitudinal Relationship between Cannabis Use and Specific Symptoms of Anxiety and Depression

Symptom	**Relationship with Cannabis Use/Substance Use**
Positive Affect	• Higher among cannabis users (Denson & Earleywine, 2006). • No difference between users and nonusers (Allen & Holder, 2014).
Negative Affect	• Lower among cannabis users (Denson & Earleywine, 2006). • No difference between users and nonusers (Allen & Holder, 2014).
Rumination	• Higher levels of the brooding subtype associated with higher levels of alcohol use; higher levels of the reflection subtype associated with lower levels of general drug use (Willem et al., 2011). • Rumination predicted increased substance use; substance use did not predict rumination (Nolen-Hoeksema et al., 2007). • Increased rumination led to increased substance use (Skitch & Abella, 2008).
Hopelessness	• Hopelessness predicted future cannabis use (Malmberg et al., 2010).
Anhedonia	• Substance use is associated with increased anhedonia (Bovasso, 2001; Cano et al., 2017; Dorard et al., 2008). • Anhedonia associated with future escalation in cannabis use; cannabis use escalation was not associated with future anhedonia (Leventhal et al., 2017).
Worry	• Increased worry associated with increased cigarette use (Farris et al., 2016)

Ecological Momentary Assessment of Cannabis Use

The difference between the acute and long-term effects of cannabis use may further explain why individuals report substance use to improve their symptoms of anxiety and depression despite contrary longitudinal research evidence, beyond differences in specific symptoms. Womack and colleagues (2016) support this claim, indicating that their findings may have been due to the study design, as "self-medication patterns may be better observed in short-term prospective studies rather than studies with assessment points several years apart" (p. 295). Research that looks at the acute effects of cannabis has the potential to further explain the relationship between cannabis use, affect, and psychiatric symptoms beyond the abundance of cross-sectional and longitudinal studies currently available.

Many studies, and a well-validated, commonly used measure of anxiety highlights the difference between the temporary state anxiety (i.e., "how you feel *right now*") and the more long-standing quality of trait anxiety (i.e., "how you *generally* feel"; State-Trait Anxiety Inventory; STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). State anxiety is characterized by feelings of apprehension, tension, nervousness, and worry, while trait anxiety is the tendency to experience state anxiety more broadly. Findings from various studies indicate that during paradigms intended to evoke emotion, the state anxiety scale shows change, whereas the trait anxiety scale does not (Kendall, Finch, Auerbach, Hooke, & Mikulka, 1976; Metzger, 1976). Typically, cross sectional and longitudinal studies examine trait anxiety, while studies looking at the acute effects of cannabis use examine state anxiety.

Research that examines the acute or momentary effects of cannabis use on affect has become more common with the advent of experience sampling or ecological momentary assessment. Ecological momentary assessment (EMA), developed by Stone and Shiffman

(1994), includes three key aspects: 1) momentary real-time assessment, 2) real-world data, and 3) repeated assessments (Shiffman, Stone, & Hufford, 2008). EMA serve the purpose of obtaining ecologically valid data about behaviour while reducing recall errors typically associated with longitudinal research designs (Moskowitz & Young, 2006; Shiffman, 2009). EMA methods have been validated for use in substance using populations, allowing for use of assessments when individuals are engaging in substance use in their natural environments (Moskowitz & Young 2006; Shiffman, 2009; Wray, Merrill, & Monti, 2014). Through the use of EMA, individuals are able to report information regarding their affect and substance use immediately after engaging in substance use from any location, increasing the likelihood of accuracy over studies that require retrospection after longer time frames, and the ecological validity over studies that examine the effects in laboratory settings.

Another benefit of EMA methods is the potential for both user- and signal-initiated assessments, that is, assessments that require the individual to initiate an EMA through the EMA software on their personal electronic device, or assessments that prompt individuals to complete an EMA using a notification on their device (Shiffman, 2009). This aids in ensuring that individuals complete assessments at the time intended by the researchers, without the participants having to remember to complete assessments at a designated time unprompted or using an email reminder. In addition, EMA allow the potential for people to serve as their own controls, where individuals can complete a user-initiated session to compare to future random or signal-initiated sessions.

Initial literature using EMA methods to examine cigarette smoking supports the belief that a different relationship emerges when examining substance use at the momentary level. Research examining daily reports of mood and cigarette smoking has found no relationship

between the two (Shiffman, 2009; Shiffman and Waters, 2004). It is only through using EMA conducted repeatedly throughout the day that a relationship between mood and cigarette smoking becomes evident, where negative affect is associated with increased likelihood of smoking and predicts lapses in smoking quit attempts (Carter et al., 2008; Shiffman, 2009). Specifically, negative affect begins increasing about six hours before a lapse occurs (Shiffman & Waters, 2004). Such research highlights the importance of using multiple assessments throughout the day to fully examine changes in mood associated with cannabis use.

Pharmacokinetics of Cannabis

As this study seeks to examine the acute effects of cannabis use, it is necessary to determine when these effects are most likely to occur. Examining research on the pharmacokinetics of cannabis use can aid in this endeavor. When smoked, THC is rapidly absorbed through the lungs, resulting in rapidly rising levels in the blood plasma (Meyer & Quenzer, 2005; Zamarripa, Vandrey, & Spindle, 2022). Peak concentrations are reached within minutes of smoking, and then steadily decrease over the course of the next hour due to a combination of metabolism in the liver and accumulation of the drug in the body's fat stores (Meyer & Quenzer, 2005). When orally consumed, cannabis results in low and variable plasma concentrations due to prolonged but poor absorption of THC, as much of it is metabolized in the gastrointestinal system before it can enter general circulation (Meyer & Quenzer, 2005; Zamarripa et al., 2022). The absorption rate is also more variable, with max blood concentrations usually occurring after 60-120 minutes (Grotenhermen 2003). As such, the method of administration is important in terms of the length of time before plasma levels increase, with smoking occurring quickly, and oral ingestion taking much longer.

In terms of subjective experience, cannabis usually begins to exert its effects within minutes of smoking. Hunault et al. (2004) found that max ratings of feeling "high" among individuals who have smoked cannabis in an experimental, laboratory setting occurs within minutes of use, with the effects of the substance being the most pronounced in the two hours after consumption. However, findings are variable, as Grotenhermen (2003) found that individuals report feeling the highest 20-30 minutes after inhalation, decreasing to low levels after three hours and back to baseline after four hours. The duration of maximal effects was found to be dose-dependent, with increasing amount of cannabis resulting in longer periods of effects (ranging from 45 to 60 minutes; Grotenhermen 2003). When taken orally, psychotropic effects usually occurred after 30-90 minutes, with maximum effects seen between two to four hours later, declining to low levels after six hours (Grotenhermen 2003). As such, acute effects of cannabis use needs to include assessments within minutes of inhalation and for up to four hours later, with longer assessment periods for orally ingested cannabis use.

While studies utilizing an experimental design are informative, allowing for more internal validity through controlling the amount and type of cannabis smoked, they lack the ecological validity associated with studies that occur outside of the research laboratory. It is possible that an individual's response to cannabis may differ in a lab setting as compared to the location where they typically engage in cannabis use and can self-select type of cannabis used (e.g., potency). In line with this, a review by Green, Kavanagh, and Young (2003) found that, across 18 laboratory studies, there were mixed findings in terms of whether participants reported increased positive affect associated with cannabis use, with some studies reporting significant increases among participants immediately after cannabis administration and others finding none (Green et al., 2003). It may be that in the laboratory setting, cannabis type and dosing is highly regulated,

whereas in EMA studies, individuals report on cannabis use where they can self-select their type of cannabis, mode of administration, and dosing, adjusting for any negative effects and maximizing positive effects. Especially given changes related to legalization, which has readily enabled individuals to determine their preferred CBD and THC potency and whether they rather use edibles or dried flower, laboratory studies may greatly underestimate the acute effects of cannabis that occur in naturalistic settings where various cannabis-related factors are self-selected.

Acute Effects of Cannabis on Affect, Anxiety, and Depression

Cannabis intoxication, as defined in the Diagnostic and Statistical Manual-5 (DSM-5), includes two or more of the following within two hours of cannabis use: bloodshot eyes, increased appetite, dry mouth, and/or tachycardia (APA, 2013). Associated symptoms of intoxication include feeling “high”, symptoms of euphoria, inappropriate laughter, grandiosity, sedation, lethargy, impairment in short-term memory, difficulty carrying out complex mental processes, impaired judgment, distorted sensory perceptions, impaired motor performance, and the sensation that time is passing slowly (APA, 2013). For some individuals, anxiety, dysphoria, or social withdrawal may occur (APA, 2013). Withdrawal from cannabis includes three or more of the following symptoms approximately one week after cessation of prolonged and heavy cannabis use: irritability, anger or aggression, nervousness or anxiety, insomnia, decreased appetite, restlessness, depressed affect, and/or physical symptoms causing discomfort (APA, 2013). Based on the DSM-5, numerous symptoms of anxiety and depression are associated with both cannabis intoxication and withdrawal, with intoxication occurring at the acute level (i.e., within two hours of cannabis use) and withdrawal occurring over a longer time span (i.e., after a week of cessation).

EMA research has examined positive and negative affect and its association with the desire to use cannabis. In a study by Shrier, Walls, Kendall, & Blood (2012), positive affect was associated with desire to use cannabis at the momentary level, and once the desire to use cannabis was present, positive and negative affect were associated with the strength of the desire. However, the study did not consider whether the individuals subsequently engaged in cannabis use once desire was present, limiting the explanatory power of these findings.

Few studies have been conducted examining positive affect before and after cannabis use. Among these studies, Shrier, Ross, and Blood (2014) found no association between cannabis use and positive affect before use. In contrast, Bhushan, Blood, and Shrier (2013) found lower positive affect before cannabis use. Dissimilar findings were also indicated by Buckner, Zvolensky, and Ecker (2013), who found positive affect was higher prior to engaging in cannabis use. Further, an examination of positive affect after engaging in cannabis use by Buckner et al. (2015) found no change in the proceeding hours. A review by Wycoff, Metrik, and Trull (2018) stated that cannabis use is not consistently associated with changes in positive affect, highlighting the mixed results emerging from the available EMA research. Based on these findings, it is unclear as to whether positive affect typically increases or decreases before and after cannabis use. These varying associations may be an indication that potential mediating or moderating factors may be influencing the effects of cannabis on positive affect.

In terms of negative affect before use, Buckner, Crosby, Silgado, Wonderlich, and Schmidt (2012) found that state anxiety, as measured by a single item affect measure, was somewhat higher in heavy cannabis users before cannabis use. Shrier et al. (2014), Bhushan et al. (2013), and Buckner et al. (2013) also found that negative affect increased prior to engaging in cannabis use. Buckner et al. (2013) further reported that when both positive and negative affect

were considered simultaneously, only negative affect remained significantly associated with subsequent cannabis use. This indicates that changes in negative affect before use likely plays a more important role in subsequent cannabis use than positive affect. Overall, EMA research to date indicates that an increase in negative affect is generally experienced before engaging in cannabis use.

Most EMA studies also have found that negative affect and symptoms of anxiety and depression decrease after use, although this finding is not universal. Looking at negative affect after use, Buckner et al. (2012) found that anxiety did not decrease significantly. However, cannabis use days were associated with lower anxiety in this study (Buckner et al., 2012). In contrast, Buckner et al. (2015) found that negative affect did decrease after use. Padovano and Miranda (2018) also found that use of cannabis produced measurable reductions in tension. Cuttler, Spradlina, and McLaughlin (2018) found participants reported a 50% reduction in depressive symptoms after engaging in medical cannabis use, and a 58% reduction in anxiety and stress, with most use episodes recorded during their study including a decrease in symptoms (i.e., depression, 89%; anxiety, 93%; and stress, 93%). The previously discussed review by Wycoff et al. (2018) also concluded that changes in negative affect do tend to occur after cannabis use, consistent with a negative reinforcement model wherein individuals use cannabis to reduce unpleasant feelings. Findings of this nature help explain why cannabis users continue to report coping motives for use despite evidence against its long-term utility for decreasing psychiatric symptoms.

Acute Effects of Nicotine on Anxiety and Depression

While evidence of the acute impact of cannabis use on anxiety and depression is limited, how nicotine use and cessation is associated with anxiety and depression has been examined with

more frequency. Studies examining nicotine cessation have suggested that individuals' relapse to nicotine use is associated with increases in negative affect, often related to withdrawal (e.g., irritability, anxiety, dysphoria; Carmody, Vieten, & Astin, 2007). Studies also indicate that individuals with anxiety disorders and depressive disorders experience greater withdrawal symptoms than those without (Carmody et al., 2007; Kassel, Stroud, & Paronis, 2003; Morissette, Tull, Gulliver, Kamholz, & Zimering, 2007). Additional studies find that withdrawal symptoms and relapse are related to anxiety sensitivity and distress tolerance (Cosci, Pistelli, Lazzarini, & Carrozzi, 2011; Johnson, Stewart, Rosenfield, Steeves, & Zvolensky, 2012; Langden et al., 2013). Therefore, it may not be the level of symptoms, but an individual's sensitivity to experiencing symptoms of anxiety and depression that predicts cannabis use.

Findings from smoking cessation studies suggest that the primary reason people experience improvements in negative affect after engaging in nicotine use is due to alleviation of withdrawal symptoms, rather than alleviation of negative affect more broadly, and individuals who engage in nicotine use mistakenly perceive this relationship as associated with improvements in negative affect universally (Perkins et al., 2010). After cessation of nicotine use, there is an initial increase in negative affect that subsequently decreases to levels lower than those exhibited while engaging in nicotine use (Perkins et al., 2010). However, some research indicates that smoking nicotine is associated with reduced negative affect and stress beyond those associated with withdrawal symptom relief, although not consistently (Kassel et al., 2003). If findings from nicotine studies are indicative of the relationship between cannabis and symptoms of anxiety and depression, then it is possible that acute improvements in symptoms are the result of alleviation from withdrawal symptoms. If this is the case, then only those who experience withdrawal symptoms, and subsequently, have higher rates of CUD, should display

improvement in symptoms after cannabis use. However, it is noteworthy that findings from the nicotine studies mentioned almost universally include individuals undertaking a cessation attempt, where withdrawal symptoms are likely. For those engaging in continuous use, they may not have the opportunity to develop withdrawal symptoms, as these typically take a longer period of abstinence to occur at a high level.

Theories on Substance Use and Affect

Various theories on how substance use is maintained through the relationship with affect and mental health symptoms have been put forth in the literature. Many of these are overlapping or essentially synonymous theories. Such theories include: the negative reinforcement model, which purports that individuals use cannabis to avoid and manage negative affect (e.g., anxiety, sadness) and use is reinforced by acute improvements in negative affect (Blume, 2001; McCarthy, Curtin, Piper, & Baker, 2010); the self-medication model, which suggests that individuals use cannabis to relieve or change negative emotion states (Blume, Schmaling, & Marlatt, 2000; Khantzian, 1997); the dual-affect regulation model, which indicates that cannabis use occurs in response to positive and negative affect depending on the context for use (Baker, Morse, & Sherman, 1987; Lynne et al., 1995); the negative affect regulation model, that states cannabis use is used to modify negative affect only (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Cooper, Kuntsche, Levitt, Barber, & Wolf, 2016; Glodosky and Cuttler 2020; Simons, Gaher, Correia, Hansen, & Christopher, 2005); and the mutual maintenance model, which indicates that individuals use cannabis to experience short-term relief from negative affective states, with cannabis use subsequently exacerbating negative affect due to withdrawal creating a “vicious cycle” (Kaysen et al., 2011; McFarlane et al., 2009; Stewart & Conrad, 2008).

EMA research on cannabis use has found confirming and disconfirming evidence for a number of these models. For example, many EMA studies have found support for the self-medication model of cannabis use (Bhushan et al., 2012; Buckner et al., 2012; Shrier et al., 2012; Shrier et al., 2014). These studies found that anxiety and negative affect increase before use, supporting the premise that individuals use cannabis in response to negative emotional states.

Findings from Shrier et al. (2012) did not align with their narrow hypothesis related to the dual-affect model. Specifically, they discussed the function of availability of cannabis use, with positive affect urges for use being present when cannabis is available, and negative affect urges when cannabis is not available. They found affect and desire to use cannabis did not vary based on drug availability. However, positive and negative affect were both independently associated with desire to use cannabis, providing some evidence for the affect-regulation model more broadly. At lower levels, as positive affect increased, likelihood of desire to use cannabis use increased, whereas at higher levels, increasing positive affect decreased desire for use (Shrier et al., 2012). The authors noted that as both affect and desire were measured at the same time (i.e., cross-sectional EMA) the temporal order cannot be assumed. In other words, the reverse relationship, where cannabis desire could predict positive affect, could also be true.

Buckner et al. (2012) reported that their findings suggest anxiety can increase cannabis craving and craving can increase anxiety, supporting a mutual maintenance model of anxiety and substance use. Specifically, the authors indicate that once difficulties with cannabis use and anxiety emerged, individuals experienced short-term relief from cannabis use, but also anxiety related to cannabis use (e.g., withdrawal, cravings) resulting in a “vicious cycle” between the two. The authors suggested that cannabis use to cope with symptoms in this manner place people

at a higher risk of cannabis-related problems and CUD (Shrier et al., 2012). In other words, use to cope is associated with increased misuse liability.

Factors Affecting the Impact of Cannabis on Affect

Frequency of Use and Cannabis Use Disorder

There are several possible explanations for the mixed findings on cannabis use and affect amongst EMA studies, one of which is the frequency of substance use. Ross and colleagues (2018) completed an EMA study where participants completed user-initiated EMA before and after engaging in cannabis use that assessed positive and negative affect. The study found that participants with cannabis dependence, as determined by DSM-IV criteria using the Adolescent Diagnostic Interview, experienced increased positive affect and decreased negative affect after cannabis use. The same study found that cannabis users who did not meet criteria for cannabis dependence experienced increased negative affect after use (Ross et al., 2018). Although not utilizing EMA, a study by Metrik, Kahler, McGeary, Monti, and Rohsenow (2011) examined the acute effects of cannabis use using an experimental design and found that the effects of cannabis on anxiety at 16 minutes after the start of smoking was influenced by the frequency of cannabis use. Individuals who frequently engaged in cannabis use were less anxious after use as compared to those who engage in less frequent cannabis use. The previously mentioned review by Green et al. (2003), which looked at the subjective effects of cannabis across 12 studies, also reported evidence that inconsistent findings may be explained by whether individuals are frequent users. Specifically, Green and colleagues (2003) found that frequent users may be less likely to experience the negative acute effects of cannabis use, and more likely to experience relaxation and other positive effects. As such, the influence of CUD diagnosis, or the frequency of use, may help to explain the variability in acute effects of cannabis use.

Type of Cannabis and Dose

The type of cannabis being consumed, specifically the levels of CBD or THC in the cannabis, has been associated with differing effects. Thomsen, Callesen, and Feldstein (2017) emphasized the importance of studying THC and CBD separately and measuring potency in studies on cannabis use, as did Hagerty, Williams, Mittal, & Hutchison (2015). Supporting these claims, a study by Martin-Santos and colleagues (2012) found that while orally administrated CBD produced very similar responses to a placebo in healthy adult males, THC produced dysphoria, increased anxiety, and increases in positive, negative, and general psychotic symptoms, dissipating over the next two hours. The authors suggested the lack of anxiolytic effects of CBD may have been due to the high dosage. This is line with other research that indicates CBD administration results in reduced anxiety at low and intermediate doses but not at high doses in preclinical studies (Lee, Bertoglio, Guimarães, & Stevenson, 2017; Blessing, Steenkamp, Manzanares, & Marmar, 2015). A review of preclinical research indicates CBD has been shown to have anti-anxiety and antidepressant-like effects in rats (de Mello Schier et al., 2014). This review concluded that more research is needed to support the antidepressant effect, but research supports the utility of CBD for anxiety reduction at moderate doses (de Mello Schier et al., 2014). More recently, laboratory studies of CBD and THC showed similar findings, with CBD showing more anxiolytic effects, and THC showing more dysphoria (Drennan, Karoly, Bryan, Hutchison, & Bidwell, 2021). Therefore, when examining cannabis use, whether the individual uses a high CBD or THC strain can greatly influence the experienced effects.

Randomized controlled trials (RCTs) including individuals with psychiatric diagnoses have also indicated acute beneficial effects of CBD for reducing anxiety. A study by Crippa and colleagues (2011), which included individuals with social anxiety disorder, found that orally

administered CBD resulted in reduced subjective anxiety and associated changes in brain activity. Another study found that, among individuals with social anxiety disorder, an oral dose of CBD resulted in reduced anxiety and decreased negative self-evaluation associated with public speaking (Bergamaschi et al., 2011). A more recent study by Masataka (2019) also found CBD oil reduced symptoms of social anxiety disorder in those diagnosed with the disorder. Similar findings have been reported by subsequent studies employing similar methodologies in nonclinical samples (Linares et al., 2018; Zuardi et al., 2017). Reviews regarding the potential for CBD to treat psychiatric and physical illnesses show some promise at the acute level (Bonaccorso, Ricciardi, Zangani, Chiappini, & Schifano, 2019; White, 2019). These studies indicate that CBD may be the primary component of cannabis that leads individuals to report decreased symptoms of anxiety. Studies which look at the use of cannabis more broadly typically do not account for the type of cannabis being used, providing another potential explanation for mixed findings.

Research on THC indicates that there may be some therapeutic benefit associated with this compound as well. Similar to CBD, THC may have different effects depending on the dosage, with lower doses producing reductions in anxiety, and higher doses causing increases in anxiety (Crippa et al., 2009; Rabinak & Phan, 2014). In a study of healthy adult males, THC intake was associated with anxiety, dysphoria, positive psychotic symptoms, physical and mental sedation, subjective intoxication, and an increase in heart rate (Martin-Santos et al., 2012). In a study that examined distress and anxiety associated with a stressful task and post-task negative appraisals in healthy individuals with a history of mild to moderate cannabis use (i.e., use in the past year but less that once per week), THC administration resulted in decreased anxiety and distress at low doses, and increases at high doses (Childs, Lutz, & de Wit, 2017). Anxiety

responses after consuming THC are also more common in drug-naive individuals and when the drug is taken in novel or stressful environments (Crippa et al., 2009). Overall, THC may have a more variable effect on anxiety as compared to CBD, with no indication of the effect on depression, and with the effects varying based on the amount used based on laboratory studies, with no research available on the topic in naturalistic settings.

Individuals who produce, sell, and use cannabis also typically distinguish between different strains of cannabis. Specifically, indica, sativa, and hybrid strains of cannabis are generally labelled based on plant morphology (Erkelens & Hazekamp, 2014). The different strains are thought to exert different effects, with indica strains being more sedating and relaxing, and sativa strains being more uplifting and energizing (Erkelens & Hazekamp, 2014). Despite individuals commonly distinguishing between the effects of these strains, at present, researchers are often unable to clearly identify what characteristics are associated with each strain, with THC and CBD levels not accounting for this distinction (Erkelens & Hazekamp, 2014). This is thought to be primarily due to extensive crossbreeding over the past several decades between the two strains (Erkelens & Hazekamp, 2014). It is possible that a more detailed chemical and genetic analysis of different cannabis strains may result in the clarification of this distinction (Erkelens & Hazekamp, 2014). Although the underlying differences between the strains may be unclear, given the differing reported subjective effects generally agreed upon by cannabis using individuals, this may be an important mediator or moderator of cannabis-related effects.

Mode of Administration of Cannabis

The mode of administration may also play a role in explaining mixed findings. Most of the research on the association between cannabis and anxiety symptoms generally looks at individuals who smoke cannabis, whereas clinical research that looks at the anxiolytic effects of

THC or CBD considers an oral mode of administration, generally in capsule form (Martin-Santos et al., 2012). These findings are likely to be different, as some of the aversive effects associated with smoking cannabis, such as anxiety and panic, are rarely observed when orally administered (Boisvert et al., 2020; Lee, Crosier, Borodovsky, Sargent, & Budney, 2016; Moreira, Grieb, & Lutz, 2009). This may be because oral administration results in lower peak serum concentration as compared to smoking cannabis and a slower onset of subjective effects (Moreira et al., 2009). Despite the potential benefits of oral administration, most cannabis users in Canada continue to engage in cannabis by smoking (Government of Canada, 2021). As such, examining the effects of orally ingested cannabis may be less relevant to the general public who access cannabis recreationally with the hopes of improving affect and psychiatric symptoms of depression and anxiety.

Psychiatric Medication or Other Substance Use

Polysubstance use, that is engaging in cannabis use at the same time as other substances (e.g., alcohol, nicotine, caffeine) also occurs among young adults, and may result in differing subjective effects. In the case of alcohol, research has found that simultaneous alcohol and cannabis use results in greater subjective effects that use of either substance independently (Hartman et al., 2015; Lukas & Orozco., 2001; Sokolovsky, Gunn, Micalizzi, White, & Jackson, 2020). Additional research has found that alcohol co-use results in prolonged subjective intoxication associated with cannabis (Fares et al., 2022; Hartman et al., 2015). Findings are mixed though, as there are studies that found the effects of co-use of alcohol and cannabis is not additive (Cloutier, Calhoun, Lanza, & Linden-Carmichael, 2022; Linden-Carmichael, Van Doren, Masters, & Lanza, 2020) and may even dampen the effects (Ballard & de Wit, 2011). Despite some contradictory evidence, a narrative review by Fares and colleagues (2022)

determined that most studies indicate that among those who engage in co-use of alcohol and cannabis, the subjective effects may be exaggerated.

Similarly, there appears to be an impact of simultaneously use of nicotine and cannabis on the acute effects as compared to cannabis use alone. Research that examines the pharmacokinetic interactions between nicotine and cannabinoids find that both substances induce the same CYP1A2 enzyme and simultaneous use of both substances results in this induction being additive (Lucas, Galettis, & Schneider, 2018). Studies on the subjective effects of co-use of cannabis and nicotine indicate increased subjective effects, in line with the pharmacokinetics of the substances (Cloutier et al., 2022; Penetar et al., 2005). However, some findings indicate no impact of co-use of nicotine on subjective cannabis effects (Haney et al., 2017; Hindocha, Freeman, Xia, Shaban, & Curran, 2017; Peters et al., 2021). Overall, research is unclear on the impact of co-use of nicotine on cannabis effects.

Studies on the impact of caffeine and cannabis co-use is not presently available in the literature outside of one preclinical study. This study found that the effects of cannabis and caffeine were higher than either substance alone in terms of impacts on enzymes and neurotransmitters (Owolabi, Olatunji, & Olanrewaju, 2017), suggesting there may be an additive effect of co-use of these substances as well. However, the lack of studies on the subjective effects in humans does not allow for firm conclusions.

Cannabis may potentially be influenced by various prescription medications as well. Lucas et al. (2018) warns clinicians to be aware of the potential for drug interactions with cannabinoids resulting from induction or inhibition of enzymes or transporters, as well as pharmacodynamic drug-drug interactions. Although studies have examined how cannabis use influences the metabolism of various prescription drugs (e.g., chlorpromazine, theophylline), the

reverse has generally not been examined (Anderson & Chan, 2016). Also, research on subjective effects is not presently available in the literature. As a result, it is unclear exactly how prescribed medication may modify the effects of cannabis use on mood and symptoms, but it is plausible that they might interact in some manner.

Motives for Use

Findings from the Ross et al. (2018) support the influence of motives on the effects of cannabis. The study found that for those who reported coping motives before engaging in cannabis use, negative affect decreased after use, but not for those with other motives (e.g., enhancement motives; Ross et al., 2018). Although only based on a single study, this highlights the possibility that motives for cannabis use may help to explain the variable effects of cannabis use on affect seen in the literature.

Gaps in the Literature on the Acute Effects

Research to date examining the acute relationship between cannabis use and affect indicate that increases in negative affect, anxiety, and depression are likely associated with use, and use is associated with subsequent decreases in these domains. Although there are number of strengths associated with research that examines the acute effects of cannabis on affect and symptoms of anxiety and depression, there are also multiple limitations which require additional research to address.

One major gap in the research is that it often focuses on affect as a means of predicting whether an individual will engage in cannabis use, rather than examining the impact of cannabis use on affect (e.g., Buckner et al., 2013; Shrier et al., 2014). Such studies only examine the individual's state before use, or the factors that result in them initiating an episode of use, but neglects whether the substance has an ameliorative effect on subsequent affect. Acute

improvement in affect, if present, is likely a maintaining factor in substance use that remains relatively unexamined. Among EMA studies that did look at the impact of cannabis use, they did not require participants to complete EMA after engaging in use, relying on random interval prompts to capture the effects rather than measuring the effects when they are at their peak (e.g., Buckner et al., 2013). Additional EMA research needs to examine not only changes in affect that preceded substance use, but also include EMA specifically timed to assess changes in affect that occur after engaging in use (i.e., within minutes of use).

Previous work that includes the momentary assessment of cannabis use, affect, anxiety, and depression has focussed primarily on positive and negative affect. In studies that examined symptoms of depression or anxiety they tended to focus on depressed and anxious mood, primarily in the form of single-item visual analog scales (e.g., Buckner et al., 2012). No EMA studies specifically examined changes in depressive and anxiety symptoms unrelated to affect or mood (e.g., anhedonia, worry). Focussing on affect ignores various other symptoms of anxiety and depression, some equally or more essential in terms of the presence of an associated disorder. Perhaps the reason for this gap in the literature is because affect scales tend to be more efficient than full symptom measures and are thought to have greater chance for adherence (Arean et al., 2016). Although it is true that affect measures tend to be shorter, symptom measures, such as the Patient Health Questionnaire-9, have been validated for use in EMA protocols, and are also associated with high rates of compliance (Arean et al., 2016; Torous et al., 2015). Given that affect may or may not vary independently from other symptoms of anxiety and depression, examining affect as well as symptomatology more broadly may provide additional insights into the relationship between cannabis use, anxiety, and depression.

Another gap in the literature is the lack of studies that account for potential mediating or moderating variables. As previously discussed, there are a variety of factors that may influence the acute relationship between cannabis use and affect, anxiety, and depression which have not been sufficiently addressed in the literature thus far, although preliminary studies point to their importance. These include the frequency of use, presence of cannabis use disorder, type of cannabis, dose/quantity, mode of administration, and motives for use. In addition, among those studies where individuals with psychiatric diagnoses or those who engage in polysubstance use are eligible to participate, few studies include in these potential modifying variables in their analyses.

Current Study

This study examined the acute relationship between cannabis use, affect, and symptoms of anxiety and depression while addressing the limitations of previous literature. This includes momentary assessment of affect and psychiatric symptoms both before and after engaging in cannabis use, within the time frame when individuals begin to subjectively feel the effects of the substance rather than up to hours later. This study also looked at additional symptoms of anxiety and depression beyond anxious and depressed mood (i.e., worry and anhedonia) and looked at affect, anxiety symptoms, and depressive symptoms all independently. These additional symptoms are key features of the associated disorders that have not been examined in EMA research previously.

This study sought to examine factors that may potentially influence the relationship between cannabis use, affect, and psychiatric symptoms including potential CUD, frequency of use, type and amount of cannabis use, and motives associated with use. Individuals with psychiatric diagnoses and those who engage in polysubstance use were permitted to participate

in the present study. Unlike previous research, the presence of a past or present psychiatric diagnosis or polysubstance use was included in analyses to determine if it was significantly associated with any effects. Having less restrictive inclusion criteria allowed for the examination of the effects of these confounds if present, rather than excluding them from the results.

The final methodological improvement included in this study is that participants used their own personal electronic devices, as opposed to a PalmPilot or PDA. Use of personal devices may be associated with increase compliance, as individuals are likely using their own devices regularly, and should require less prompting to complete EMA as compared to completing EMA on a device they only use for that purpose. Torous et al. (2015), whose study protocol had patients use their own smart phones to monitor their psychiatric symptoms, believed that high levels of compliance and ease of use of the app may have been related to the fact that participants used their own devices rather than one provided to them by the researchers. Although compliance is usually considered sufficient in previous EMA studies, use of personal electronic devices helps ensure the validity of the results.

Many parts of the protocol included in the current study were recommended by Wycoff and colleagues (2018) in their review of research on affect and cannabis use in daily life, including: a) attempts to ensure an increased sample size; b) characterizing participants in terms of their motives, not only at baseline, but for each episode of use; c) including both random and event-based prompts; d) quantifying cannabis use more specifically; and e) including measurement of substance use other than cannabis (Wycoff et al., 2018).

Overall, the selected method allows for an improved understanding of the relationship between cannabis use, affect, anxiety, and depression, and how cannabis use disorder and motives for use influence this relationship. Research questions and specific hypotheses

associated with the study are listed below. The selection of these research questions was based on the intention to examine potential reasons for the inconsistent findings related to the effects of cannabis use on affect and symptoms. More specifically, whether these inconsistent findings can be explained by differences in coping motives or CUD, in line with existing theories on substance use maintenance (e.g., negative reinforcement model). Findings will aid in determining if mood and symptom improvements are primarily associated with alleviation of withdrawal symptoms, if they are associated with improvements in negative states more broadly, or if they are unrelated to levels of affect, anxiety, and depression.

Research Questions and Hypotheses

1. **The Association Between Affect, Symptoms of Anxiety and Depression, and CUD Symptoms Before Use**

   Research Question: Do individuals with high levels of CUD symptoms show differential changes in affect and symptoms of anxiety and depression within the four hours prior to cannabis use compared to those with low levels of CUD symptoms?

   Hypotheses: a) Participants who have a high level of symptoms of CUD will experience a decrease in positive affect, and an increase in negative affect and symptoms of anxiety and depression before cannabis use.

   b) Participants with a low level of symptoms of CUD will experience an increase in positive affect and decreased negative affect and symptoms of anxiety and depression before cannabis use.

2. **The Association Between Affect, Symptoms of Anxiety and Depression, and CUD Symptoms After Use**

Research Question: Do individuals with high levels of CUD symptoms show differential changes in affect and symptoms of anxiety and depression immediately after cannabis use and over the course of the next four hours compared to those with low levels of CUD symptoms?

Hypotheses: a) Participants with a high level of CUD symptoms will experience an increase in positive affect and a decrease in negative affect and symptoms of anxiety and depression after cannabis use.

b) Participants with a low level of CUD symptoms will experience decreased positive affect and increased negative affect and symptoms of anxiety and depression after cannabis use.

3. **The Association Between Affect, Symptoms of Anxiety and Depression, and Momentary Coping Motives Before Use**

   Research Question: Do individuals with momentary coping motives show differential changes in affect and symptoms of anxiety and depression within the four hours prior to cannabis use compared to those with other momentary motives for use?

   Hypotheses: a) Participants with momentary coping motives will experience an increase in negative affect and symptoms of anxiety and depression before engaging in cannabis use. No change in positive affect is hypothesized for those with coping motives before use.

   b) Participants with non-coping motives will experience an increase in positive affect before engaging in use.

4. **The Association Between Affect, Symptoms of Anxiety and Depression, and Coping Motives After Use**

   Research Question: Do individuals with momentary coping motives for cannabis use show differential changes in affect and symptoms of anxiety and depression immediately after

cannabis use and over the course of the next four hours compared to those with other momentary motives for use?

Hypotheses: a) Participants who endorse coping motives will experience reduced negative affect and symptoms of anxiety and depression after cannabis use. No change in positive affect is hypothesized for those with coping motives.

b) Participants who endorse other momentary motives (e.g., social, expansion) will experience increased positive affect after cannabis use.

Method

Participants

Potential participants were identified during a larger longitudinal study on alcohol and cannabis use in undergraduate students. Participants in the larger study were recruited from undergraduate courses and physical advertisements on campus at Lakehead University. Participants who report engaging in weekly cannabis use during the larger study were invited to participate in the present study. Inclusionary criteria for the present study, and the corresponding pilot study, included being between 18 and 30 years of age, engaging in weekly cannabis use, and having access to a personal communication device that can download and run the EMA software and transmit the results via the internet. Participants in eligible courses received two bonus points for their participation in the larger longitudinal study and up to an additional three bonus points for participating in the EMA study based on compliance. Participants who were not eligible to receive bonus points received $10 for their participation in the longitudinal study and up to $90 for their participation in the EMA study. The amount of compensation received was based on their completion rate of the Random EMA sessions.

Sample Size. To determine an appropriate sample size, I conducted a power calculation in G*Power (Erdfelder, Lang, & Buchner, 2007) for a within-between repeated measures analysis of variance (ANOVA), which is equivalent to a linear mixed model (LMM) with no missing values (van Ballegooijen et al., 2016). The power calculation indicated a required sample size of 64 participants to detect a change in affect and psychiatric symptoms across five time points, with two levels of potential CUD, based on the smallest meaningful effect size (i.e., Cohen's $d = 0.3$; $f = 0.15$, $1 - \beta = 0.80$, $\alpha = 0.05$, $r = 0.5$, $\varepsilon = 0.8$). Most studies examining treatment outcomes using the GAD-2 and PHQ-2 reported higher effect sizes (i.e., $d = .73$ and .55, respectively), so this was a conservative estimate of the effect size to ensure sufficient power. Expecting a 20% noncompliance rate, I aimed to recruit at least 79 participants.

Measures

Demographics questions. Participants were asked to indicate their age, sex, gender, and ethnicity during the baseline questionnaire session. Participants were also asked to indicate any current or previous psychiatric diagnoses made by a mental health professional or physician, as well as any prescribed psychiatric medication they are taking.

Assessment of present substance use. Participants were asked to indicate the age at which they began using cannabis. Present cannabis use and other substance use at baseline were assessed using a measure adapted from a survey created by the National Institute on Alcohol Abuse and Alcoholism (2003) that measures quantity and frequency. This adapted measure asks participants a question regarding the frequency with which participants normally use alcohol, cannabis, and other substances. Participants were asked to indicate the how often they engage in use of each specific substance (i.e., number of times either weekly, monthly, or yearly) and the maximum, average, and minimum amount they typically consume on a single occasion of

substance use. For alcohol, participants were asked to convert the amount of alcohol to a standard drink. The adapted measure of cannabis and alcohol use has been utilized in a previous study examining university students' substance use (Marshall, Mushquash, Mushquash, Mazmanian, & McGrath, 2020). For cannabis, participants were also asked the type(s) of cannabis they use (e.g., flower, extracts), potency of THC and CBD, and the mode of administration (e.g., joint, vaporizing, edibles). Participants were also asked if their cannabis use is considered medicinal (i.e., prescribed by a medical professional), and if so, for what condition. I created my own set of questions to ascertain this information.

Momentary assessment of substance use. Assessment of substance use at the momentary level was assessed using a set of questions that ask if the participant has engaged in cannabis use, alcohol use, tobacco use, or other substance use since the previous EMA. These questions were included in all Before Cannabis and After Cannabis EMA. To minimize participant burden, substance use questions were not included in the Random EMA. If the participant reported engaging in any substance use during a Random EMA, they received an additional prompt to complete the substance use questions. This also helped us to determine if participants neglected to complete a user-initiated EMA before engaging in cannabis use. If the participant responded yes to engaging in alcohol or substance use since the last EMA, they were asked to indicate the approximate amount of each substance used since the previous EMA, using a standard drink for alcohol, and standardized unit of cannabis. Participants were also be asked to indicate the method of cannabis ingestion, the type of cannabis, and potency, in terms of THC or CBD.

Positive and Negative Affect Schedule (PANAS). The Positive and Negative Affect Schedule (PANAS; Shrier et al., 2012; Watson, Clark, & Tellegen, 1988) was used to determine

affective content. Participants were asked to indicate the degree to which they feel ten positive (e.g., alert, inspired, strong) and ten negative words (e.g., guilty, irritable, hostile) on a 5-point Likert-type scale from 1 (*not at all)* to 5 (*extremely)* at baseline. Participants also completed a subset of six positive and six negative words for each EMA during the EMA period with instructions to indicate the degree to which they feel these words at the present moment (Shrier et al., 2014). The PANAS has demonstrated internal consistency (α = .85-.89) and validity based on confirmatory factor analysis in nonclinical samples (Crawford & Henry, 2004). The PANAS also displays good internal consistency in a sample of cannabis-using young adults (α = 84-86; Ross et al., 2018). The PANAS is consistently used in EMA research examining the association between cannabis use and affect (Buckner et al., 2015; Dvorak, Pearson, & Day, 2014; Ross et al., 2018; Shrier et al., 2014).

Patient Health Questionnaire-9 (PHQ-9). This study employed the Patient Health Questionnaire-9 (PHQ-9; Kroenke, Spitzer, & Williams, 2001) to measure baseline symptoms of depression. Participants were asked to report symptoms of depression on a four-point Likert-type scale from 0 (*none at all*) to 3 (*nearly all the time/every day*). The PHQ-9 has demonstrated internal consistency (α = .87) and convergent validity with the mental health component of the 12-item Short Form Health Survey (SF-12) in the general population ($r = -0.68$, $p < .001$; Kocalevent, Hinz, & Brähler, 2013). Scores on the PHQ-9 obtained through personal smart phones for self-monitoring have been found to be correlated with paper-based scores, and results indicate that smart phone-based assessment with the PHQ-9 may be more sensitive to symptoms of depression than paper-based measurement (Torous et al., 2015).

Generalized Anxiety Disorder Screener (GAD-7). This study utilized the Generalized Anxiety Disorder Screener (GAD-7; Spitzer, Kroenke, Williams, & Löwe, 2006) to assess

participants' baseline level of anxiety symptoms. Participants were asked to report symptoms of anxiety on a 4-point Likert-type scale from 0 (*none at all*) to 3 (*nearly all the time*). The GAD-7 has demonstrated high internal consistency (α = .89) and convergent validity with the PHQ-9 depression scale (r = 0.64) in the general population (Löwe et al., 2008).

Patient Health Questionnaire-2 (PHQ-2) and Generalized Anxiety Disorder Screener (GAD-2). The Patient Health Questionnaire-2 (PHQ-2) and the Generalized Anxiety Disorder Screener-2 (GAD-2) both consist of two items from the PHQ-4 (Kroenke, Spitzer, Williams, & Löwe, 2009). The PHQ-2 and the GAD-2 were used to assess a subset of depression (i.e., depressed mood, anhedonia) and anxiety symptoms (anxious mood, worry) at the momentary level. Participants completed the PHQ-2 and the GAD-2 at each EMA during the EMA period with the timeframe modified to inquire about the time since the last EMA. The PHQ-4 has demonstrated good internal consistency (α = .81), appropriate item-total correlations (r = .66-.80) and high convergent validity with diagnostic status in a sample of American undergraduate students (Khubchandani, Brey, Kotecki, Kleinfelder, & Anderson, 2016). The PHQ-2 and the GAD-2 showed reliability and validity among members of the general population (Löwe et al., 2010). Also, the measures displayed good discriminant validity, and sensitivity and specificity at a cutoff of greater than or equal to a score of 3 among adults receiving internet-delivered cognitive behavioural therapy (Kroenke, Spitzer, Williams, Monahan, & Löwe, 2007; Staples et al., 2019).

Marijuana Motives Measure (MMM). *Marijuana Motives Measure (MMM).* The Marijuana Motives Measure (MMM; Simons et al., 1998) is a 25-item measure of reasons individuals may endorse for using cannabis. The MMM includes 5 subscales: coping, enhancement, socialization, conformity, and expansion (Simons, Correia, Carey, & Borsari,

1998). Participants were asked to report the frequency with which they endorse various motives for cannabis use on a five-point Likert-type scale from 0 (*almost never/never*) to 4 (*almost always/always*). Participants completed the MMM during the baseline questionnaire session. This measure is thought to be more indicative of trait motives for use, or the tendency to use for certain reasons across a variety of contexts. The MMM has shown evidence of internal consistency (α = .86-.93), test-retest reliability (r = .72 - .85 $p < .01$ for the subscales) and construct validity based on factor analysis in a sample of college students and young adults from the general community (Marshall et al., 2020; Simons, Correia, & Carey, 2000; Zvolensky et al., 2007).

Momentary Marijuana Motives Measure (MMM) Checklist. A checklist version of the categories contained in the Marijuana Motives Measure (Simons et al., 1998) was used to determine participants' motives for use at the momentary level before engaging in use, with instructions to select the main reason they are about to engage in use from the previously listed five motive categories. Participants completed the modified MMM during user-initiated EMA where the participant reported they were about in engage cannabis use for the first time during a use episode. This measure was intended to be a measure of state motives, that may vary from episode to episode. Previous EMA studies have used the MMM modified in this manner (Ross et al., 2018; Shrier and Scherer, 2014).

The Cannabis Use Disorder Identification Test - Revised (CUDIT-R). The Cannabis Use Disorder Identification Test - Revised (CUDIT-R; Adamson et al., 2010) is a measure of problematic cannabis use and potential CUD. Participants were asked to rate the frequency of behaviours associated with CUD on a scale from 0 (*never*) to 4 (*daily or almost daily*; Adamson et al., 2010). The CUDIT-R was completed during the baseline session through the EMA

software. The CUDIT-R has displayed good internal consistency (α = .83) and convergent validity with self-reported DSM-5 criteria for CUD and the Marijuana Problem Index score (r = .71-.79) in a sample of a college students (Schultz, Bassett, Messina, & Correia, 2019). The cutoff score for potential CUD is a total score of 13, with approximately 91% of patients with a current cannabis use disorder scoring at or above this score (i.e., sensitivity) and 90% of patients without a current cannabis use disorder scoring below this score (i.e., specificity; Adamson et al., 2010).

Compliance. The percentage of random and signal-initiated prompts completed was calculated for each participant. The number of times a participant reported using cannabis during a random-interval EMA without having completed a corresponding user-initiated EMA was also calculated. In addition, participants indicated their level of agreement with the statements "I completed an assessment before each time I engaged in cannabis use during the study period" and "I reported my cannabis use accurately during the study period" on 5-point Likert-type scale from 0 (*strongly disagree)* to 4 (*strongly agree)* at the end of the EMA period.

To help ensure the validity of the data, participants completed an infrequency item (i.e., an item that few people would reasonably endorse) during their post-cannabis use EMA (e.g., my favourite poet is Robert Moore).

Procedure

The current study examined the association between cannabis use, affect, and psychiatric symptoms through multiple, short assessments, completed multiple times throughout the day (i.e., EMA). Ethics approval for the study was obtained through the Lakehead University Research Ethics Board.

This study consisted of both a pilot study and the complete final study. For both, participants completed the consent process in the research laboratory or via zoom with a research assistant and if they consented to participate, engaged in the baseline session. Upon consenting to complete the EMA portion of the study, they also downloaded the EMA software on their personal electronic device and learning how to complete the EMA using their personal device. In addition, consenting participants completed the baseline questionnaires during the initial laboratory session. The baseline questionnaires included the demographic questions, assessment of past substance use, the GAD-7, the PHQ-9, the PANAS (with instructions to respond based on the past 2 weeks), and the MMM. Baseline questionnaires were either completed by participants using paper and pen or through SurveyMonkey after COVID-19 lockdowns occurred and took approximately 20 minutes to complete. Participants also completed an initial user-initiated EMA on their phones through the EMA software during the initial session to ensure they understood how to use the software and to minimize the possibility of technical difficulties once the EMA period has started. Participants completed the CUDIT-R during this start-up session. Participants received information regarding what to do in the event of technical difficulties (e.g., not receiving prompts, inability to complete EMA). During the initial session, participants were observed to determine if there may be any conditions that could potentially interfere with compliance during the study (e.g., active psychotic symptoms, severe substance use-related difficulties). Participants completed additional measures in association with a broader longitudinal study during the initial session as well. The entire session took approximately 30 minutes to one hour.

All EMA included the PANAS for assessing affect, the GAD-2 to assess symptoms of anxiety, the PHQ-2 to assess symptoms of depression, and questions regarding any alcohol or

substance use since the previous EMA. For user-initiated EMA that occurred before an episode of cannabis use, the EMA also included the MMM checklist to assess the participant's motives for use. Each EMA took an average of about 1 minute to complete (Mean Random EMA Length = 59.7 seconds, *SD* = 75.9; Mean After Cannabis EMA Length = 77.2 seconds, *SD* = 45.2).

During the EMA period, participants were asked to complete assessments during waking hours, and were instructed that they were permitted to silence prompts while they were asleep. Participants were told that it was acceptable for them not to respond to EMA prompts when it is inconvenient (i.e., at work or during class) and to ensure they do not respond when it is unsafe to do so (i.e., while driving). Participants were required to complete the Random EMA within 15 minutes of the prompt and the After Cannabis EMA within 5 minutes. On average, participants responded to the EMA prompts within 3 minutes (Mean Random EMA Time to Response = 176.4 seconds, *SD* = 248.9; Mean After Cannabis Time to Response = 51.8 seconds, *SD* = 69.0). Fifteen minutes was chosen to maximize the likelihood of Random EMA completion, given that compensation was based on the Random EMA, and given that the specific time at which they were completed was of less importance, given their random nature. Five minutes to complete the After Cannabis EMA was selected to ensure participants completed the EMA as close to the prompt as possible without cutting them off while completing the session, given the importance of the timing and completion of these sessions. If the participant was unable to complete the EMA session within the allotted time, the EMA request expired, and the session was considered missed. At the end of the EMA assessment period, participants were asked the questions regarding compliance. If participants did not complete the compliance questions through the final session in the EMA software, they were asked to respond to the questions via email when

they were informed of their overall level of compliance and associated compensation. A table of completion times for each of the measures is included in the Appendix (Table 2).

The software being used, LifeData, is HIPAA compliant (LifeData, 2015). To maintain confidentiality, all EMA results were de-identified before being received from participants' personal devices. Participants' names were only attached to means of providing compensation, obtained during the initial in-lab session. Similarly, for those who completed measures through SurveyMonkey rather than in the lab, results were de-identified before being submitted.

A pilot study was conducted to ensure the functionality of the software and gain feedback on how to ensure participants' compliance with the protocol. Pilot participants completed the full study protocol and were contacted after completion to discuss any difficulties associated with completing the study. The pilot was concluded after participants repeatedly reported no technical difficulties, being able to understand the protocol instructions without need for amendments, and when most of the participants completion rates for the Random EMA sessions were at least 80%, across all signal-initiated random sessions (i.e., including those that were missed due to being busy or unavailable).

Participants completed EMA sessions for one week during a period where they reported they were likely to engage in cannabis use. A notification to complete an EMA popped up on participants' personal devices six times per day randomly during two-hour intervals from 10am to 10pm. Participants were also asked to access the app and complete user-initiated EMA before episodes of cannabis use. Participants were further prompted to complete a signal-initiated EMA session after engaging in cannabis use at 5, 15, 30, 45, 60, 90, 120, 180, and 240 minutes later. Completion times for the random, user-, and signal-initiated EMA are displayed in Figure 1.

Figure 1

Timing of Ecological Momentary Assessments

10am	**12pm**	**2pm**	**4pm**	**6pm**	**6:32pm**	**8pm**	**10pm**
Random EMA	Random EMA	Random EMA	Random EMA	Random EMA	**CANNABIS USE**	Random EMA	Random EMA
Substance Use	Substance Use	Substance Use	Substance Use	Substance Use		Substance Use	Substance Use
Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)		Mood (PANAS)	Mood (PANAS)
Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)		Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)

Before Use	**5 minutes later**	**15 minutes later**	**30 minutes later**	**45 minutes later**	**60 minutes later**	**90 minutes later**	**120 minutes**	**180 minutes later**	**240 minutes later**
Substance Use	Substance Use	Substance Use	Substance Use	Substance Use	Substance Use	Substance Use	Substance Use	Substance Use	Substance Use
Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)	Mood (PANAS)
Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)	Depression and Anxiety (PHQ-2 and GAD-2)
Motives (MMM)									

Note. GAD-2 = Generalized Anxiety Screener – 2; MMM = Marijuana Motives Measure; PANAS = Positive and Negative Affect Schedule; PHQ-2 = Patient Health Questionnaire-2.

Statistical Analyses

I conducted multi-level modelling with the following structures for each hypothesis:

1. **The Association Between Affect, Symptoms of Anxiety and Depression, and CUD Symptoms Before Use**

   Subject Variable: Participant*Episode of Use

Random Variable: Time*Participant

Repeated Measure: Time

Fixed Variables: Sex; Age of Onset of Use; Baseline Cannabis Use Disorder Symptoms; Baseline Cannabis Use Disorder Symptoms*Time

Outcome Variables: Positive Affect; Negative Affect; Depression Symptoms; Anxiety Symptoms

2. **The Association Between Affect, Symptoms of Anxiety and Depression, and CUD Symptoms After Use**

   Subject Variable: Participant*Episode of Use

   Random Variable: Time*Participant

   Repeated Measure: Time

   Fixed Variables: Sex; Age of Onset of Use; Baseline Cannabis Use Disorder Symptoms; Baseline Cannabis Use Disorder Symptoms*Time

   Outcome Variables: Positive Affect; Negative Affect; Depression Symptoms; Anxiety Symptoms

3. **The Association Between Affect, Symptoms of Anxiety and Depression, and Coping Motives Before Use**

   Subject Variable: Participant*Episode of Use

   Random Variable: Time*Participant

   Repeated Measure: Time

   Fixed Variables: Sex; Age of Onset of Use; Momentary Coping Motives; Momentary Coping Motives*Time

Outcome Variables: Positive Affect; Negative Affect; Depression Symptoms; Anxiety Symptoms

4. **The Association Between Affect, Symptoms of Anxiety and Depression, and Coping Motives After Use**

   Subject Variable: Participant*Episode of Use

   Random Variable: Time*Participant

   Repeated Measure: Time

   Fixed Variables: Sex; Age of Onset of Use; Momentary Coping Motives; Momentary Coping Motives*Time

   Outcome Variables: Positive Affect; Negative Affect; Depression Symptoms; Anxiety Symptoms

Linear mixed model analyses are more appropriate for this type of study in comparison to traditional approaches, such as an ANOVA, as this method does not assume independent cases, and is more tolerant of missing data (Gueorguieva & Krystal, 2004; Salim, Mackinnon, Christensen, Griffiths, 2008).

Results

Participant Demographics

Ninety-two students participated in the study. Eight participants did not complete any Before Cannabis Use sessions during the EMA period and were therefore excluded, resulting in 84 participants being included in the analyses. Participants were predominantly White females, with no psychiatric diagnosis, who were not on prescribed medications (~60-70% across these variables). Most had engaged in alcohol use during their lifetime, did not use nicotine in the past month, and had used illicit substances in their lifetime (e.g., cocaine, ecstasy). Detailed

participant demographics are presented in Table 3. Descriptive statistics for all baseline measures, including level of CUD symptoms (CUDIT-R), motives for use over the past month (MMM), positive affect and negative affect (PANAS), symptoms of anxiety (GAD-7), and symptoms of depression (PHQ-9) are presented in Table 4.

Symptom Measure Cut-offs

In terms of cut-offs for the symptom measures, on the CUDIT-R, 14.3% of participants were in the nonproblematic use range (n = 12), 21.4% were in the hazardous use range (n = 18), and 56% were in the possible cannabis use disorder range (n = 47; 7 missing). On the PHQ-9, 26.2% were in the normal range (n = 22), 33.3% in the mild range (n = 28), 22.6% in the moderate range (n = 19), 13.1% in the moderately severe range (n = 11), and 4.8% in the severe depression range (n = 4). On the GAD-7, 33.3% were in the normal range (n = 28), 31.0% in the mild range (n = 26), 20.2% in the moderate range (n = 17), and 14.3% in the severe range anxiety (n = 12; 1 missing).

Compliance and Validity

EMA Completion Rates. Participants completed an average of 73% of the Random EMA. Participants completed an average of 65% of After Cannabis EMA from Time 1 (5 minutes after use) to Time 4 (45 minutes after use). More specifically, 70% of participants completed the EMA 5 minutes after use, 60% of participants completed the EMA 15 minutes after use, 55% of participants completed the EMA 30 minutes after use, and 51% of participants completed the EMA 45 minutes after use. Rates of EMA responding were consistently low across the later After Cannabis EMA (e.g., 2 hours, 37%; 3 hours, 33%; 4 hours, 45%). Correlational analyses examining individual level factors (i.e., age, age of onset, baseline cannabis frequency, CUD symptoms, baseline coping motives, baseline anxiety symptoms, and

baseline depression symptoms) associated with the percent of After Cannabis EMA responded to indicated that age of onset of use and baseline frequency of cannabis use was significantly correlated. Specifically, those with an older age of onset responded to more After Cannabis EMA, $r(600) = 0.324$, $p < .001$, and those with a higher baseline frequency of cannabis use responded to more after Cannabis EMA, $r(608) = .232$, $p < .001$.

Self-reported Compliance. Of the 77 participants who completed the Final Day Session, participants' average response to the question "I completed an assessment before each time I engaged in cannabis use during the study period" was 4.39 ($SD = 0.87$) out of 5. Participants average response to the question "I reported my cannabis use accurately during the study period" was 4.52 ($SD = 0.64$). Sixty-nine participants (90%) indicated they accurately reported the amount of cannabis use they engaged in the during the one-week EMA period (*agree* or *strongly agree*). Seventy-six participants (99%) indicated they completed a Before Cannabis EMA before each episode of cannabis use (*agree* or *strongly agree*). According to the EMA data, participants endorsed using cannabis during a random-interval EMA without having completed a corresponding Before Cannabis EMA 83 times (2.3% of the Random-Interval EMAs).

Infrequency Questions. Rates of accurate responding to the infrequency questions included in the post-cannabis use EMA ranged from 88.4% to 99.3% across the 11 items. Overall, 94.4% of infrequency questions completed during an After Cannabis EMA were answered correctly.

Cannabis Use

Baseline Cannabis Use. Participants primarily engaged in smoking high THC, low CBD strains of cannabis flower for nonmedicinal purposes, although a substantial number of

participants were uncertain as to the amount of THC or CBD in the cannabis they were using. Detailed information on participants' cannabis use reported at baseline are presented in Table 5.

Momentary Cannabis Use, Mood, and Symptoms. Participants engaged in a total of 609 tracked episodes of cannabis use (i.e., the number of Before Cannabis Use EMA successfully completed triggering After Cannabis EMA). The average number of episodes per participant across the week-long assessment period was 7.24, with an average of 3.48 grams per episode (*SD* = 1.47). Most cannabis use episodes included smoked cannabis (*n* = 584; 96%). Descriptive statistics for the momentary assessments are presented in Table 6. Means and 95% confidence intervals for change in affect, anxiety, and depression across all time points are displayed in Figures 2-5.

Figure 2

Positive Affect Across Time Before and After Cannabis Use

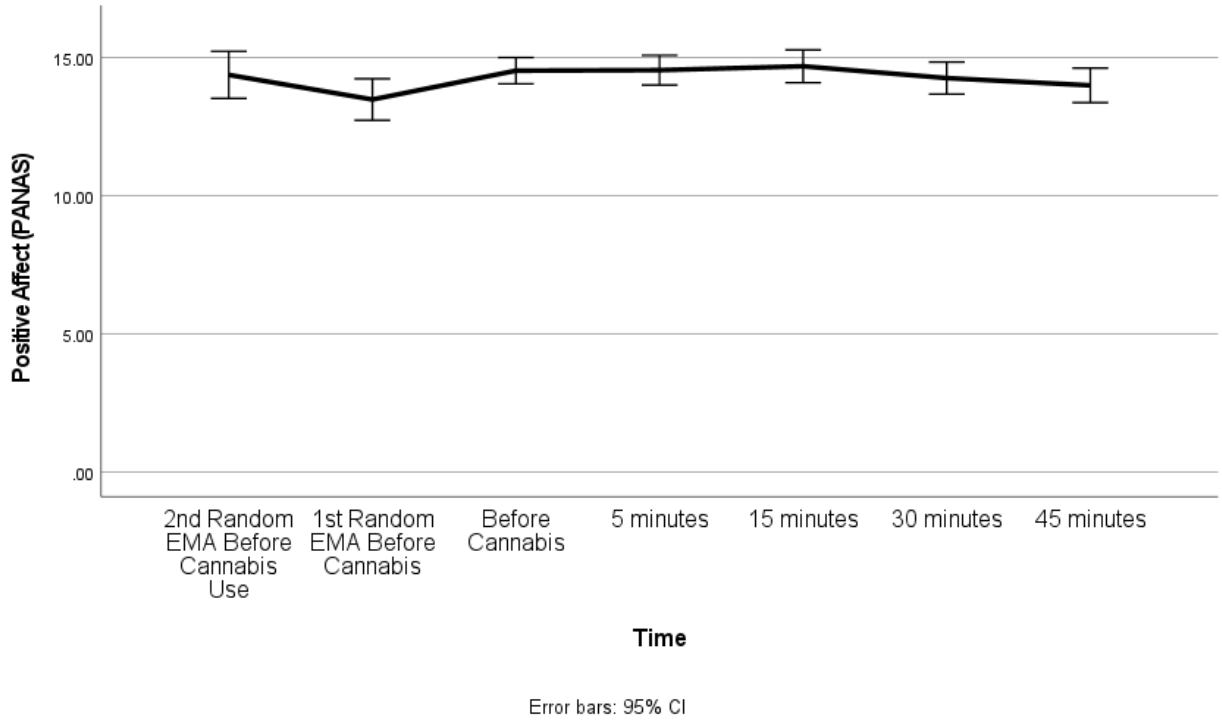


Figure 3

Negative Affect Across Time Before and After Cannabis Use

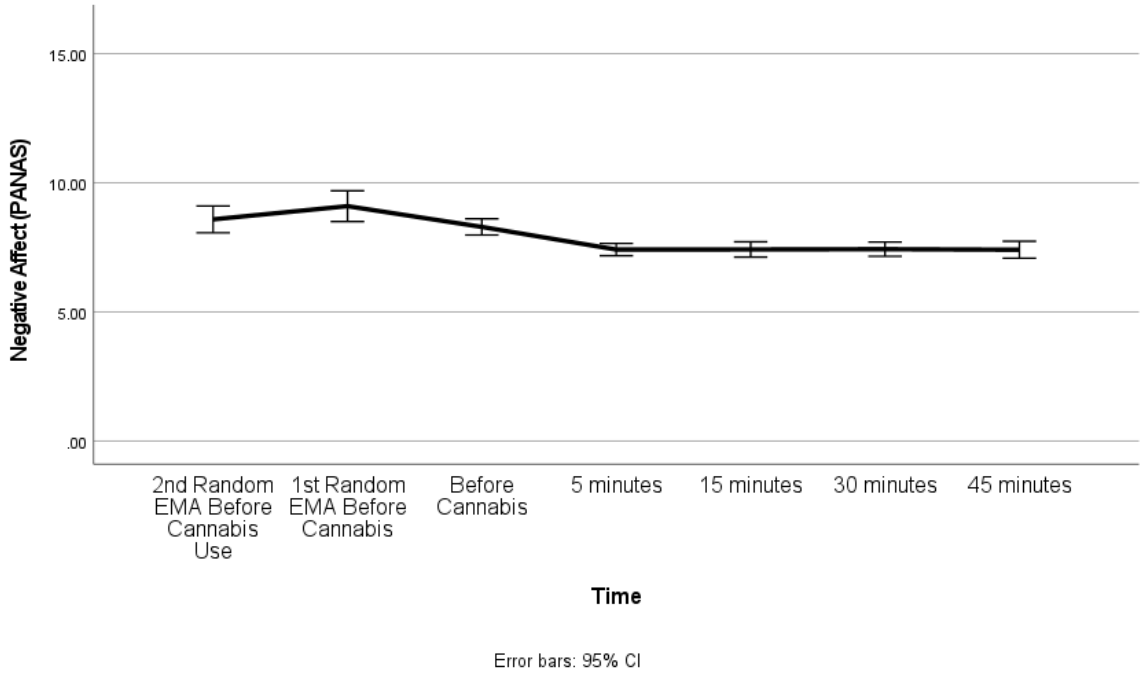


Figure 4

Anxiety Across Time Before and After Cannabis Use

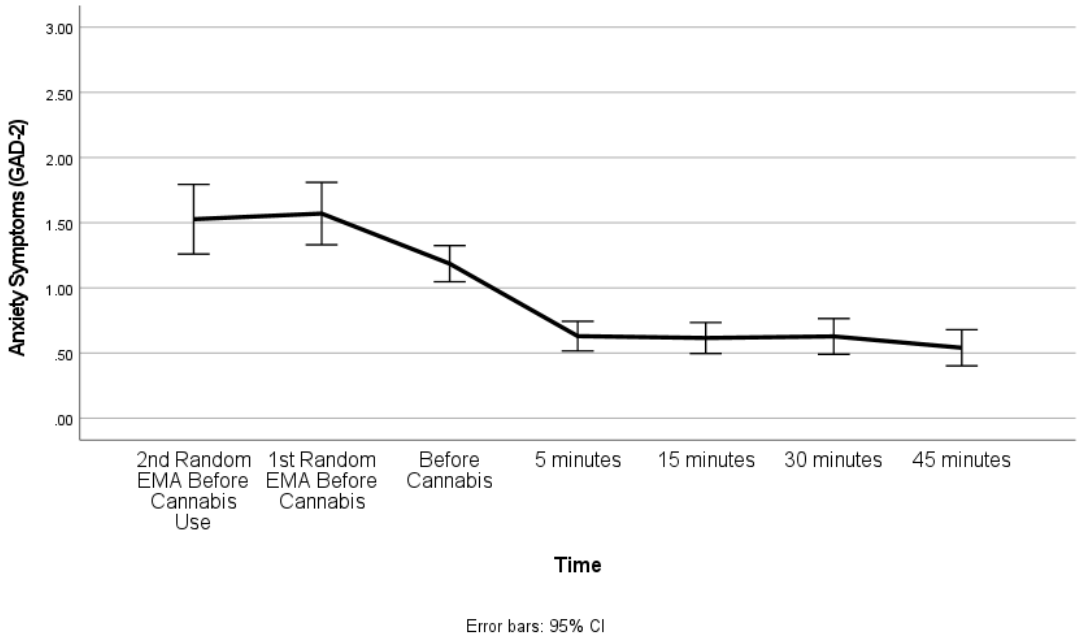
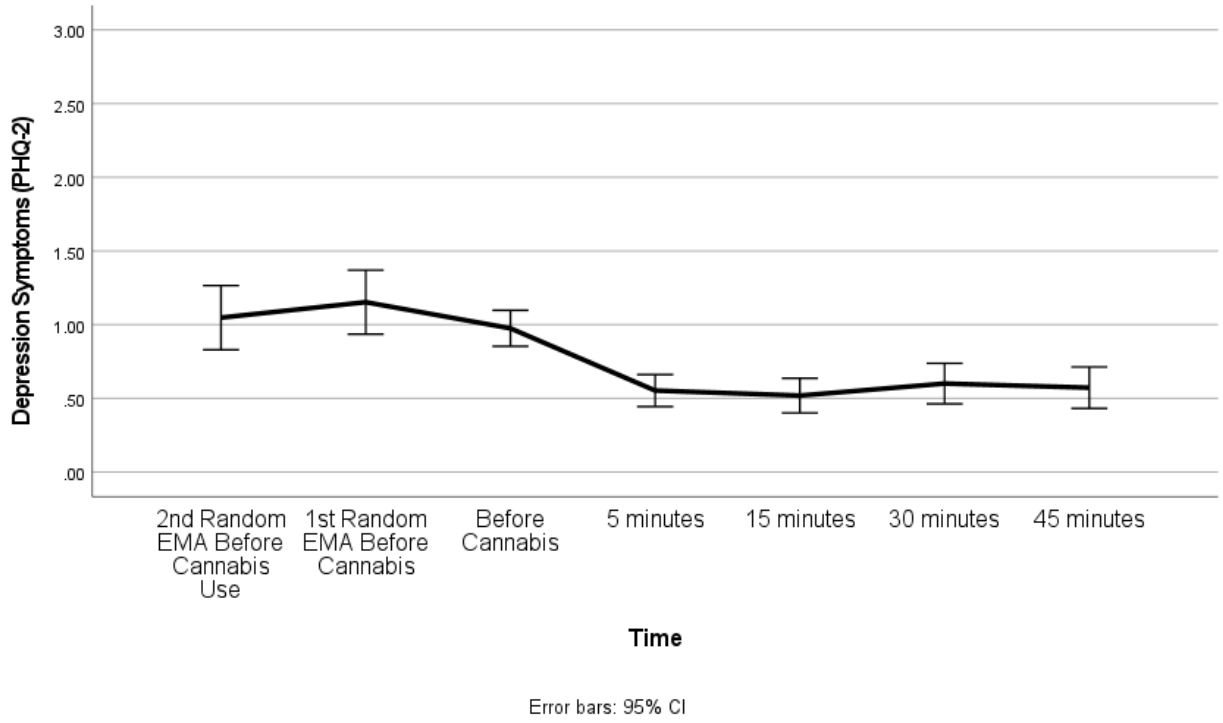


Figure 5

Depression Affect Across Time Before and After Cannabis Use



Momentary Other Substance Use. Of all the cannabis use episodes (*n* = 609), 47.6% included substance use other than cannabis. Specifically, 11.5% of episodes included alcohol use (*n* = 70), 26.8% of episodes included nicotine use (*n* = 163), and 16.7% of episodes included caffeine use (*n* = 102). Only one episode included illicit substance use (i.e., 'molly', 0.002% of episodes). Among these episodes, some included multiple substances other than cannabis. Specifically, 2.1% of episodes included alcohol and nicotine use (*n* = 13), 3% of episodes included nicotine and caffeine use (*n* = 18), 1.6% of episodes included alcohol and caffeine use (*n* = 10), and 0.3% of episodes included alcohol, nicotine, and caffeine use (*n* = 2).

Momentary Motives. Motives reported before cannabis use are displayed in Table 7. Most participants reported enhancement motives for use at the momentary level, in line with motives reported at baseline across the past month of use. Over half of participants had more

than more than one motive for use (n = 46; 55%), with participants reporting anywhere from one motive across all sessions to up to four different motives.

Generalized Linear Mixed Modelling Analyses

Before completing the Generalized Linear Mixed Modelling (GLMM) analyses, the normality of scores of the dependent variables were assessed through visual inspection of the QQ-plots (Ghasemi & Zahediasl, 2012). PHQ-2, GAD-2, PANAS Positive, and PANAS Negative scores were all found to be highly skewed. As a result, all analyses were run using a gamma distribution with a log link function. PHQ-2 and GAD-2 scores were transformed (i.e., by adding one) to ensure all scores were positive integers. PHQ-2 and GAD-2 scores were analyzed using AR1 as a covariance type, and PANAS scores using an Unstructured covariance type. Covariance types for all analyses were selected through examination of the null model (i.e., no fixed effects, only the intercept) under different structures to determine which produced the lowest -2 log likelihood (West et al., 2007). All models included gender and onset of cannabis use as fixed effects. Other potential fixed variables were considered for inclusion based on whether they were significantly related to model fit (i.e., produced a significant change in -2 log likelihood through inclusion as compared to the null model). Models also included Time, the predictor variable (i.e., CUD symptoms or coping motives), and the interaction term for the two variables. Time for analyses related to before cannabis was limited to the Random EMA completed during the previous two 2-hour time intervals on the same day to ensure proximity to the cannabis use episode. After cannabis analyses were limited to the first four time points after cannabis use (i.e., 5, 15, 30, and 45 minutes after) as these were most likely to be completed as compared to later time points. Also, they represented the acute effects of cannabis best, as peak effects were observed as occurring within this window, with minimal changes after 45 minutes.

Residuals for the analysis were examined using histograms and QQ-plots to assess for normality (Grace-Martin, 2011). Residuals for all analyses displayed sufficient normality to support model selection. Data used in the analyses were missing completely at random as indicated by a nonsignificant Little's Missing Completely at Random test (Little, 1988), $\chi 2$ (28) = 40.5, p = 0.06. As a result, we employed maximum pseudo-likelihood to handle missing data through use of GLMM (IBM Corporation, 2012). For all models examining momentary coping motives, a dichotomous variable was created indicating if the primary motive for use was coping vs. any other motive (e.g., social, expansion). Coping motives were also group mean centred to isolate within-person variability. McFadden's Pseudo R^2 was calculated as an estimate of effect size of improvement from null model to full model for analyses where possible (i.e., -2 log likelihood of the full model was divided by the -2 log likelihood of null model and subtracted from 1; University of Los Angeles, California Statistical Consulting Group, 2011).

Variables that were not included in the analyses and the reasons for their exclusion are listed below:

- *Ethnicity:* limited variability (70% White) and not significantly related to model fit
- *Type of Cannabis Use:* excessive missing data, limited variability (i.e., primarily high THC flower), and not related to model fit
- *Amount of Cannabis Use:* potentially inaccuracies related to difficulties with standardization and not significantly related to model fit
- *Mode of Admin:* limited variability (i.e., 96% smoked cannabis) and not significantly related to model fit

- *Other Substance Use:* overall and alcohol, nicotine, and caffeine individually were not significantly related to model fit; limited variability (i.e., 11.5% of episodes included alcohol use; 27% nicotine;17% caffeine)
- *Psychiatric Medication Use*: not significantly related to model fit

To confirm some of the above conclusions, analyses were conducted with the inclusion of substance use overall and individual substances (i.e., alcohol, nicotine, caffeine). Similar results were found in terms of Beta coefficients and significance as compared to the models without these variables that are presented in this paper. These findings further support the initial decision to exclude these variables based on the lack of improvement in model fit noted above.

Rates of completion were examined for each of the models that included Random EMA sessions (i.e., Before Use analyses), wherein only those who completed at least 80% of the Random EMA sessions were included in the analyses. The results were essentially the same as the results that follow, therefore the entire sample was used to maximize power. In addition, I examined models that included only After Cannabis EMA where the infrequency questions were answered correctly. Again, the results remained unchanged, and all episodes were subsequently included in the displayed results.

The Association Between Positive Affect and CUD Symptoms Before Use. The overall model examining if CUD symptoms at baseline (CUDIT-R) were significantly associated with momentary positive affect (EMA PANAS Positive) before use was significant. Gender was significantly associated with positive affect at all time points, with men displaying higher levels of positive affect than women. CUD symptoms were also significantly associated with positive affect at all time points, with those with higher CUD symptoms displaying lower levels of positive affect. Time was not significant, indicating that positive affect did not change

significantly before cannabis use for all participants. The interaction terms of CUD symptoms and time (CUDIT-R*Time) was also not significantly related to positive momentary affect, indicating that participants' level of CUD symptoms were not associated with change in positive affect before use. Fixed effects and fixed coefficients (i.e., Beta coefficients and confidence intervals) are displayed in Tables 8-9. Null models had lower -2 log likelihood, indicating that the addition of fixed effects did not improve model fit, therefore pseudo R^2 was not calculated.

The Association Between Positive Affect and CUD Symptoms After Use. The overall model examining if CUD symptoms at baseline (CUDIT-R) were significantly associated with momentary positive affect (EMA PANAS Positive) was significant. Time was not significantly associated with momentary positive affect after use, indicating that positive affect did not change after cannabis use across all participants. Age of onset and gender were significantly associated with positive affect after use at all time points, where those with a higher age of onset had higher levels of positive affect, and males displayed higher positive affect. Baseline CUD symptoms were significantly associated with positive affect at all time points, where those with higher CUD symptoms showed lower positive affect. The interaction terms of CUD symptoms and time (CUDIT-R*Time) was not significantly related to positive momentary affect, indicating no differential change in positive affect based on severity of CUD symptoms. Fixed effects and fixed coefficients are displayed in Tables 10-11. Null models had lower -2 log likelihood, indicating that the addition of fixed effects did not improve model fit, therefore pseudo R^2 was not calculated.

The Association Between Negative Affect and CUD Symptoms Before Use. The overall model examining if CUD symptoms at baseline were significantly associated with momentary negative affect was not significant. Gender was significantly associated with positive

affect, with males displaying greater positive affect than females. Time was not significant, indicating negative affect did not change before use across all participants. The interaction term (CUDIT-R*Time) was also not significant, indicating that participants' level of CUD symptoms were not associated with change in negative affect before use. Fixed effects and fixed coefficients are displayed in Tables 12-13. Null models had lower -2 log likelihood, indicating that the addition of fixed effects did not improve model fit, therefore pseudo R^2 was not calculated.

The Association Between Negative Affect and CUD Symptoms After Use. The overall model examining if CUD symptoms at baseline were significantly associated with momentary negative affect was significant. Gender was significantly associated with negative affect across all time points, with males displaying lower negative affect than women. Time was not significantly associated with negative affect for use, where participants did not show change in negative affect after use. The interaction term (CUDIT-R*Time) was not significant, indicating no differential change in negative affect after cannabis use based on severity of CUD symptoms. Fixed effects and fixed coefficients are displayed in Tables 14-15. Given that the -2 log likelihood was a positive integer for the full model and a negative integer for the null model, calculation of pseudo R^2 was not an accurate representation of effect size.

The Association Between Anxiety and CUD Symptoms Before Use. The overall model examining if CUD symptoms at baseline were significantly associated with momentary symptoms of anxiety (EMA GAD-2) before use was significant. Gender was significantly associated with momentary symptoms of anxiety. Specifically, females displayed higher levels of momentary anxiety than men. Time was not significant, indicating anxiety symptoms did not change before use across all participants. The interaction term (CUDIT-R*Time) was also not

significant, indicating participants' change in anxiety before use was not related to their level of CUD symptoms. Fixed effects and fixed coefficients are displayed in Tables 16-17. Pseudo R^2 for the model was 0.025.

The Association Between Symptoms of Anxiety and CUD Symptoms After Use. The overall model examining if CUD symptoms at baseline were significantly associated with momentary symptoms of anxiety (EMA GAD-2) was significant. Gender was significantly associated with momentary symptoms of anxiety. Specifically, females displayed higher levels of momentary anxiety than men. Time was not significantly associated with momentary symptoms of anxiety, indicating no change across all participants after use. The interaction term was also not significant (CUDIT-R*Time), with no differential change in anxiety after use based on CUD symptoms. Fixed effects and fixed coefficients are displayed in Tables 18-19. Pseudo R^2 for the model was 0.236.

The Association Symptoms of Depression and CUD Symptoms Before Use. The overall model examining if CUD symptoms at baseline were significantly associated with momentary symptoms of depression (EMA PHQ-2) was not significant. Time was not significantly associated with momentary symptoms of depression, indicating symptoms of depression did not change before cannabis use across all participants. The interaction term was also not significant (CUDIT-R*Time), indicating change in depression symptoms before use was not related to participants' level of CUD symptoms. Fixed effects and fixed coefficients are displayed in Tables 20-21. Pseudo R^2 for the model was 0.013.

The Association Between Symptoms of Depression and CUD Symptoms After Use. The overall model examining if CUD symptoms at baseline were significantly associated with momentary symptoms of depression (EMA PHQ-2) was not significant. Time was not

significantly associated with momentary symptoms of depression, with depression symptoms showing no change across all participants. The interaction term was also not significant (CUDIT-R*Time), with no differential change in symptoms of depression after use based on CUD symptom severity. Fixed effects and fixed coefficients are displayed in Tables 21-22. Pseudo R^2 for the model was 0.185.

The Association Between Positive Affect and Momentary Coping Motives Before Use. The overall model examining if coping motives reported at the momentary level (EMA Coping Motives) were associated with momentary positive affect (EMA PANAS Positive) before cannabis use was significant. Gender and age of onset were significantly related to positive affect before use. Specifically, males had higher levels of positive affect and those with a younger age of onset had lower positive affect. Coping motives were associated with positive affect before use across all time points, with those who reported coping motives reporting lower levels of positive affect. Time and the interaction term of momentary coping motives by time (EMA Coping Motives*Time) were not significant, indicating there was no change in positive affect before cannabis use, and that change in positive affect across time was not associated with whether participants had coping motives for use. Fixed effects and fixed coefficients (i.e., Beta coefficients and confidence intervals) are displayed in Tables 23-24. Null models had lower -2 log likelihood, indicating that the addition of fixed effects did not improve model fit, therefore pseudo R^2 was not calculated.

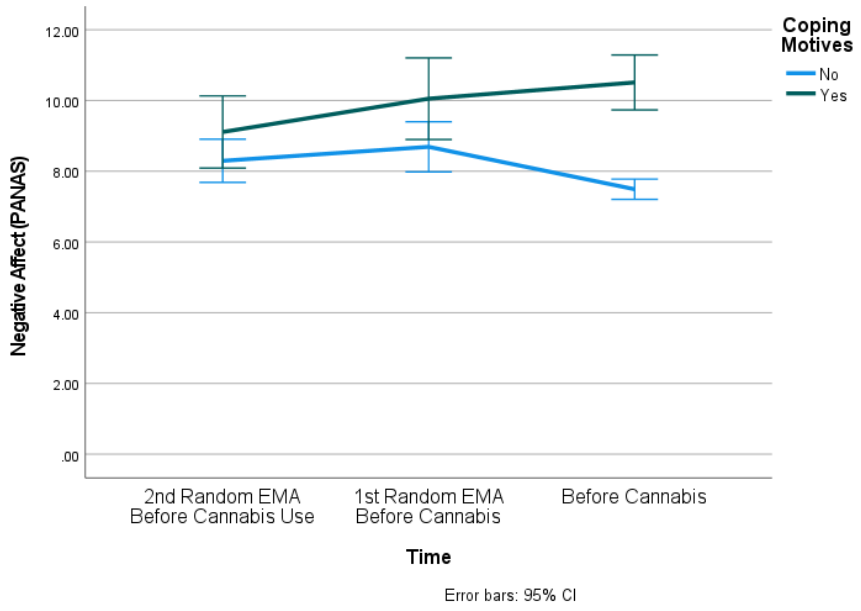
The Association Between Positive Affect and Coping Motives After Use. The overall model examining whether coping motives after use were significantly related to momentary positive affect was significant. Age of onset, gender, and momentary coping motives were significantly related to positive affect after cannabis use. Specifically, those with a younger age

of onset had lower levels of positive affect, females had lower levels of positive affect, and momentary coping motives were associated with lower positive affect. Time was not significant, indicating no change in positive affect after use across all participants. Also, the interaction between coping motives and time (EMA Coping Motives*Time) was not significant, with no differential change in positive affect after use based on coping motives. Fixed effects and coefficients are displayed in Tables 25-26. Null models had lower -2 log likelihood, indicating that the addition of fixed effects did not improve model fit, therefore pseudo R^2 was not calculated.

The Association Between Negative Affect and Momentary Coping Motives Before Use. The overall model examining if momentary coping motives before use were associated with momentary negative affect (EMA PANAS Negative) was significant. Gender and momentary coping motives were both significantly related to negative affect before cannabis use, with females displaying higher levels of negative affect, and momentary coping motives associated with higher negative affect. Time was not significant, indicating that participants overall did not exhibit significant changes in negative affect before engaging in cannabis use. The interaction term (EMA Coping Motives * Time) was significant, indicating that change in negative affect across time before use was associated with whether participants had coping motives at the momentary level. Specifically, participants with coping motives displayed an increase in negative affect before cannabis use, while those without coping motives displayed a decrease in negative affect. Fixed effects and fixed coefficients are displayed in Tables 27-28. Means for the significant interaction are displayed in Figure 6. Pseudo R^2 for the model was 0.177.

Figure 6

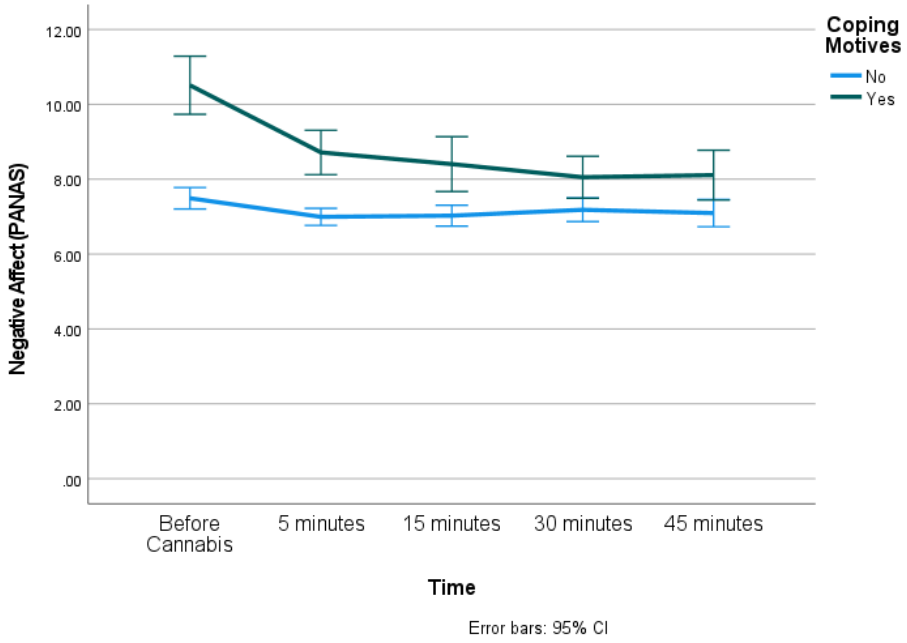
Before Cannabis Use: Negative Affect Across Time by Coping Motives



The Association Between Negative Affect and Coping Motives After Use. The overall model examining if coping motives was associated with momentary negative affect was significant. Gender and momentary coping motives were significantly associated with momentary negative affect. Specifically, males showed lower levels of negative affect and those with coping motives showed higher levels of negative affect. Time was not significant, indicating negative affect did not change significantly for all participants after use. The interaction term was significant (EMA Coping Motives*Time), with those with coping motives showing a decrease in negative affect, and those with other motive showing no change in negative affect after use. Fixed effects and coefficients are displayed in Tables 29-30. Means and 95% confidence intervals for the significant interaction are displayed in Figure 7. Given that the -2 log likelihood was a positive integer for the full model and a negative integer for the null model, calculation of pseudo R^2 was not an accurate representation of effect size.

Figure 7

After Cannabis Use: Negative Affect Across Time by Coping Motives



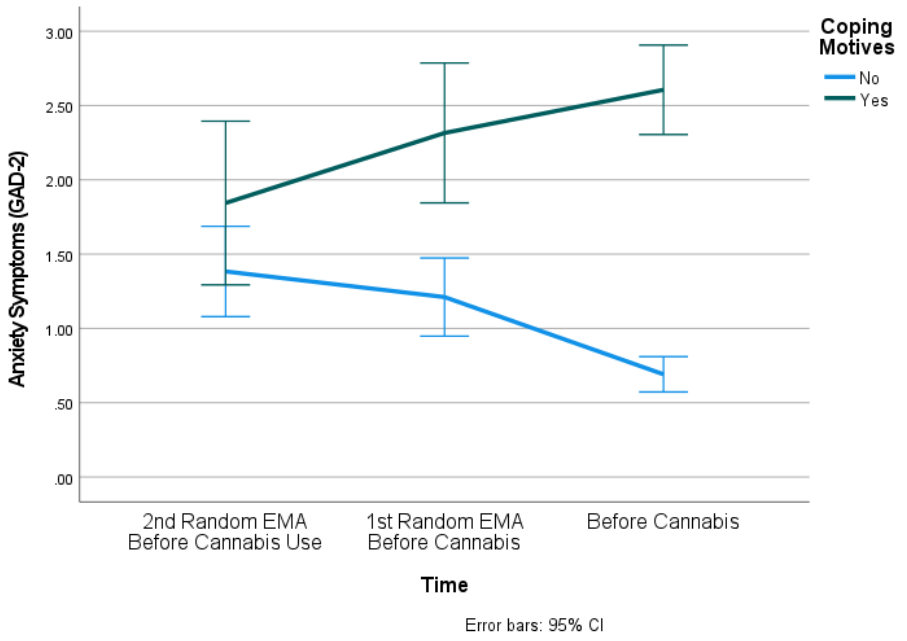
The Association Between Symptoms of Anxiety and Momentary Coping Motives

Before Use. The overall model examining if momentary coping motives were significant related to symptoms of anxiety (EMA GAD-2) before use was significant. Gender and momentary coping motives were significantly related to symptoms of anxiety before use, with females displaying higher anxiety symptoms and momentary coping motives associated with higher momentary anxiety. Time was not significant, indicating no change in anxiety symptoms after use across all participants. The interaction term (EMA Coping Motives*Time) was significant, indicating that changes in anxiety across time were associated with whether participants had coping motives. Specifically, those with coping motives showed increases in anxiety symptoms before cannabis use, while those without coping motives showed a decrease in anxiety. Fixed

effects and fixed coefficients are displayed in Tables 31-32. Means and 95% confidence intervals for the significant interaction is displayed in Figure 8. Pseudo R^2 for the model was 0.064.

Figure 8

Before Cannabis Use: Anxiety Symptoms Across Time by Coping Motives

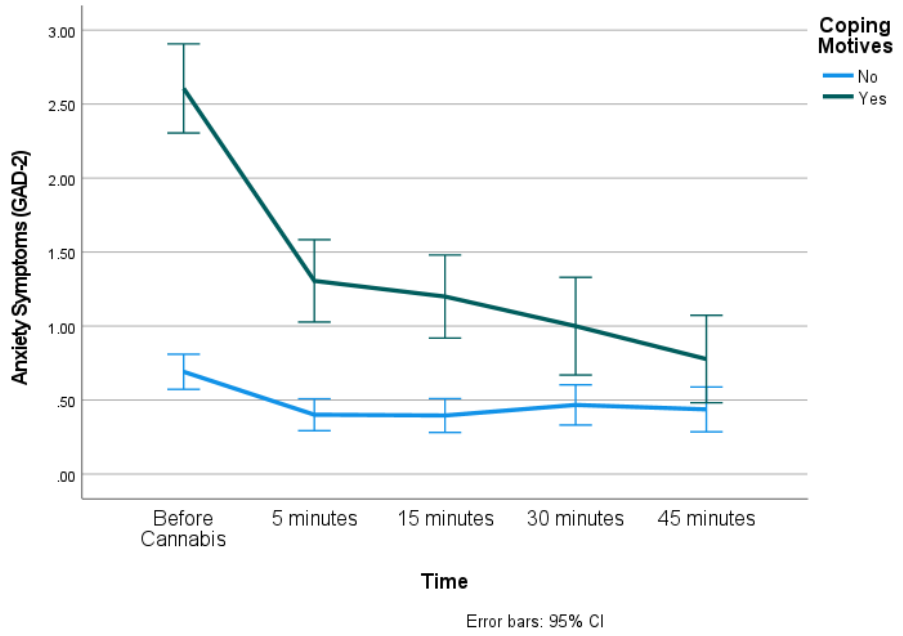


The Association Between Symptoms of Anxiety and Coping Motives After Use. The overall model examining whether coping motives were associated with momentary anxiety symptoms (EMA GAD-2) was significant. Gender, momentary coping motives, and time were significantly associated with anxiety symptoms after use. Specifically, females displayed higher anxiety symptoms, anxiety symptoms decreased across time for all participants, and those with coping motives showing higher levels of symptoms than those with other motives. Also, the interaction terms was significant (EMA Coping Motives*Time), with those with coping motives showing a greater decrease in symptoms of anxiety after use than those with other motives. Fixed

effects and coefficients are displayed in Tables 33-34. Means and 95% confidence intervals for the significant interaction are displayed in Figure 9. Pseudo R^2 for the model was 0.25.

Figure 9

After Cannabis Use: Anxiety Symptoms Across Time by Coping Motives

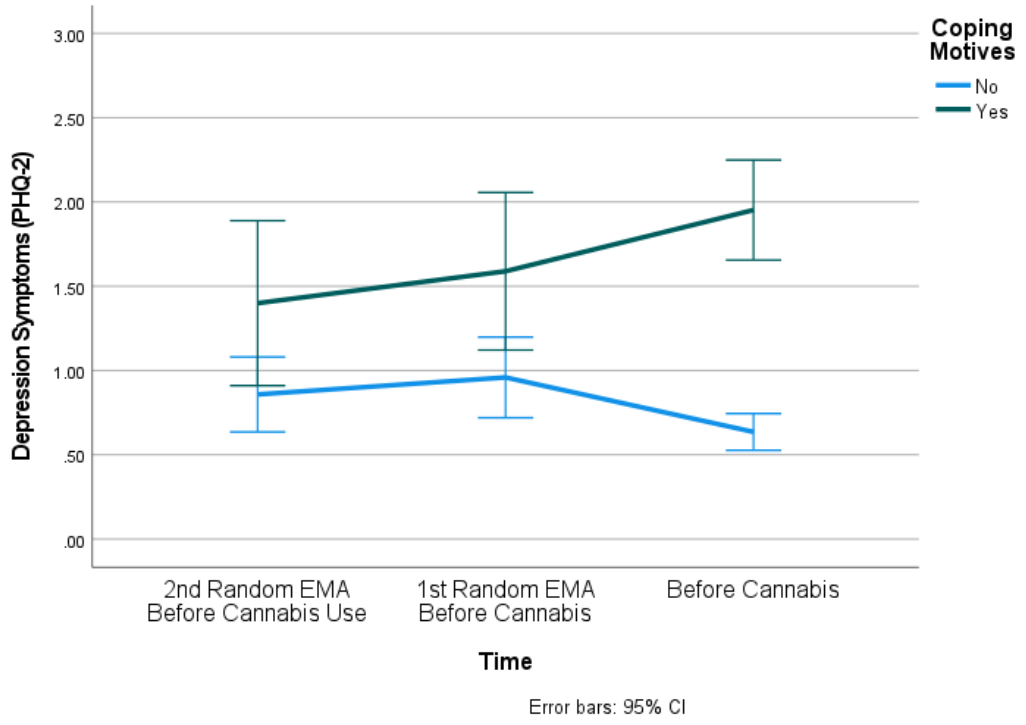


The Association Between Symptoms of Depression and Momentary Coping Motives Before Use. The overall model examining if momentary coping motives were significant related to symptoms of depression (EMA PHQ-2) before use was significant. Momentary coping motives were significantly related to symptoms of depression before use, with momentary coping motives associated with higher depression symptoms. Time was not significant, with depression symptoms not changing significantly before use across all participants. The interaction term (EMA Coping Motives*Time) was significant, indicating that changes in depression across time were associated with whether participants had coping motives. Specifically, those with coping motives showed increases in depression symptoms before cannabis use, while those without coping motives showed minimal change. Fixed effects and

fixed coefficients are displayed in Tables 35-36. Means and 95% confidence intervals for the significant interaction are displayed in Figure 10. Pseudo R^2 for the model was 0.021.

Figure 10

Before Cannabis Use: Depression Symptoms Across Time by Coping Motives



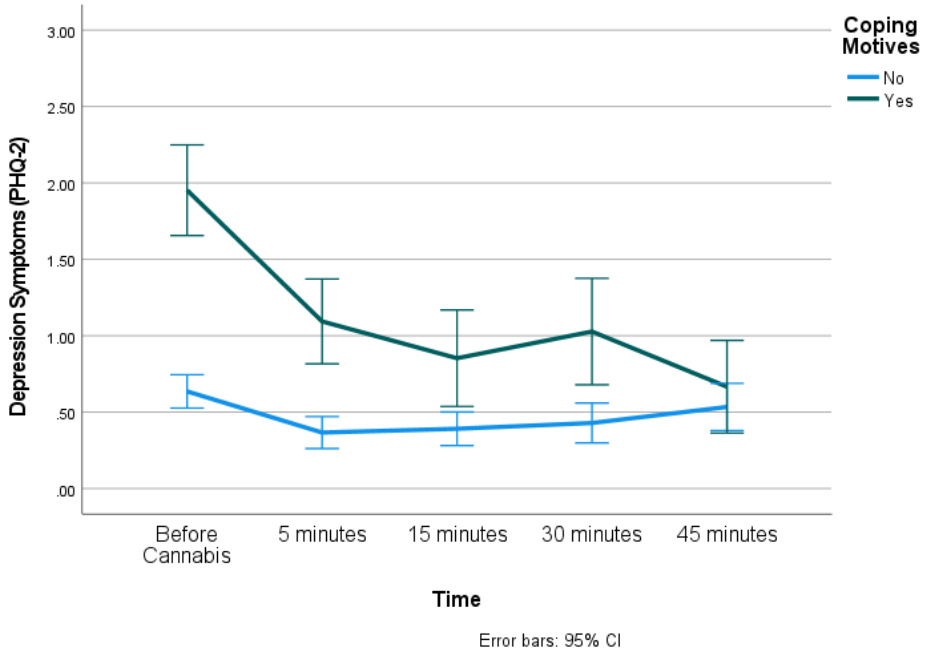
The Association Between Symptoms of Depression and Coping Motives After Use.

The overall model examining whether coping motives were associated with momentary depression symptoms (EMA PHQ-2) was significant. Time and momentary coping motives were significantly associated with depression symptoms after use, with symptoms decreasing across time, and those with coping motives showing higher levels of symptoms than those with other motives. Also, the interaction terms was significant (EMA Coping Motives*Time), with those with coping motives shower a greater decrease in symptoms of depression after use than those with other motives. Fixed effects and coefficients are displayed in Tables 37-38. Means and 95%

confidence intervals for the significant interaction are displayed in Figure 11. Pseudo R^2 for the model was 0.191.

Figure 11

After Cannabis Use: Depression Symptoms Across Time by Coping Motives



Discussion

This study examined the relationship between cannabis use, affect, and symptoms of anxiety and depression, along with potential moderators of this relationship in vivo using ecological momentary assessment. The aim was to determine if changes in affect and symptoms of anxiety and depression before and after cannabis use were associated with symptoms of CUD and coping motives to inform if changes were primarily related to withdrawal associated with CUD or improvements more broadly.

Cannabis Use Among Young Adults

Most of the young adults in our sample used cannabis for recreational purposes, primarily through smoking dried flower that is high in THC and low in CBD. A substantial number of young adults in this sample were unaware of the amount and potency of the cannabis they were using. Although many of the guidelines around safe cannabis consumption mention potency (Fischer et al., 2022), many young adults are not able to report this information, placing them at an increased risk of problematic or unsafe use (i.e., increased misuse liability). These individuals are much less able to engage in safe use, as they are unaware of how much or what type of cannabis there are using. The present findings emphasize that it is important that cannabis users be informed about the ways they can decrease the risks associated with their cannabis use. It may also be beneficial to determine ways to aid cannabis users in making decisions about risk when they are uncertain about the amount and type of cannabis they are using.

Participants in this study also primarily reported enhancement motives for use at baseline and at the momentary level. This is in line with previous EMA research by Buckner et al. (2015) who found most participants engaged in cannabis use with enhancement motives (77.7%), and research by Ross et al. (2018), who found 89.7% of participants used cannabis for either enhancement, social, or expansion reasons. Fewer participants reported coping motives in this study as compared to some previous research EMA research, with Buckner et al. (2015) finding 62.7% reported coping motives. In contrast, Ross et al. (2018) found 10.3% of participants reported either coping or conformity motives, much less than in the present study. Overall, the present sample seems to be somewhat different in terms of their momentary motives for use than those in previous research, which could influence the impact of coping motives on momentary changes in affect, anxiety, and depression.

The finding that some participants reported different motives across episodes of use highlights the importance of measuring motives for use at the momentary level when considering momentary changes in affect and symptoms. The Ross et al. (2018) study did not indicate whether participants varied in their momentary motives for use, and no other studies reported momentary motives. This is a unique finding from this study that indicates that the tendency to use cannabis for certain reasons is not necessarily equivalent to an individual's momentary motives for use.

Results from this study indicate that cannabis use effects typically occur rapidly. This is congruent with previous research on the pharmacology and pharmacokinetics of the drug. By Hunault et al. (2004) who found that max ratings of feeling "high" among individuals who have smoked cannabis in an experimental setting occurs within minutes of use. Grotenhermen (2003), who found individuals report maximum effects 20-30 minutes after inhalation, diverged from our results, as effects had typically decreased significantly by this point in the present study. This highlights the importance of examining the effects of cannabis use immediately (i.e., within minutes) after cannabis use begins, rather than after even a slightly a longer delay.

The Association Between Affect, Symptoms of Anxiety and Depression, and CUD Symptoms Before Use

The first hypothesis, that: a) participants with high levels of CUD symptoms would experience a decrease in positive affect and an increase in negative affect and symptoms of anxiety and depression before use; and b) participants with a low level of symptoms of CUD will experience increased positive affect and decreased negative affect and symptoms of anxiety and depression before use, was not supported. This relationship has not been examined previously in the literature. The hypothesis was based on the premise that those with CUD might be more

likely to engage in cannabis use in response to withdrawal symptoms (i.e., increases in negative affect, anxiety, and depression), in line with a negative reinforcement model of use specific to those with CUD. Those without CUD were hypothesized to engage in use for primarily social, enhancement, or enjoyment reasons, which would presumably be associated with higher positive affect. Although the relationship between CUD, affect, and symptoms of anxiety and depression before use has not been examined in the EMA literature, in the longitudinal research an abundance of research indicates that CUD symptoms are consistently associated with coping motives for use (Bresin & Mekawi, 2019; Fox, Towe, Stephens, Walker, & Roffman, 2011, Schultz et al., 2019; van der Pol et al., 2013). However, in this study, affect, anxiety, and depression did not show change before cannabis use across all participants, or differentially based on CUD symptoms. In contrast, Shrier et al. (2012) found that positive and negative affect before use was significantly associated with the desire to use cannabis use, with increased desire to use associated with increased negative and positive affect once desire was present. Also, higher positive affect predicted increased desire at lower levels of positive affect, with higher levels of positive affect showing decreased desire. Buckner et al. (2012) also found that craving increased as anxiety increased, and Buckner et al. (2013) found cannabis use likelihood increased with increases in positive and negative affect, in contrast to the present findings. Differing results could highlight the difference between desire to use and craving and actual patterns of use, although it is unclear why results differed from the Buckner et al. (2013) study, given similar methods were used.

Overall, based on my findings, cannabis use may not always be a response to changes in affect, anxiety, or depression and may be a response to some other internal or external state. For example, Shrier et al. (2012) found that being in the presence of friends was significantly

associated with desire for cannabis use and subsequent use. Also, Buckner et al. (2012, 2103) found the presence of others using cannabis was associated with increased likelihood of use. Perhaps the environment plays a more significant role than mood in determining cannabis use.

Given that those with high levels of CUD symptoms did not show differential change in affect and symptoms of anxiety and depression within the four hours before use, it is unlikely that participants were only engaging in use due to increasing withdrawal symptoms. Or at least, these specific withdrawal symptoms. This suggests that the mood and symptom improvements seen in this study are not solely the result of alleviation of withdrawal symptoms. Buckner et al. (2015) included a measure of withdrawal in their EMA study, but symptoms that showed change before and after use were primarily symptoms of anxiety (i.e., anxiety/nervousness, irritability, and restlessness). Their study did not examine CUD symptoms or diagnosis as a moderator. However, they concluded that those who report increased anxiety symptoms before use and decreased symptoms after use were experiencing these changes due to withdrawal. This conclusion is not supported by the present findings.

The Association Between Affect, Symptoms of Anxiety and Depression, and CUD Symptoms After Use

The second hypothesis, that: a) participants who have a high level of CUD symptoms will experience an increase in positive affect and a decrease in negative affect and symptoms of anxiety and depression after use; and b) participants who have a low level of CUD symptoms will experience decreased positive affect and increased negative affect and symptoms of anxiety and depression after use, was also not confirmed. Participants who have high levels of CUD symptoms did not experience a significant increase in positive affect or decrease in negative affect, anxiety, and depression after cannabis use. This is incongruent with previous research by

Ross et al. (2018) that found participants with cannabis dependence experience decreased negative affect after cannabis use. The results reported by Ross et al. (2018) also differed from the current study in that there was increased positive affect among those with CUD, whereas our study showed no change in positive affect, regardless of CUD symptoms. This may be because participants in the study by Ross et al. (2018) were attempting to quit cannabis, resulting in greater positive affect when they engaged in use due to having been abstinent. Overall, evidence is unclear as to whether those with CUD benefit acutely from cannabis use in terms of affect and symptoms of anxiety and depression, but the current findings suggest they do not.

In the present study, individuals who did not have CUD also did not experience changes in negative affect and symptoms of anxiety and depression. This contrasts findings by Ross et al. (2018), which found increased negative affect in those who do not have CUD. Ross et al. (2018) also found no significant change in positive affect after use among those without CUD, in line with the present findings. Differing results may be related to the timing of the EMA in this study, as those in the Ross et al. (2018) study were comparatively quite removed from the onset of cannabis use. In our study, peak effects were seen in five minutes, and were essentially nonexistent by 45 minutes later, indicating a high possibility that these acute effects could have been missed using a different time frame of assessments. Buckner et al. (2015) found that use of cannabis to modify positive affect may not be very effective in his sample of primarily dependent individuals, consistent with the present study. Our findings that those with CUD do not experience increases in positive affect associated with cannabis use provides further support the premise that acute changes in positive affect are not the primary motivating factor for cannabis use.

The Association Between Affect, Symptoms of Anxiety and Depression, and Momentary Coping Motives Before Use

The third hypothesis, that: a) participants with momentary coping motives will experience an increase in negative affect and symptoms of anxiety and depression, and no change in positive affect before engaging in use; and b) participants with non-coping motives will experience an increase in positive affect before engaging in use, was partly confirmed. Participants with coping motives experienced an increase in negative affect, anxiety, and depression before engaging in use. Buckner et al. (2015) also found this increase in negative affect before use among individuals with coping motives, and Buckner et al. (2012) found anxiety increased craving across all cannabis users. In contrast to my hypothesis, participants with non-coping motives displayed no change in positive affect before cannabis use. Although not specific to those with coping motives, Buckner et al. (2015) found no change in positive affect before cannabis use across all individuals, in line with the present findings. Based on the findings from this study, for individuals with coping motives a rise in negative affect and symptoms of anxiety and depression occurs before use, whereas for those without coping motives, they experience decreasing levels negative affect, anxiety, and depression before use. This indicates that momentary motives for use are more directly related to affect before use than symptoms of CUD and could indicate that a more generalized alleviation of negative states, as opposed to withdrawal symptoms specifically, explains why individuals experience benefits from cannabis use.

The Association Between Affect, Symptoms of Anxiety and Depression, and Coping Motives After Use

The fourth hypothesis, that a) participants who endorse momentary coping motives will experience reduced negative affect as well as anxiety and depressive symptoms; and b) participants who endorse other motives will experience increased positive affect, was partly confirmed. Participants who endorsed coping motives experienced reduced negative affect and decreased symptoms of anxiety and depression. Ross et al. (2018) found that negative affect increased after use among those with coping/conformity motives, but again, they were examining a much longer time frame after engaging in use than the present study (i.e., random times within 3-hour intervals during each participant's waking hours), and this could explain why initial decreases were not seen.

Those with non-coping motives also experienced reductions in negative affect and symptoms of anxiety and depression. However, those with coping motives showed a greater degree of change than those who had non-coping motives. Buckner et al. (2015) found that regardless of coping motives, individuals experienced increases in negative affect before use and decreases after, which mirrors the present findings. Overall, research supports the premise that those with coping motives experience greater acute benefits after cannabis use in terms of negative affect and symptoms of anxiety and depression. This likely maintains the perception that cannabis use is effective for mood and symptom management, encouraging use for coping in the future.

Taken together, findings indicate that the degree of change in negative affect and symptoms of anxiety and depression may be related to coping motives, but that the pattern of change occurs similarly regardless of motives for use. It is potentially concerning that those with coping motives experience more acute benefits from cannabis use, given that coping motives increase the likelihood of problematic cannabis use and CUD in the future (Fox et al., 2011,

Schultz et al., 2019; van der Pol & van Laar, 2013). This research highlights that while cannabis use may have acute benefits, the risk of CUD should be a concern among those who seek out these benefits.

Research seeking to identify the underlying reason for the association between coping motives and the acute effects of cannabis points to distress tolerance and emotion dysregulation. Greater perceived distress intolerance is associated with a greater number of cannabis dependence symptoms and cannabis-related problems, and the relationships are mediated by coping motives (Farris, Metrik, Bonn-Miller, Kahler, & Zvolensky, 2016). Peraza and colleagues (2019) found that lower distress tolerance was associated with increased cannabis use to cope. Also, Dvorak and Day (2014) found individuals with emotion regulation difficulties are more likely to experience negative consequences associated with cannabis use. These studies signify that those with coping motives experience greater benefits because they are more reliant on cannabis use for relief from distressing emotions and for emotion regulation, as exhibited in this study by improvements in mood and symptoms among those with coping motives. However, CUD did not show the same relationship as coping-motivated cannabis use, underscoring that use may be in in response to any distress, including symptoms of anxiety and depressive symptoms, not necessarily just withdrawal symptoms. Otherwise, those with high levels of CUD symptoms would have shown increased negative affect and symptoms of anxiety and depression before cannabis use in this study, as these individuals theoretically experience higher levels of withdrawal, but this was not the case.

Effect Sizes and Clinically Significant Change

Effect sizes for models producing significant interactions in this study based on pseudo R^2 values were relatively small (i.e., around .2). This indicates that while coping motives are

associated with differential change in mood and anxiety and depression symptoms, these differences are not large. Effect sizes for models with nonsignificant interactions were generally small (i.e., around .05) therefore the lack of significant findings was unlikely related to the sample size being too small to detect an effect for most of the analyses. Effect sizes for the before use analyses were also typically smaller than those after use. This further supports the importance of examining effects not only before cannabis use, but after use as well, as differences in effects may be more pronounced after cannabis use.

Studies using the PHQ-2 and GAD-2 before and after treatment can aid in determining if the present findings might be clinically significant. Bisby et al. (2022) analyzed treatment outcome from an 8-week online psychological pain management program based on the principles of cognitive behavior therapy and found that PHQ-2 scores decreased by an average of 34% and GAD-2 scores decreased by and average of 32%. Also, a study by Staples et al. (2019) examined outcomes from an internet-delivered Cognitive Behavioural Therapy (iCBT) and percentage change for the PHQ-2 was 50.0% and for the GAD-7 was 52.9%. In the present study, percent change across all participants based on averages from before to after cannabis use was 47% for GAD-2 and 43.9% for PHQ-2, comparable to findings from long-term clinical studies. Effects were more pronounced for those with coping motives (e.g., 49% decrease from pre- to post-use for those with coping motives on GAD-2), further supporting the clinical significance of the present findings.

Cannabis for Improving Affect and Reducing Symptoms of Anxiety and Depression

Findings from this study are congruent with previous research that indicates that acutely, cannabis use is associated with decreased negative affect and symptoms of anxiety and depression. This is likely why individuals report improvements in symptoms associated with

cannabis use despite longitudinal studies that indicate a worsening of symptoms over longer periods of time. As such, my study adds to the base of literature that supports various overlapping models of substance use including self-medication, negative reinforcement, and negative affect regulation models of cannabis use. The present results, along with previous findings, do not support the dual-affect model as changes in positive affect do not seem to occur before or after cannabis use. Further, this study adds to the evidence that acute improvements are more consistently found in naturalistic settings, where individuals can self-select cannabis type and mode of administration, as compared to laboratory settings. As previously stated, alleviation of withdrawal in the context of CUD does not appear to be the sole reason for improvements in mood and symptoms after use displayed in this study.

Findings highlight that while cannabis may be helpful for mood and symptom improvement at the momentary level, the risks and benefits of cannabis use likely differ across individuals and across time. Additional information about who benefits most from cannabis use and who does not, both short-term and long-term, is still required. Variable risks and benefits based on the individual does not necessarily preclude the use of cannabis to treat psychiatric symptoms. Especially given that symptoms of CUD, one of the biggest risks associated with cannabis use for coping, mirror many of the difficulties associated with other psychiatric medications. For example, the CUDIT-R examines frequency of use and time spent under the influence, which would be high when any substance is used medicinally. Also, use for symptom management would likely involve side effects that would lead individuals to consider decreasing their use. As such, several symptoms could be associated with therapeutic cannabis use, as opposed to problematic cannabis use. Additionally, commonly prescribed medication for psychiatric symptoms often involve some degree of dependence, tolerance, and negative effects

(Bet, Hugtenburg, Penninx, & Hoogendijk, 2013; Cosci & Chouinard, 2020; Fava, 2020; Fluyau, Revadigar, & Manobianco, 2018). However, for such medications, risks are accurately quantified based on the highest quality evidence available for consideration when selecting such medications, which is not the case for cannabis at this time. A clear understanding of the risks associated with cannabis use as compared to other psychiatric medications is therefore needed.

Moreover, it is unlikely that cannabis use typical in naturalistic settings (i.e., recreational use, smoking dried flower) will ever be the primary means recommended by medical professionals when suggesting use of cannabis as a psychiatric medication, assuming the risks and benefits are fully considered. Specifically, oral administration of high CBD, low THC variations are likely to be the lowest risk way to obtain the benefits of cannabinoids (Fischer et al., 2022). As a result, the findings of this study may do little to inform whether cannabis can be used effectively and safely for symptom reduction in the medicinal context, as it is unclear whether the benefits seen in this sample of predominantly recreational smokers are similar to those experienced by individuals who use cannabis medicinally through a more regulated oral administration. Research may do well to focus more on more low-risk forms of cannabis use when seeking evidence of whether cannabis is appropriate for the treatment of psychiatric symptoms.

On the other hand, the large number of individuals using cannabis for the purpose of improving mental health who choose smoking cannabis as their primary mode of ingestion (Asselin et al., 2022) points towards a clear need for information related to the effects of smoked cannabis as compared to edible forms. There is evidence from both laboratory and cross-sectional survey studies that smoked cannabis is associated with greater subjective effects than oral modes of administration (Boisvert et al., 2020; Lee, Crosier, Borodovsky, Sargent, &

Budney, 2016; Moreira et al., 2009), in line with the pharmacokinetic differences between smoked and orally ingested cannabis previously discussed (Meyer & Quenzer, 2005; Zamarripa et al., 2022). Given such findings, it is unsurprising that individuals who use cannabis for modifying affect and symptoms of anxiety and depression elect smoking as their primary mode of administration. At the same time, use of combustible cannabis products is also associated with more problematic and high-risk use (i.e., increased misuse liability; Simpson, Cho, & Barrington-Trimis, 2021). Again, individuals who smoke high THC cannabis for mood and symptom management need to be fully informed to enable them to carefully weigh the health risks associated with this method, as the acute benefits are unlikely to outweigh the long-term risks identified in the longitudinal research, including physical health risks and exacerbation of mental health symptoms. As most people do not obtain cannabis through their medical professional, especially since it was legalized for recreational use in Canada (Smith et al., 2021), many individuals will not receive medical advice about their use and the risks and benefits. Therefore, ensuring this information is readily available to the public so cannabis users can make informed decisions independently is necessary to reduce the risk of harm associated with cannabis use in the general population.

Equivalence of Trait Affect and Symptoms of Anxiety and Depression

One of the novel features of this study was using both affect measures as well as symptom measures to identify changes after cannabis use. This study put forth the premise that affect and specific symptoms of anxiety and depression may show different relationships with cannabis use at the momentary level. However, this was generally not the case, with negative affect, anxious mood and worry, and depressed mood and anhedonia all displaying essentially the same relationship across time with coping motives and CUD symptoms. Of course, this was a

limited range of anxiety and depression symptoms, and additional symptoms could show a different relationship (e.g., suicidality, muscle tension, sleep). However, the current findings indicate that use of an affect measure may be a reasonable proxy for some symptoms of anxiety and depression.

Other Substance Use and Psychiatric Medications

Assessing whether other substances might interact with cannabis use in the context of use for symptoms management is needed to determine if there are any contraindications. In the present study, when other substance use during a cannabis use episode was included in the model, both across all substances and each substance individually (i.e., alcohol, nicotine, caffeine), they did not significantly improve prediction over a model without other substance use. This indicates that the impact of simultaneous substance use was minimal in the present study.

Specifically, alcohol use did not improve prediction over a models without the inclusion of alcohol use. In addition, further analyses confirmed these findings, where the inclusion of alcohol did not affect the results in terms of Beta coefficients and effect sizes and was not found to be significant predictor in any of the models. This is congruent with research by Cloutier and colleagues (2022) and Linden-Carmichael and colleagues (2020), who found alcohol use did not result in different acute effects of cannabis. However, very few participants engaged in simultaneous alcohol use during this study (i.e., approximately 12% of episodes contained alcohol use in addition to cannabis), which limits the ability to make conclusions based on the present sample.

For nicotine and caffeine use, the number of participants who engaged in simultaneous use was somewhat higher than alcohol use (i.e., approximately 23% and 17%, respectively), yet

these substances were not associated with differing cannabis effects. This supports the premise that nicotine does not modify the subjective effects of cannabis use, in line with much of the previous research on this topic (Haney et al., 2017; Hindocha et al., 2017; Peters et al., 2021). It also adds to the body of literature on caffeine use and cannabis, where there are few studies to indicate if there is an impact of co-use, providing evidence that there is no substantial change in subjective effects.

Similarly, while approximately one-third of individuals were taking prescription psychiatric medications, this was not associated with significant improvements in model predication, and therefore it is unlikely that they would underly different subjective effects. Although Lucas and colleagues (2018) highlighted the potential for interaction effects, no actual evidence of interactions has been identified. Although this study did not include all forms of medication, it provides evidence that psychiatric medication does not influence the subjective effects of cannabis. Overall, findings from this study indicate that the acute cannabis effects are not greatly influenced by other substances, although this cannot be concluded based on this study alone.

Limitations

The results of this study have various implications for young adults who use cannabis to improve their mental health. At the same time, there are several limitations through which these findings need to be interpreted. First, although I intended to examine if the amount of cannabis use played a role in any of the associations observed, many participants did not provide this information, likely because they did not know. Among those who did provide this information, it was difficult to ensure the amounts reported were standardized, as the gram equivalent of various units of measurement provided was often unclear and likely could vary across participants and

use episodes (e.g., “3 bong bowls” could be a different amount of cannabis from participant to participant and use episode to use episode). As participants engaged in different modes of administration, it is challenging to examine the amount of cannabis used in a naturalistic setting without significantly increasing participant burden by requiring them to weigh their cannabis each time they engage in use. And this is only in the event they smoke dried flower, not some form of concentrate or edibles, which would need to be standardized in an entirely different manner and made comparable. I did attempt this, but the decision-making process was incredibly unclear, and likely inaccurate in many cases. This is probably why type of cannabis use did not contribute significantly to the model in this study. Lack of standardization has been a problem cited as present throughout the literature on cannabis use (Freeman & Lorenzetti, 2020; Wycoff et al., 2018). A feasible means of standardizing these should be created and made widely available to improve the ability to examine cannabis use outside a standardized lab setting.

Similarly, many participants were unaware of the THC and CBD content of the cannabis they were using, the strain, or any other details beyond that it was dried flower. For some individuals, this was because they grew their own cannabis (i.e., “home grown”) and had no way to determine this information. For others, they may not have been the ones purchasing the cannabis, they may not have concerned themselves with the information when purchasing, or they may be obtaining cannabis from the illegal market. This again led to the variable not significantly contributing to prediction of outcomes.

Missing data was a primary limitation of this study beyond having to exclude cannabis-related factors. Although compliance was, on average, reasonable for the Random EMA (i.e., about 75%) the After Cannabis EMA were less consistently completed (i.e., 65%), with EMA hours away from the initial assessment rarely completed (i.e., 30-40%). This is likely because

participants were compensated based on their completion of the random sessions only. This was necessary for ethical reasons, given that compensation based on completion of before and after cannabis sessions would not allow for compensation of those who ultimately did not engage in cannabis use during the EMA period. Also, those who engaged in more episodes of cannabis use would have an increased chance of not being fully compensated as compared to those who only engaged in use once. Lack of additional compensation may have influenced the rate of responding to the After Cannabis EMA. An additional reason may be that participants were sleeping after cannabis use, and therefore were not able to respond to later EMA. This was reported by several participants during the study. Post hoc analyses also found that those who engage in a higher frequency and quantity of cannabis use at baseline were more likely to complete the After Cannabis Use EMA, which could influence the results, as findings may be more or less pronounced for these individuals (e.g., due to tolerance). While it is unclear exactly to what degree the amount of missing data influenced the results, it is likely that this is a limitation that may skew the findings.

There have also been some criticisms of the measure of affect use in this study (i.e., the PANAS). Specifically, Harmon-Jones, Bastian, & Harmon-Jones (2016a) indicated that because the PANAS requests participants indicate how they feel “right now”, it may miss meaningful emotional reactions to events. The authors reported the findings of three studies that display the instructions for measuring affect are important, as asking individuals how they felt during a specific emotional experience reported a greater degree of emotional reaction than those who were asked how they feel in the moment (i.e., after the experience; Harmon-Jones et al., 2016a). While the current study aimed to use EMA to capture individuals affect in the moment, it may have been more effective to ask how the individuals felt immediately after engaging in use (e.g.,

after the first “puff”). It is possible that this would have produced larger effect sizes than the ones seen in this study. Harmon-Jones, Bastian, & Harmon-Jones (2016b) noted an additional problem with the PANAS, wherein it could be argued it represents more positive and negative activation than affect, especially given studies that show anger (i.e., and approach-motivated negative emotion) loads more heavily onto the positive affect scale. The decision to use the PANAS was made in the interest of comparability, as recent EMA studies typically use the PANAS. Also, based on feasibility, as it is one of the shortest most cost-effective affect measures. However, there may be some issues with the continued use of this measure in EMA studies, given the potential impacts on the results.

While this study measured self-reported motives for use, an additional way to determine motives is also through context-related questions. There is research that indicates whether a person is engaging in cannabis use alone or with others plays a role in cannabis effects. Spinella, Stewart, and Barret (2019) found that those who used cannabis alone were more likely to report coping motives, endorsed more symptoms of CUD, and had higher rates of cannabis use in the past 30 days. Okey, Waddell, and Corbin (2022) found a similar relationship, with frequent cannabis use in solitary contexts associated with greater negative cannabis consequences, both directly and indirectly via coping motives. In EMA studies, Shrier et al. (2012) found companionship was associated with increased likelihood of cannabis use, as did Buckner et al. (2012; 2013). The lack of inclusion of a question about whether individuals were alone or with others in the current study ignored a potential moderator of the relationship between cannabis use, affect, and anxiety and depression symptoms.

This study also examined symptoms of CUD based on a short self-report measure (i.e., CUDIT-R), rather than using a diagnostic interview. While this measure displayed high

sensitivity (91%) and specificity (90%) as compared to diagnosis made using a structured clinical interview (Adamson et al., 2010), it is possible that the relationship between cannabis use and acute symptoms of anxiety and depression for individuals with a confirmed diagnosis of CUD may be different than those with high scores on a screening measure. Although, being able to identify individuals along a spectrum of CUD symptoms rather than a dichotomous variable may more readily display any underlying relationship with severity of the disorder, rather than presence or absence, which could be considered a strength of the current study.

In terms of generalizability, although it was unclear what type of cannabis was used by those in this study, information provided at baseline indicates that most of the participants engaged primarily in smoking of high THC cannabis use. These findings may not generalize to those who use products without THC. As previously discussed, research indicates high CBD strains may have very different effects than high THC strains, often showing opposite effects, and there may be differing effects based on the combination and timing of each (Batalla et al., 2014; Bhattacharyya et al. 2010; Martin-Santos et al., 2012). If more participants had engaged in use of high-CBD strains of cannabis use, I may have been able to examine the difference between the two.

Similarly, mode of consumption may result in different effects of cannabis use. Mode of inhalation seems to play a limited role in outcomes when self-selected (e.g., bong vs. joint), given that this was not significantly related to model fit. Research indicates that oral routes of administration often show differing effects than smoking (Moreira et al., 2009). As so few participants chose methods other than smoking in this study, this association could not be examined. It is possible that if more participants who consumed cannabis orally or nasally were included in the study, they may have experienced different effects.

The frequency of use among participants may also limit generalizability. Participants were required to engage in at least weekly cannabis use, as this was necessary to limit the length of the period of EMA completion while ensuring they completed EMA for at least one episode of cannabis use. The average amount of use during the study period was approximately once per day. This means that the results may not be the same in a group of infrequent users, who would likely show lower rates of coping motives and CUD. Across studies, research indicates that those who engage in frequent cannabis use are less likely to experience the anxiety-inducing effects due to their increased tolerance to the psychoactive effects (Green et al., 2003; LaFrance, Stueber, Glodosky, Mauzay, & Cuttler, 2020; Metrik et al., 2011; Ross et al., 2018). Based on other research, novices are more likely to show increases in symptoms of anxiety after cannabis use, rather than decreases. It should not be assumed that individuals who engage in infrequent use would respond in a similar manner to the participant in the present study.

Although the present study sought to examine multiple symptoms of depression and anxiety in relation to cannabis use, ultimately only anhedonia and worry were included beyond the mood symptoms. Longer measures were not as feasible or relevant given the interval between After Cannabis EMA (e.g., reporting effects on sleep 5 minutes after use). These items could have been completed later but it would have reduced comparability across earlier time points and increased participant burden. Also, choosing the appropriate time to ensure changes were related to cannabis use proved difficult. For example, if EMA were completed at a specific time each night, participants could engage in use of cannabis after this time, as many did in this study, and then this information would not be caught until late the next day. I could have asked such questions a certain amount of time after a Before Cannabis EMA, as was done with the After Cannabis EMA, but again, this would not guarantee that they had eaten or slept since the

episode of use. Leaving this to a user-initiated session before bed and when they wake up (e.g., to capture sleep) also likely would have decreased compliance and increased participant burden. Ultimately, it was elected not to include these other symptoms, but it is possible they would show different relationships over time than those examined in the present study.

A final comment on generalizability is that participants were mostly White, female, university students. Related to the mental health and functioning of those included in the study, many had psychiatric conditions (30%) and many were above cutoffs for anxiety (15% severe) and depression symptoms at baseline (18% moderate-severe to severe). As well, many were above cutoff for likely CUD (56%). Despite this, the sample is a relatively high-functioning, nonclinical, nontreatment-seeking group of individuals. Findings may not generalize to individuals from different demographics, with less mental health difficulties, those who are seeking treatment, or individuals who are lower functioning.

Beyond participant factors, the context in which the study was conducted may also limit the generalizability of the results. Data were collected in Canada a year after legalization of cannabis occurred, which may be associated with higher rates of cannabis use and cannabis use disorder (Cerdá et al., 2020; Hall & Lynskey, 2020; Leung et al., 2018; Melchior et al., 2019; Smart & Liccardo Pacula, 2019; Turna et al., 2021). Also, the latter half the data were collected during the COVID-19 pandemic, which was also associated with increased cannabis use, mental health difficulties, and cannabis use to cope with mental health difficulties (Bartel et al., 2020; Chong, Acar, West, & Wong, 2022; Gill et al., 2022; Rotermann, 2020; Turna et al., 2021). As such, rates of use, mental health difficulties, and coping motives may be overestimated in the sample of participants obtained for this study.

Future Research

Future research of a similar nature will need to address the difficulties measuring cannabis use in the naturalistic setting. Many participants were not able to provide information on potency or even the amount used, and the quantities were rarely comparable across individuals in terms of units of measurement. One way to improve this might be to have a standard cannabis unit to reflect the dose of THC across all types of cannabis products (Freeman & Lorenzetti, 2020). This does not aid in the lack of knowledge of amount, though. This might explain why other studies tend not to examine factors like type of THC and amount of use, because individuals often do not know. This was probably even more likely before the legal market, when cannabis potency was not labelled or known. It is possible that if participants were given the same type and amount of cannabis to smoke in naturalistic settings that it would have had fewer positive effects, as individuals likely self-select what is most effective for mood and symptom management. This could explain differences in findings between naturalistic and experimental studies, as the latter involves strictly controlling cannabis amount and type across all participants, and participants in these studies show increases in negative affect more frequently. This places a high importance on improving the means by which to track of type and amount of cannabis in naturalistic settings to determine whether differences between naturalistic studies and lab studies are due to these variables. One method might be to provide participants with kits that allow them to determine the strain and THC/CBD content as well as weigh the amount being used, although this would greatly increase participant burden. As such, how to best measure cannabis use in naturalistic settings, without restricting cannabis type and amount for participants, is a subject for further study.

Future research would also do well to include additional symptoms of anxiety and depression, as previously discussed. While this is challenging to measure effectively, it is

essential to understanding affects of cannabis on mental health conditions to determine if all symptoms show the same response to cannabis use, or if it is more effective on mood symptoms, anhedonia, and worry.

It may be helpful to include individuals who engage in polysubstance use more frequently in future research to determine how this relates to the effects of cannabis. Findings from this study indicate that the acute cannabis effects are not greatly influenced by alcohol use, but there were a limited number of individuals who engaged in simultaneous alcohol use, likely influencing these results. There were a larger number of individuals who engaged in nicotine and caffeine use and who took psychiatric medications than those who used alcohol in this study, and limited impacts on subjective effects of cannabis were found for these substances as well. However, given the limited number of studies examining co-use available in the literature, and the absence of studies examining prescribed medications, it is not possible to compare the present findings to other studies. Therefore, more research examining polysubstance use and prescribed medications is needed to confirm these preliminary conclusions.

Finally, most of the research that does look at the effectiveness of cannabis compares it to a placebo, rather than an active control. Additional research comparing the acute and long-term effects of cannabis use and other medication prescribed for anxiety and depression would help illuminate whether cannabis use presents with unique risks not associated with other medications, or if the risk/benefit profile is comparable.

Implications

Acute changes in affect and symptoms are likely responsible for the perception that cannabis use aids in the management of these symptoms, supporting a negative reinforcement model of cannabis use for many individuals. Positive acute effects are even more pronounced for

those with coping motives. While this is evidence that acutely, cannabis use is associated with improvements in mood and symptoms, this also indicates increased misuse liability, as individuals are more likely to engage in use for these effects in the future at increasing doses, resulting in problematic use patterns. For clinicians working with individuals using cannabis for symptom relief, it is important to acknowledge that there are likely real short-term benefits associated with cannabis use. However, individuals who report positive acute changes associated with cannabis use should be educated on how to minimize these risks while obtaining these benefits (e.g., by using lower THC products, consuming cannabis orally rather than by smoking) as most individuals do not engage in cannabis use in this manner. More broadly, information on the short- and long-term effects of cannabis use needs to be made clearly and publicly available, as individuals often do not report their cannabis use for mood and symptom management to their medical providers, yet still engage in use for these purposes.

Conclusion

Findings from this study support the premise that cannabis use is associated with improvements in symptoms of anxiety and depression after use in naturalistic settings (i.e., in vivo), especially for those who report coping motives. Also, that symptoms of CUD, including withdrawal symptoms, are not associated with changes in anxiety and depression symptoms after cannabis use before or after use, indicating that improvements may not be solely the result of alleviation of withdrawal symptoms. The results of this study help elucidate the relationship between cannabis use, affect, and symptoms of anxiety and depression. Given the relatively recent legalization of cannabis in Canada and associated impacts, such findings have implications for a potentially growing number of individuals considering using cannabis to improve their affect and psychiatric symptoms. However, additional research on this topic is

needed to fully elucidate the potential risk and benefits so that individuals engaging in cannabis use for symptom management can be fully informed.

References

Adamson, S. J., Kay-Lambkin, F. J., Baker, A. L., Lewin, T. J., Thornton , L., Kelly, B. J., & Sellman, J. D. (2010). An improved brief measure of cannabis misuse: The cannabis use disorders identification test – revised (CUDIT-R). *Drug and Alcohol Dependence, 110*, 137-143. doi:10.1016/j.drugalcdep.2010.02.017

Adamson, S. J., Kay-Lambkin, F., Baker, A., Frampton, C. M. A., Sellman, D., & Lewin, T. J. (2015). Measuring change in cannabis use. *Addiction Research & Theory, 23*(1), 43-49. doi:http://dx.doi.org.ezproxy.lakeheadu.ca/10.3109/16066359.2014.926895

Allen, J., & Holder, M. D. (2014). Marijuana use and well-being in university students. *Journal of Happiness Studies*, *15*(2), 301-321. doi:10.1007/s10902-013-9423-1

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Anderson, G. D., & Chan, L. N. (2016). Pharmacokinetic drug interactions with tobacco, cannabinoids and smoking cessation products. *Clinical Pharmacokinetics*, *55*(11), 1353-1368. doi:10.1007/s40262-016-0400-9

Arean, P. A., Hallgren, K. A., Jordan, J. T., Gazzaley, A., Atkins, D. C., Heagerty, P. J., & Anguera, J. A. (2016). The use and effectiveness of mobile apps for depression: Results from a fully remote clinical trial. *Journal of Medical Internet Research*, *18*(12), e330. doi:10.2196/jmir.6482

Arout, C. A., Haney, M., Herrmann, E. S., Bedi, G., & Cooper, Z. D. (2021). A placebo-controlled investigation of the analgesic effects, abuse liability, safety and tolerability of a range of oral cannabidiol doses in healthy humans. *British Journal of Clinical Pharmacology*, *88*(1), 347-355. doi:10.1111/bcp.14973

Asselin, A., Lamarre, O. B., Chamberland, R., McNeil, S. J., Demers, E., & Zongo, A. (2022). A description of self-medication with cannabis among adults with legal access to cannabis in Quebec, Canada. *Journal of Cannabis Research*, *4*(1), 1-15. doi:10.1186/s42238-022-00135-y

Baker, T. B., Morse, E., & Sherman, J. E. (1987). The motivation to use drugs: A psychobiological analysis of urges. In: Rivers PC, editor. *The Nebraska Symposium on Motivation: Alcohol Use and Abuse.* (pp. 257–323). Lincoln, NE: University of Nebraska Press.

Baker, T. B., Piper, M. E., McCarthy, D. E., Majeskie, M. R., & Fiore, M. C. (2004). Addiction motivation reformulated: An affective processing model of negative reinforcement. *Psychological Review*, *111*(1), 33-51. doi:10.1037/0033-295X.111.1.33

Ballard, M. E., & de Wit, H. (2011). Combined effects of acute, very-low-dose ethanol and delta (9)-tetrahydrocannabinol in healthy human volunteers. *Pharmacology Biochemistry and Behavior*, *97*(4), 627-631. doi:10.1016/j.pbb.2010.11.013

Bartel, S. J., Sherry, S. B., & Stewart, S. H. (2020). Self-isolation: A significant contributor to cannabis use during the COVID-19 pandemic. *Substance Abuse*, *41*(4), 409-412. doi:10.1080/08897077.2020.1823550

Batalla, A., Crippa, J. A., Busatto, G. F., Guimaraes, F. S., Zuardi, A. W., Valverde, O., ... & Martin-Santos, R. (2014). Neuroimaging studies of acute effects of THC and CBD in humans and animals: a systematic review. *Current Pharmaceutical Design*, *20*(13), 2168-2185. Retrieved from https://benthamscience.com/journals/current-pharmaceutical-design/

Bergamaschi, M. M., Queiroz, R. H. C., Chagas, M. H. N., De Oliveira, D. C. G., De Martinis, B. S., Kapczinski, F., ... & Martín-Santos, R. (2011). Cannabidiol reduces the anxiety

induced by simulated public speaking in treatment-naive social phobia patients. *Neuropsychopharmacology*, *36*(6), 1219-1226. doi:10.1038/npp.2011.6

Bet, P. M., Hugtenburg, J. G., Penninx, B. W., & Hoogendijk, W. J. (2013). Side effects of antidepressants during long-term use in a naturalistic setting. *European Neuropsychopharmacology*, *23*(11), 1443-1451. doi:10.1016/j.euroneuro.2013.05.001

Bhattacharyya, S., Morrison, P. D., Fusar-Poli, P., Martin-Santos, R., Borgwardt, S., Winton-Brown, T., ... & McGuire, P. K. (2010). Opposite effects of Δ-9-tetrahydrocannabinol and cannabidiol on human brain function and psychopathology. *Neuropsychopharmacology*, *35*(3), 764-774. doi:10.1038/npp.2009.184

Bhushan, D., Blood, E. A., & Shrier, L. A. (2013). Momentary affective states predicting substance use events in depressed youth. *Mental Health and Substance Use*, *6*(3), 203-218. doi:10.1080/17523281.2012.708357

Bisby, M. A., Karin, E., Scott, A. J., Dudeney, J., Fisher, A., Gandy, M., ... & Dear, B. F. (2022). Examining the psychometric properties of brief screening measures of depression and anxiety in chronic pain: The Patient Health Questionnaire 2-item and Generalized Anxiety Disorder 2-item. *Pain Practice*, *22*(4), 478-486. doi:10.1111/papr.13107

Blessing, E. M., Steenkamp, M. M., Manzanares, J., & Marmar, C. R. (2015). Cannabidiol as a potential treatment for anxiety disorders. *Neurotherapeutics*, *12*(4), 825-836. doi:10.1007/s13311-015-0387-1

Blume, A. W. (2001). Negative reinforcement and substance abuse: Using a behavioral conceptualization to enhance treatment. *The Behavior Analyst Today*, *2*(2), 86-90. Retrieved from https://psycnet.apa.org/

Blume, A. W., Schmaling, K. B., & Marlatt, G. A. (2000). Revisiting the self-medication hypothesis from a behavioral perspective. *Cognitive and Behavioral Practice*, *7*(4), 379-384. doi:10.1016/S1077-7229(00)80048-6

Boisvert, E. E., Bae, D., Pang, R. D., Davis, J. P., Kelley-Quon, L. I., Barrington-Trimis, J. L., ... & Leventhal, A. M. (2020). Subjective effects of combustible, vaporized, and edible cannabis: Results from a survey of adolescent cannabis users. *Drug and Alcohol Dependence*, *206*, 107716. doi:10.1016/j.drugalcdep.2019.107716

Bonaccorso, S., Ricciardi, A., Zangani, C., Chiappini, S., & Schifano, F. (2019). Cannabidiol (CBD) use in psychiatric disorders: A systematic review. *Neurotoxicology, 74,* 282-298. doi:10.1016/j.neuro.2019.08.002

Bonn-Miller, M. O., Boden, M. T., Bucossi, M. M., & Babson, K. A. (2014). Self-reported cannabis use characteristics, patterns and helpfulness among medical cannabis users. *The American Journal of Drug and Alcohol Abuse*, *40*(1), 23-30. doi:10.3109/00952990.2013.821477

Bovasso, G. B. (2001). Cannabis abuse as a risk factor for depressive symptoms. *American Journal of Psychiatry*, *158*(12), 2033-2037. doi:10.1176/appi.ajp.158.12.2033

Bresin, K., & Mekawi, Y. (2019). Do marijuana use motives matter? Meta-analytic associations with marijuana use frequency and problems. *Addictive Behaviors*, *99*, 106102. doi:10.1016/j.addbeh.2019.106102

Buckner, J. D., Crosby, R. D., Silgado, J., Wonderlich, S. A., & Schmidt, N. B. (2012). Immediate antecedents of marijuana use: An analysis from ecological momentary assessment. *Journal of Behavior Therapy and Experimental Psychiatry, 43*(1), 647–655. doi:10.1016/j.jbtep.2011.09.010.

Buckner, J. D., Zvolensky, M. J., & Ecker, A. H. (2013). Cannabis use during a voluntary quit attempt: An analysis from ecological momentary assessment. *Drug and Alcohol Dependence, 132*(3), 610–616. doi:10.1016/j.drugalcdep.2013.04.013.

Buckner, J. D., Zvolensky, M. J., Crosby, R. D., Wonderlich, S. A., Ecker, A. H., & Richter, A. (2015). Antecedents and consequences of cannabis use among racially diverse cannabis users: An analysis from ecological momentary assessment. *Drug & Alcohol Dependence*, *147*, 20-25. doi:10.1016/j.drugalcdep.2014.12.022

Calhoun, S. R., Galloway, G. P., & Smith, D. E. (1998). Abuse potential of dronabinol (Marinol®). *Journal of Psychoactive Drugs*, *30*(2), 187-196. doi:10.1080/02791072.1998.10399689

Cano, M. Á., de Dios, M. A., Correa-Fernández, V., Childress, S., Abrams, J. L., & Roncancio, A. M. (2017). Depressive symptom domains and alcohol use severity among Hispanic emerging adults: Examining moderating effects of gender. *Addictive Behaviors*, *72*, 72-78. doi:10.1016/j.addbeh.2017.03.015

Carmody, T. P., Vieten, C., & Astin, J. A. (2007). Negative affect, emotional acceptance, and smoking cessation. *Journal of Psychoactive Drugs*, *39*(4), 499-508. doi:10.1080/02791072.2007.10399889

Carter, B. L., Lam, C. Y., Robinson, J. D., Paris, M. M., Waters, A. J., Wetter, D. W., & Cinciripini, P. M. (2008). Real-time craving and mood assessments before and after smoking. *Nicotine & Tobacco Research*, *10*(7), 1165-1169. doi:10.1080/14622200802163084

CBC News. (February 27, 2020). *A 'range of options': Thunder Bay's first cannabis store set to open Monday.* Retrieved from https://www.cbc.ca/news/canada/thunder-bay/thunder-bay-tokyo-smoke-opening-1.5477059

Cerdá, M., Mauro, C., Hamilton, A., Levy, N. S., Santaella-Tenorio, J., Hasin, D., ... & Martins, S. S. (2020). Association between recreational marijuana legalization in the United States and changes in marijuana use and cannabis use disorder from 2008 to 2016. *JAMA Psychiatry*, *77*(2), 165-171. doi:10.1001/jamapsychiatry.2019.3254

Cheung, J. T., Mann, R. E., Ialomiteanu, A., Stoduto, G., Chan, V., Ala-Leppilampi, K., & Rehm, J. (2010). Anxiety and affect disorders and cannabis use. *The American Journal of Drug and Alcohol Abuse*, *36*(2), 118-122. doi:10.3109/00952991003713784

Childs, E., Lutz, J. A., & de Wit, H. (2017). Dose-related effects of delta-9-THC on emotional responses to acute psychosocial stress. *Drug and Alcohol Dependence*, *177*, 136-144. doi:10.1016/j.drugalcdep.2017.03.030

Chong, W. W. Y., Acar, Z. I., West, M. L., & Wong, F. (2022). A scoping review on the medical and recreational use of cannabis during the COVID-19 pandemic. *Cannabis and Cannabinoid Research* [online ahead of print]. doi:10.1089/can.2021.0054

Cloutier, R. M., Calhoun, B. H., Lanza, S. T., & Linden-Carmichael, A. N. (2022). Assessing subjective cannabis effects in daily life with contemporary young adult language. *Drug and Alcohol Dependence*, *230*, 109205. doi:10.1016/j.drugalcdep.2021.109205

Cooper, Z. D., & Abrams, D. I. (2019). Considering abuse liability and neurocognitive effects of cannabis and cannabis-derived products when assessing analgesic efficacy: A comprehensive review of randomized-controlled studies. *The American Journal of Drug and Alcohol Abuse*, *45*(6), 580-595. doi:10.1080/00952990.2019.1669628

Cooper, M. L., Kuntsche, E., Levitt, A., Barber, L. L., & Wolf, S. (2016). Motivational models of substance use: A review of theory and research on motives for using alcohol, marijuana, and tobacco. In *The Oxford handbook of substance use and substance use disorders*, ed. K. J. Sher, 375–421. New York, NY: Oxford University Press. doi:10.1093/oxfordhb/9780199381678.013.017.

Corroon, J. M., Mischley, L. K., & Sexton, M. (2017). Cannabis as a substitute for prescription drugs–a cross-sectional study. *Journal of Pain Research*, *10*, 989-998. doi:10.2147/JPR.S134330

Cosci, F., & Chouinard, G. (2020). Acute and persistent withdrawal syndromes following discontinuation of psychotropic medications. *Psychotherapy and Psychosomatics*, *89*(5), 283-306. doi:10.1159/000506868

Cosci, F., Pistelli, F., Lazzarini, N., & Carrozzi, L. (2011). Nicotine dependence and psychological distress: Outcomes and clinical implications in smoking cessation. *Psychology Research and Behavior Management*, 119-128. doi:0.2147/PRBM.S14243

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology*, *43*(3), 245-265. doi:10.1348/0144665031752934

Crippa, J. A. S., Derenusson, G. N., Ferrari, T. B., Wichert-Ana, L., Duran, F. L., Martin-Santos, R., ... & Filho, A. S. (2011). Neural basis of anxiolytic effects of cannabidiol (CBD) in generalized social anxiety disorder: A preliminary report. *Journal of Psychopharmacology*, *25*(1), 121-130. doi:10.1177/0269881110379283

Crippa, J. A., Zuardi, A. W., Martín-Santos, R., Bhattacharyya, S., Atakan, Z., McGuire, P., & Fusar-Poli, P. (2009). Cannabis and anxiety: A critical review of the evidence. *Human Psychopharmacology: Clinical and Experimental*, *24*(7), 515-523. doi:10.1002/hup.1048

Cuttler, C., Spradlin, A., & McLaughlin, R. J. (2018). A naturalistic examination of the perceived effects of cannabis on negative affect. *Journal of Affective Disorders*, *235*, 198-205. doi:10.1016/j.jad.2018.04.054

Dawes, G. M., Sitharthan, T., Conigrave, K. M., Phung, N., & Weltman, M. (2011). Patients admitted for inpatient cannabis detoxification: Withdrawal symptoms and impacts of common comorbidities. *Journal of Substance Use*, *16*(5), 392-405. doi:10.3109/14659891.2010.499491

de Mello Schier, A.R. , de Oliveira Ribeiro, N. P., Coutinho, D. S., Machado, S., Arias-Carrión, O., Crippa, J. A., ... & Silva, A. C. (2014). Antidepressant-like and anxiolytic-like effects of cannabidiol: A chemical compound of cannabis sativa. *CNS & Neurological Disorders-Drug Targets*, *13*(6), 953-960. Retrieved from https://benthamscience.com/journals/CNSNDDT

Degenhardt, L., Hall, W., & Lynskey, M. (2003). Exploring the association between cannabis use and depression. *Addiction*, *98*(11), 1493-1504. doi:10.1046/j.1360-0443.2003.00437.x

Denson, T. F., & Earleywine, M. (2006). Decreased depression in marijuana users. *Addictive Behaviors*, *31*(4), 738-742. doi:10.1016/j.addbeh.2005.05.052

Dorard, G., Berthoz, S., Phan, O., Corcos, M., & Bungener, C. (2008). Affect dysregulation in cannabis abusers. *European Child & Adolescent Psychiatry*, *17*(5), 274-282. doi:10.1007/s00787-007-0663-7

Dozois, D. J. A., & Mental Health Research Canada. (2021). Anxiety and depression in Canada during the COVID-19 pandemic: A national survey. *Canadian Psychology, 62*(1), 136–142. doi:10.1037/cap0000251

Dvorak, R. D., & Day, A. M. (2014). Marijuana and self-regulation: Examining likelihood and intensity of use and problems. *Addictive Behaviors*, *39*(3), 709-712. doi:10.1016/j.addbeh.2013.11.001

Dvorak, R. D., Pearson, M. R., & Day, A. M. (2014). Ecological momentary assessment of acute alcohol use disorder symptoms: Associations with affect, motives, and use on planned drinking days. *Experimental and Clinical Psychopharmacology*, *22*(4), 285-297. doi:10.1037/a0037157

Erdfelder, E., Lang, A. & Buchner, A. (2007). *G*Power Statistical Power Analyses for Windows and Mac.* Retrieved from http://www.gpower.hhu.de/

Erkelens, J. L., & Hazekamp, A. (2014). That which we call Indica, by any other name would smell as sweet. *Cannabinoids*, *9*(1), 9-15. Retrieved from www.cannabis-med.org

Fares, A., Wright, M., Matheson, J., Mann, R. E., Stoduto, G., Le Foll, B., Wickens, C. M., Brands, B., & Di Ciano, P. (2022). Effects of combining alcohol and cannabis on driving, breath alcohol level, blood THC, cognition, and subjective effects: A narrative review. *Experimental and Clinical Psychopharmacology*. Advance online publication. doi:10.1037/pha0000533

Farris, S. G., Metrik, J., Bonn-Miller, M. O., Kahler, C. W., & Zvolensky, M. J. (2016). Anxiety sensitivity and distress intolerance as predictors of cannabis dependence symptoms, problems, and craving: The mediating role of coping motives. *Journal of Studies on Alcohol and Drugs*, *77*(6), 889-897. doi:10.15288/jsad.2016.77.889

Farris, S. G., Zvolensky, M. J., Norton, P. J., Hogan, J., Smith, A. H., Talkovsky, A. M., ... & Schmidt, N. B. (2016). Smoking-specific experiential avoidance is indirectly associated with trait worry and smoking processes among treatment-seeking smokers. *Behavioral Medicine*, *42*(4), 254-263. doi:10.1080/08964289.2014.984650

Feingold, D., Weiser, M., Rehm, J., & Lev-Ran, S. (2015). The association between cannabis use and affect disorders: a longitudinal study. *Journal of Affective Disorders*, *172*, 211-218. doi:10.1016/j.jad.2014.10.006

Fischer, B., Robinson, T., Bullen, C., Curran, V., Jutras-Aswad, D., Medina-Mora, M. E., ... & Hall, W. (2022). Lower-risk cannabis use guidelines (LRCUG) for reducing health harms from non-medical cannabis use: A comprehensive evidence and recommendations update. *International Journal of Drug Policy*, 103381. doi:10.1016/j.drugpo.2021.103381

Fischer, B., Russell, C., Sabioni, P., van den Brink, W., Le Foll, B., Hall, W., Rehm, J. & Room, R. (2017). Lower-risk cannabis use guidelines (LRCUG): A comprehensive update of evidence and recommendations. *American Journal of Public Health, 107*(8). doi:10.2105/AJPH.2017.303818

Fluyau, D., Revadigar, N., & Manobianco, B. E. (2018). Challenges of the pharmacological management of benzodiazepine withdrawal, dependence, and discontinuation. *Therapeutic Advances in Psychopharmacology*, *8*(5), 147-168. doi:10.1177/2045125317753340

Fox, C. L., Towe, S. L., Stephens, R. S., Walker, D. D., & Roffman, R. A. (2011). Motives for cannabis use in high-risk adolescent users. *Psychology of Addictive Behaviors, 25*(3), 492–500. doi:10.1037/a0024331

Freeman, T. P., & Lorenzetti, V. (2020). 'Standard THC units': A proposal to standardize dose across all cannabis products and methods of administration. *Addiction*, *115*(7), 1207-1216. doi:10.1111/add.14842

Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: A guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, *10*(2), 486-489. doi:10.5812/ijem.3505

Gill, P. K., Du, C., Khan, F., Karimi, N., Sabharwal, K., & Agarwal, M. (2022). The psychological effects of COVID-19 spread in young Canadian adults. *International Journal of Social Psychiatry*, *68*(1), 216-222. doi:10.1177/0020764020988878

Glodosky, N. C., & Cuttler, C. (2020). Motives matter: Cannabis use motives moderate the associations between stress and negative affect. *Addictive Behaviors* 102, 106188. doi:10.1016/j.addbeh.2019.106188

Government of Canada. (2021). *Canadian Cannabis Survey 2021: Summary.* Retrieved from https://www.canada.ca/en/health-canada/services/drugs-medication/cannabis/research-data/canadian-cannabis-survey-2021-summary.html

Green, B. O. B., Kavanagh, D., & Young, R. (2003). Being stoned: A review of self-reported cannabis effects. *Drug and Alcohol Review*, *22*(4), 453-460. doi:10.1080/09595230310001613976

Grotenhermen, F. (2003). Pharmacokinetics and pharmacodynamics of cannabinoids. *Clinical Pharmacokinetics*, *42*(4), 327-360. doi:10.2165/00003088-200342040-00003

Gueorguieva, R., & Krystal, J. H. (2004). Move over ANOVA: progress in analyzing repeated-measures data and its reflection in papers published in the archives of general psychiatry. *Archives of General Psychiatry*, *61*(3), 310-317. doi:10.1001/archpsyc.61.3.310

Hagerty, S. L., Williams, S. L. Y., Mittal, V. A., & Hutchison, K. E. (2015). The cannabis conundrum: Thinking outside the THC box. *The Journal of Clinical Pharmacology*, *55*(8), 839-841. doi:10.1002/jcph.511

Hall, W., & Lynskey, M. (2020). Assessing the public health impacts of legalizing recreational cannabis use: The US experience. *World Psychiatry*, *19*(2), 179-186. doi:10.1002/wps.20735

Haney, M., Bedi, G., Cooper, Z. D., Glass, A., Vosburg, S. K., Comer, S. D., & Foltin, R. W. (2013). Predictors of marijuana relapse in the human laboratory: Robust impact of tobacco cigarette smoking status. *Biological Psychiatry*, *73*(3), 242-248. doi:10.1016/j.biopsych.2012.07.028

Hanna, R. C., Perez, J. M., & Ghose, S. (2017). Cannabis and development of dual diagnoses: A literature review. *The American Journal of Drug and Alcohol Abuse*, *43*(4), 442-455. doi:10.1080/00952990.2016.1213273

Harmon-Jones, C., Bastian, B., & Harmon-Jones, E. (2016a). Detecting transient emotional responses with improved self-report measures and instructions. *Emotion*, *16*(7), 1086-1096. doi:10.1037/emo0000216

Harmon-Jones, C., Bastian, B., & Harmon-Jones, E. (2016b). The discrete emotions questionnaire: A new tool for measuring state self-reported emotions. *PloS one*, *11*(8), e0159915. doi:10.1371/journal.pone.0159915

Hartman, R. L., Brown, T. L., Milavetz, G., Spurgin, A., Gorelick, D. A., Gaffney, G., & Huestis, M. A. (2016). Controlled vaporized cannabis, with and without alcohol: Subjective effects and oral fluid-blood cannabinoid relationships. *Drug Testing and Analysis*, *8*(7), 690-701. doi:10.1002/dta.1839

Hindocha, C., Freeman, T. P., Xia, J. X., Shaban, N. D., & Curran, H. V. (2017). Acute memory and psychotomimetic effects of cannabis and tobacco both 'joint' and individually: A placebo-controlled trial. *Psychological Medicine*, *47*(15), 2708-2719. doi:10.1017/S0033291717001222

Hoehn-Saric, R., McLeod, D. R., Funderburk, F., & Kowalski, P. (2004). Somatic symptoms and physiologic responses in generalized anxiety disorder and panic disorder: An ambulatory monitor study. *Archives of General Psychiatry*, *61*(9), 913-921. doi:10.1001/archpsyc.61.9.913

Hser, Y. I., Mooney, L. J., Huang, D., Zhu, Y., Tomko, R. L., McClure, E., ... & Gray, K. M. (2017). Reductions in cannabis use are associated with improvements in anxiety, depression, and sleep quality, but not quality of life. *Journal of Substance Abuse Treatment*, *81*, 53-58. doi:10.1016/j.jsat.2017.07.012

Hunault, C. C., Böcker, K. B., Stellato, R. K., Kenemans, J. L., de Vries, I., & Meulenbelt, J. (2014). Acute subjective effects after smoking joints containing up to 69 mg Δ9-tetrahydrocannabinol in recreational users: A randomized, crossover clinical trial. *Psychopharmacology*, *231*(24), 4723-4733. doi:10.1007/s00213-014-3630-2

Johnson, K. A., Bonn-Miller, M. O., Leyro, T. M., & Zvolensky, M. J. (2009). Anxious arousal and anhedonic depression symptoms and the frequency of current marijuana use: Testing the mediating role of marijuana-use coping motives among active users. *Journal of Studies on Alcohol and Drugs*, *70*(4), 543-550. doi:10.15288/jsad.2009.70.543

Johnson, K. A., Stewart, S., Rosenfield, D., Steeves, D., & Zvolensky, M. J. (2012). Prospective evaluation of the effects of anxiety sensitivity and state anxiety in predicting acute nicotine

withdrawal symptoms during smoking cessation. *Psychology of Addictive Behaviors*, *26*(2), 289-297. doi:10.1037/a0024133

Kaysen, D., Atkins, D. C., Moore, S. A., Lindgren, K. P., Dillworth, T., & Simpson, T. (2011). Alcohol use, problems, and the course of posttraumatic stress disorder: A prospective study of female crime victims. *Journal of Dual Diagnosis*, 7(4), 262–279. doi:10.1080/15504263.2011.620449

Kedzior, K. K., & Laeber, L. T. (2014). A positive association between anxiety disorders and cannabis use or cannabis use disorders in the general population-a meta-analysis of 31 studies. *BMC Psychiatry*, *14*(1), 136. doi:10.1186/1471-244X-14-136

Kendall, P. C., Finch Jr, A. J., Auerbach, S. M., Hooke, J. F., & Mikulka, P. J. (1976). The State-Trait Anxiety Inventory: A systematic evaluation. *Journal of Consulting and Clinical Psychology*, *44*(3), 406-412. doi:10.1037/0022-006X.44.3.406

Khantzian, E. J. (1997). The self-medication hypothesis of substance use disorders: A reconsideration and recent applications. *Harvard Review of Psychiatry*, *4*(5), 231-244. Retrieved from https://www.tandfonline.com/journals/ihrp20

Khubchandani, J., Brey, R., Kotecki, J., Kleinfelder, J., & Anderson, J. (2016). The psychometric properties of PHQ-4 depression and anxiety screening scale among college students. *Archives of Psychiatric Nursing*, *30*(4), 457-462. doi:10.1016/j.apnu.2016.01.014

Kocalevent, R. D., Hinz, A., & Brähler, E. (2013). Standardization of the depression screener patient health questionnaire (PHQ-9) in the general population. *General Hospital Psychiatry*, *35*(5), 551-555. doi:10.1016/j.genhosppsych.2013.04.006

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9. *Journal of General Internal Medicine*, *16*(9), 606-613. doi:10.1046/j.1525-1497.2001.016009606.x

Kroenke, K., Spitzer, R. L., Williams, J. B., & Löwe, B. (2009). An ultra-brief screening scale for anxiety and depression: The PHQ–4. *Psychosomatics*, *50*(6), 613-621. doi:10.1016/S0033-3182(09)70864-3

Kroenke, K., Spitzer, R. L., Williams, J. B., Monahan, P. O., & Löwe, B. (2007). Anxiety disorders in primary care: prevalence, impairment, comorbidity, and detection. *Annals of Internal Medicine*, *146*(5), 317-325. doi:10.7326/0003-4819-146-5-200703060-00004

LaFrance, E. M., Stueber, A., Glodosky, N. C., Mauzay, D., & Cuttler, C. (2020). Overbaked: Assessing and predicting acute adverse reactions to Cannabis. *Journal of Cannabis Research*, *2*(1), 1-10. doi:10.1186/s42238-019-0013-x

Lee, C., Round, J. M., Klarenbach, S., Hanlon, J. G., Hyshka, E., Dyck, J. R., & Eurich, D. T. (2021). Gaps in evidence for the use of medically authorized cannabis: Ontario and Alberta, Canada. *Harm Reduction Journal*, *18*(1), 1-9. doi:10.1186/s12954-021-00509-0

Lee, D. C., Crosier, B. S., Borodovsky, J. T., Sargent, J. D., & Budney, A. J. (2016). Online survey characterizing vaporizer use among cannabis users. *Drug and Alcohol Dependence*, *159*, 227-233. doi:10.1016/j.drugalcdep.2015.12.020

Lee, J. L., Bertoglio, L. J., Guimarães, F. S., & Stevenson, C. W. (2017). Cannabidiol regulation of emotion and emotional memory processing: Relevance for treating anxiety-related and substance abuse disorders. *British Journal of Pharmacology*, *174*(19), 3242-3256. doi:10.1111/bph.1372

Leung, J., Chan, G., Stjepanović, D., Chung, J. Y. C., Hall, W., & Hammond, D. (2022). Prevalence and self-reported reasons of cannabis use for medical purposes in USA and Canada. *Psychopharmacology*, *239*(5), 1509-1519. doi:10.1007/s00213-021-06047-8

Leung, J., Chiu, C. Y. V., Stjepanović, D., & Hall, W. (2018). Has the legalisation of medical and recreational cannabis use in the USA affected the prevalence of cannabis use and cannabis use disorders?. *Current Addiction Reports*, *5*(4), 403-417. doi:10.1007/s40429-018-0224-9

Leventhal, A. M., Cho, J., Stone, M. D., Barrington-Trimis, J. L., Chou, C. P., Sussman, S. Y., ... & Strong, D. R. (2017). Associations between anhedonia and marijuana use escalation across mid-adolescence. *Addiction*, *112*(12), 2182-2190. doi:10.1111/add.13912

Lev-Ran, S., Roerecke, M., Le Foll, B., George, T. P., McKenzie, K., & Rehm, J. (2013). The association between cannabis use and depression: A systematic review and meta-analysis of longitudinal studies. *Psychological Medicine*, *44*(4), 797-810. doi:10.1017/S0033291713001438

LifeData. (2015). *LifeData.* Retrieved from https://www.lifedatacorp.com/

Linares, I. M., Zuardi, A. W., Pereira, L. C., Queiroz, R. H., Mechoulam, R., Guimarães, F. S., & Crippa, J. A. (2019). Cannabidiol presents an inverted U-shaped dose-response curve in a simulated public speaking test. *Brazilian Journal of Psychiatry*, *41*(1), 9-14. doi:10.1590/1516-4446-2017-0015

Linden-Carmichael, A. N., Van Doren, N., Masters, L. D., & Lanza, S. T. (2020). Simultaneous alcohol and marijuana use in daily life: Implications for level of use, subjective intoxication, and positive and negative consequences. *Psychology of Addictive Behaviors*, *34*(3), 447-453. doi:10.1037/adb0000556

Liquor Control Board of Ontario. (2022). *Store locator.* Retrieved from https://www.lcbo.com/en/stores/

Löwe, B., Decker, O., Müller, S., Brähler, E., Schellberg, D., Herzog, W., & Herzberg, P. Y. (2008). Validation and standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the general population. *Medical Care*, *46*(3), 266-274. doi:10.1097/MLR.0b013e318160d093

Löwe, B., Wahl, I., Rose, M., Spitzer, C., Glaesmer, H., Wingenfeld, K., ... & Brähler, E. (2010). A 4-item measure of depression and anxiety: Validation and standardization of the Patient Health Questionnaire-4 (PHQ-4) in the general population. *Journal of Affective Disorders*, *122*(1-2), 86-95. doi:10.1016/j.jad.2009.06.019

Lucas, C. J., Galettis, P., & Schneider, J. (2018). The pharmacokinetics and the pharmacodynamics of cannabinoids. *British Journal of Clinical Pharmacology*, *84*(11), 2477-2482. doi:10.1111/bcp.13710

Lucas, P., Walsh, Z., Crosby, K., Callaway, R., Belle-Isle, L., Kay, R., ... & Holtzman, S. (2016). Substituting cannabis for prescription drugs, alcohol and other substances among medical cannabis patients: The impact of contextual factors. *Drug and Alcohol Review*, *35*(3), 326-333. doi: 10.1111/dar.12323

Lukas, S. E., & Orozco, S. (2001). Ethanol increases plasma Δ9-tetrahydrocannabinol (THC) levels and subjective effects after marihuana smoking in human volunteers. *Drug and Alcohol Dependence*, *64*(2), 143-149. doi:10.1016/S0376-8716(01)00118-1

Malmberg, M., Overbeek, G., Monshouwer, K., Lammers, J., Vollebergh, W. A., & Engels, R. C. (2010). Substance use risk profiles and associations with early substance use in adolescence. *Journal of Behavioral Medicine*, *33*(6), 474-485. doi:10.1007/s10865-010-9278-4

Marshall, N., Mushquash, A. R., Mushquash, C. J., Mazmanian, D., & McGrath, D. S. (2020). Marijuana use in undergraduate students: The short-term relationship between motives and frequency of use. *Journal of Substance Use*, *25*(3), 284-289. doi:10.1080/14659891.2019.1683906

Martin-Santos, R., A. Crippa, J., Batalla, A., Bhattacharyya, S., Atakan, Z., Borgwardt, S., … K. McGuire, P. (2012). Acute Effects of a Single, Oral dose of d9-tetrahydrocannabinol (THC) and Cannabidiol (CBD) Administration in Healthy Volunteers. *Current Pharmaceutical Design*, *18*(32), 4966–4979. doi:10.2174/138161212802884780

Masataka, N. (2019). Anxiolytic effects of repeated cannabidiol treatment in teenagers with social anxiety disorders. *Frontiers in Psychology*, *10,* 2466. doi:10.3389/fpsyg.2019.02466

McCarthy, D. E., Curtin, J. J., Piper, M. E., & Baker, T. B. (2010). Negative reinforcement: Possible clinical implications of an integrative model. In J. D. Kassel (Ed.), *Substance Abuse and Emotion* (pp. 15–42). American Psychological Association. doi:10.1037/12067-001

McFarlane, A.C., Browne, D., Bryant, R. A., O'Donnell, M., Silove, D., Creamer, M., & Horsley, K. (2009). A longitudinal analysis of alcohol consumption and the risk of posttraumatic symptoms. *Journal of Affective Disorders*, 118(1–3), 166–172. doi:10.1016/j.jad.2009.01.017

Melchior, M., Nakamura, A., Bolze, C., Hausfater, F., El Khoury, F., Mary-Krause, M., & Da Silva, M. A. (2019). Does liberalisation of cannabis policy influence levels of use in adolescents and young adults? A systematic review and meta-analysis. *BMJ open*, *9*(7), e025880. doi:10.1136/bmjopen-2018-025880

Metrik, J., Kahler, C. W., McGeary, J. E., Monti, P. M., & Rohsenow, D. J. (2011). Acute effects of marijuana smoking on negative and positive affect. *Journal of Cognitive Psychotherapy, 25*(1), 31-46. doi:10.1891/0889-8391.25.1.31

Metzger, R. L. (1976). A reliability and validity study of the State-Trait Anxiety Inventory. *Journal of Clinical Psychology, 32*(2), 276–278. doi:10.1002/1097-4679(197604)32:2<276::AID-JCLP2270320215>3.0.CO;2-G

Meyer, J. S., & Quenzer, L. F. (2005). *Psychopharmacology: Drugs, the brain, and behavior*. Sunderland, MA: Sinauer Associates Inc.ret

Moitra, E., Anderson, B. J., & Stein, M. D. (2016). Reductions in cannabis use are associated with affect improvement in female emerging adults. *Depression and Anxiety*, *33*(4), 332-338. doi:10.1002/da.22460

Moreira, F. A., Grieb, M., & Lutz, B. (2009). Central side-effects of therapies based on CB1 cannabinoid receptor agonists and antagonists: focus on anxiety and depression. *Best Practice & Research Clinical Endocrinology & Metabolism*, *23*(1), 133–144. doi:10.1016/j.beem.2008.09.003

Moskowitz, D. S., & Young, S. N. (2006). Ecological momentary assessment: What it is and why it is a method of the future in clinical psychopharmacology. *Journal of Psychiatry and Neuroscience*, *31*(1), 13-20. Retrieved from https://jpn.ca/

Myran, D. T., Staykov, E., Cantor, N., Taljaard, M., Quach, B. I., Hawken, S., & Tanuseputro, P. (2022). How has access to legal cannabis changed over time? An analysis of the cannabis retail market in Canada 2 years following the legalisation of recreational cannabis. *Drug and Alcohol Review*, *41*(2), 377-385. doi:10.1111/dar.13351

National Institute on Alcohol Abuse and Alcoholism, Task Force on Recommended Alcohol Questions. (2003). *National Council on Alcohol Abuse and Alcoholism Recommended Sets of Alcohol Consumption Questions.* Retrieved from *http://www.niaaa.nih.gov/research/guidelines-and-resources/recommended-alcFIX Tohol-questions*

Nolen-Hoeksema, S., Stice, E., Wade, E., & Bohon, C. (2007). Reciprocal relations between rumination and bulimic, substance abuse, and depressive symptoms in female adolescents. *Journal of Abnormal Psychology*, *116*(1), 198-207. doi:10.1037/0021-843X.116.1.198

Okey, S. A., Waddell, J. T., & Corbin, W. R. (2022). I smoke alone: Indirect effects of solitary cannabis use on negative consequences through coping motives. *Journal of Studies on Alcohol and Drugs (Online only)*. doi:10.15288/jsad.21-00200

Ontario Cannabis Store. (2022). *Find an authorized store*. Retrieved from https://ocs.ca/pages/store-locator

Owolabi, J. O., Olatunji, S. Y., & Olanrewaju, A. J. (2017). Caffeine and cannabis effects on vital neurotransmitters and enzymes in the brain tissue of juvenile experimental rats. *Annals of Neurosciences*, *24*(2), 65-73. doi:10.1159/000475895

Padovano, H., & Miranda, R. (2018). Subjective cannabis effects as part of a developing disorder in adolescents and emerging adults. *Journal of Abnormal Psychology*, *127*(3), 282-293. doi:10.1037/abn0000342

Peeters, F., Berkhof, J., Delespaul, P., Rottenberg, J., & Nicolson, N. A. (2006). Diurnal mood variation in major depressive disorder. *Emotion*, *6*(3), 383-391. doi:10.1037/1528-3542.6.3.383

Penetar, D. M., Kouri, E. M., Gross, M. M., McCarthy, E. M., Rhee, C. K., Peters, E. N., & Lukas, S. E. (2005). Transdermal nicotine alters some of marihuana's effects in male and female volunteers. *Drug and Alcohol Dependence*, *79*(2), 211-223. doi:10.1016/j.drugalcdep.2005.01.008

Peters, E. N., Herrmann, E. S., Smith, C., Wilhelm, J. A., Koszowski, B., Halquist, M., ... & Pickworth, W. B. (2021). Impact of smoked cannabis on tobacco cigarette smoking intensity and subjective effects: A placebo-controlled, double blind, within-subjects human laboratory study. *Experimental and Clinical Psychopharmacology*, *29*(4), 345-354. doi:10.1037/pha0000391

Piper, B. J., DeKeuster, R. M., Beals, M. L., Cobb, C. M., Burchman, C. A., Perkinson, L., ... & Abess, A. T. (2017). Substitution of medical cannabis for pharmaceutical agents for pain, anxiety, and sleep. *Journal of Psychopharmacology*, *31*(5), 569-575. doi:10.1177/0269881117699616

Rabinak, C., & Phan, K. L. (2014). Cannabinoid modulation of fear extinction brain circuits: A novel target to advance anxiety treatment. *Current Pharmaceutical Design*, *20*(13), 2212-2217. doi:10.2174/13816128113199990437

Ross, C. S., Brooks, D. R., Aschengrau, A., Siegel, M. B., Weinberg, J., & Shrier, L. A. (2018). Positive and negative affect following marijuana use in naturalistic settings: An ecological momentary assessment study. *Addictive Behaviors*, *76*, 61-67. doi:10.1016/j.addbeh.2017.07.020

Rotermann, M. (2020). *Canadians who report lower self-perceived mental health during the COVID-19 pandemic more likely to report increased use of cannabis, alcohol and tobacco.* Retrieved from https://www.thevitalbeat.ca/documents/11/Stat_can_substance_abuse.pdf

Salim, A., Mackinnon, A., Christensen, H., & Griffiths, K. (2008). Comparison of data analysis strategies for intent-to-treat analysis in pre-test–post-test designs with substantial dropout rates. *Psychiatry Research*, *160*(3), 335-345. doi:10.1016/j.psychres.2007.08.005

Schoedel, K. A., Szeto, I., Setnik, B., Sellers, E. M., Levy-Cooperman, N., Mills, C., ... & Sommerville, K. (2018). Abuse potential assessment of cannabidiol (CBD) in recreational polydrug users: A randomized, double-blind, controlled trial. *Epilepsy & Behavior*, *88*, 162-171. doi:10.1016/j.yebeh.2018.07.027

Schultz, N. R., Bassett, D. T., Messina, B. G., & Correia, C. J. (2019). Evaluation of the psychometric properties of the cannabis use disorders identification test-revised among college students. *Addictive Behaviors, 95*, 11-15. doi:10.1016/j.addbeh.2019.02.016

Sexton, M., Cuttler, C., Finnell, J. S., & Mischley, L. K. (2016). A cross-sectional survey of medical cannabis users: patterns of use and perceived efficacy. *Cannabis and Cannabinoid Research*, *1*(1), 131-138. doi:10.1089/can.2016.0007

Shiffman, S. (2009). Ecological momentary assessment (EMA) in studies of substance use. *Psychological Assessment*, *21*(4), 486-497. doi:10.1037/a0017074

Shiffman, S., & Waters, A. J. (2004). Negative affect and smoking lapses: A prospective analysis. *Journal of Consulting and Clinical Psychology*, *72*(2), 192-201. doi:10.1037/0022-006X.72.2.192

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review Clinical Psychology*, *4*, 1-32. doi:10.1146/annurev.clinpsy.3.022806.091415

Shrier, L. A., & Scherer, E. B. (2014). It depends on when you ask: Motives for using marijuana assessed before versus after a marijuana use event. *Addictive Behaviors*, *39*(12), 1759-1765. doi:10.1016/j.addbeh.2014.07.018

Shrier, L. A., Ross, C. S., & Blood, E. A. (2014). Momentary positive and negative affect preceding marijuana use events in youth. *Journal of Studies on Alcohol and Drugs*, *75*(5), 781-789. doi:10.15288/jsad.2014.75.781

Shrier, L. A., Walls, C. E., Kendall, A. D., & Blood, E. A. (2012). The context of desire to use marijuana: Momentary assessment of young people who frequently use marijuana. *Psychology of Addictive Behaviors*, *26*(4), 821-829. doi:10.1037/a0029197

Simons, J. S., Correia, C. J., Carey, K. B., & Borsari, B. E. (1998). Validating a five-factor marijuana motives measure: Relations with use, problems, and alcohol motives. *Journal of Counseling Psychology, 45*(3), 265-273. doi:10.1037/0022-0167.45.3.265

Simons, J., Correia, C. J., & Carey, K. B. (2000). A comparison of motives for marijuana and alcohol use among experienced users. *Addictive Behaviors*, *25*(1), 153-160. doi:10.1016/S0306-4603(98)00104-X

Simons, J. S., Gaher, R. M., Correia, C. J., Hansen, C. L. & Christopher, M. S. (2005). An affective-motivational model of marijuana and alcohol problems among college students. *Psychology of Addictive Behaviors* 19 (3):326–34. doi:10.1037/0893-164X.19.3.326.

Simpson, K. A., Cho, J., & Barrington-Trimis, J. L. (2021). The association of type of cannabis product used and frequency of use with problematic cannabis use in a sample of young adult cannabis users. *Drug and Alcohol Dependence*, *226*, 108865. doi:10.1016/j.drugalcdep.2021.108865

Skitch, S. A., & Abela, J. R. (2008). Rumination in response to stress as a common vulnerability factor to depression and substance misuse in adolescence. *Journal of Abnormal Child Psychology*, *36*(7), 1029-1045. doi:10.1007/s10802-008-9233-9

Smart, R., & Pacula, R. L. (2019). Early evidence of the impact of cannabis legalization on cannabis use, cannabis use disorder, and the use of other substances: Findings from state policy evaluations. *The American Journal of Drug and Alcohol Abuse*, *45*(6), 644-663. doi:10.1080/00952990.2019.1669626

Smith, J., Smith, J., Mader, J., Guestier, G., Conn, L., & Maddigan, J. (2021). An exploration of self-reported medicinal cannabis use among a sample of Eastern Canadian postsecondary students. *The Journal of Behavioral Health Services & Research*, 1-13. doi:10.1007/s11414-021-09763-3

Sokolovsky, A. W., Gunn, R. L., Micalizzi, L., White, H. R., & Jackson, K. M. (2020). Alcohol and marijuana co-use: Consequences, subjective intoxication, and the operationalization of simultaneous use. *Drug and Alcohol Dependence*, *212*, 107986. doi:10.1016/j.drugalcdep.2020.107986

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of Internal Medicine*, *166*(10), 1092-1097. doi:10.1001/archinte.166.10.1092

Staples, L. G., Dear, B. F., Gandy, M., Fogliati, V., Fogliati, R., Karin, E., ... & Titov, N. (2019). Psychometric properties and clinical utility of brief measures of depression, anxiety, and general distress: The PHQ-2, GAD-2, and K-6. *General Hospital Psychiatry*, *56*, 13-18. doi:10.1016/j.genhosppsych.2018.11.003

Stewart, S. H., & Conrod, P. J. (2008). Anxiety disorder and substance use disorder co-morbidity: Common themes and future directions. In *Anxiety and Substance Use Disorders.* (pp. 239-257). Springer, Boston, MA.

Stone, A. A., & Shiffman, S. (1994). Ecological momentary assessment (EMA) in behavorial medicine. *Annals of Behavioral Medicine, 16*(3), 199-202. doi:10.1093/abm/16.3.199

Swift, W., Gates, P., & Dillon, P. (2005). Survey of Australians using cannabis for medical purposes. *Harm Reduction Journal*, *2*(1), 18. doi:10.1186/1477-7517-2-18

Tan, P. Z., Forbes, E. E., Dahl, R. E., Ryan, N. D., Siegle, G. J., Ladouceur, C. D., & Silk, J. S. (2012). Emotional reactivity and regulation in anxious and nonanxious youth: A cell-phone ecological momentary assessment study. *Journal of Child Psychology and Psychiatry*, *53*(2), 197-206. doi:10.1111/j.1469-7610.2011.02469.x

Thomsen, R. K., Callesen, M. B., & Feldstein, S. W. (2017). Recommendation to reconsider examining cannabis subtypes together due to opposing effects on brain, cognition and behavior. *Neuroscience & Biobehavioral Reviews*, *80*, 156–158. doi:10.1016/j.neubiorev.2017.05.025

Toronto Star. (April 1, 2019). *At first cannabis store in Toronto, 'everything we planned for is happening' — while supplies last.* Retrieved from https://www.thestar.com/news/cannabis/2019/04/01/its-the-first-day-to-buy-pot-at-a-store-in-ontario-customers-are-lining-up-to-be-part-of-history.html

Torous, J., Staples, P., Shanahan, M., Lin, C., Peck, P., Keshavan, M., & Onnela, J. P. (2015). Utilizing a personal smartphone custom app to assess the patient health questionnaire-9 (PHQ-9) depressive symptoms in patients with major depressive disorder. *JMIR Mental Health*, *2*(1), e8. doi:10.2196/mental.3889

Turna, J., Patterson, B., & Ameringen, M. (2017). Is cannabis treatment for anxiety, affect, and related disorders ready for prime time?. *Depression and Anxiety, 34,* 1006-1017. doi:10.1002/da.22664

Turna, J., Zhang, J., Lamberti, N., Patterson, B., Simpson, W., Francisco, A. P., ... & Van Ameringen, M. (2021). Anxiety, depression and stress during the COVID-19 pandemic: Results from a cross-sectional survey. *Journal of Psychiatric Research*, *137*, 96-103. doi:10.1016/j.jpsychires.2021.02.059

University of Los Angeles, California Statistical Consulting Group. (2011). *FAQ: What are pseudo R-squareds?* Retrieved from https://stats.oarc.ucla.edu/other/mult-pkg/faq/general/faq-what-are-pseudo-r-squareds/

U.S. Department of Health and Human Services Food and Drug Administration Center for Drug Evaluation and Research. (2017). *Assessment of Abuse Potential of Drugs.* Retrieved from https://www.fda.gov/regulatory-information/search-fda-guidance-documents/assessment-abuse-potential-drugs

van Ballegooijen, W., Ruwaard, J., Karyotaki, E., Ebert, D. D., Smit, J. H., & Riper, H. (2016). Reactivity to smartphone-based ecological momentary assessment of depressive symptoms (AffectMonitor): Protocol of a randomised controlled trial. *BMC Psychiatry*, *16*(1), 359.

van Der Pol, P., Liebregts, N., De Graaf, R., Korf, D. J., van den Brink, W., & van Laar, M. (2013). Predicting the transition from frequent cannabis use to cannabis dependence: a three-year prospective study. *Drug and Alcohol Dependence*, *133*(2), 352-359. doi:10.1016/j.drugalcdep.2013.06.009

Walsh, Z., Gonzalez, R., Crosby, K., Thiessen, M. S., Carroll, C., & Bonn-Miller, M. O. (2017). Medical cannabis and mental health: A guided systematic review. *Clinical Psychology Review*, *51*, 15-29. doi:10.1016/j.cpr.2016.10.002

Ware, M. A., & St Arnaud-Trempe, E. (2010). The abuse potential of the synthetic cannabinoid nabilone. *Addiction*, *105*(3), 494-503. doi:10.1111/j.1360-0443.2009.02776.x

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063-1070. Retrieved from http://www.apa.org/pubs/journals/psp/

Webb, C. W., & Webb, S. M. (2014). Therapeutic benefits of cannabis: A patient survey. *Hawai'i Journal of Medicine & Public Health*, *73*(4), 109-111. Retrieved from http://hawaiijournalhealth.org/

White, C. M. (2019). A review of human studies assessing cannabidiol's (cbd) therapeutic actions and potential. *The Journal of Clinical Pharmacology*, *59*(7), 923-934. doi:10.1002/jcph.1387

Willem, L., Bijttebier, P., Claes, L., & Raes, F. (2011). Rumination subtypes in relation to problematic substance use in adolescence. *Personality and Individual Differences*, *50*(5), 695-699. doi:10.1016/j.paid.2010.12.020

Womack, S. R., Shaw, D. S., Weaver, C. M., & Forbes, E. E. (2016). Bidirectional associations between cannabis use and depressive symptoms from adolescence through early adulthood among at-risk young men. *Journal of Studies on Alcohol and Drugs*, *77*(2), 287-297. doi:10.15288/jsad.2016.77.287

Wray, T. B., Merrill, J. E., & Monti, P. M. (2014). Using ecological momentary assessment (EMA) to assess situation-level predictors of alcohol use and alcohol-related

consequences. *Alcohol Research: Current Reviews*, *36*(1), 19-27. Retrieved from https://www.arcr.niaaa.nih.gov/

Wycoff, A. M., Metrik, J., & Trull, T. J. (2018). Affect and cannabis use in daily life: A review and recommendations for future research. *Drug and Alcohol Dependence*, *191*, 223-233. doi:10.1016/j.drugalcdep.2018.07.001

Zamarripa, C. A., Vandrey, R., & Spindle, T. R. (2022). Factors that impact the pharmacokinetic and pharmacodynamic effects of cannabis: A review of human laboratory studies. *Current Addiction Reports*, 1-14. doi:10.1007/s40429-022-00429-4

Zuardi, A. W., Rodrigues, N. P., Silva, A. L., Bernardo, S. A., Hallak, J. E., Guimarães, F. S., & Crippa, J. A. (2017). Inverted U-shaped dose-response curve of the anxiolytic effect of cannabidiol during public speaking in real life. *Frontiers in Pharmacology*, *8*, 259. doi10.3389/fphar.2017.00259

Zvolensky, M. J., Vujanovic, A. A., Bernstein, A., Bonn-Miller, M. O., Marshall, E. C., & Leyro, T. M. (2007). Marijuana use motives: A confirmatory test and evaluation among young adult marijuana users. *Addictive Behaviors*, *32*(12), 3122-3130. doi:10.1016/j.addbeh.2007.06.010

Appendix 1: Tables

Table 2

Completion Times for Measures

Baseline Questionnaires	**Randomized Signal-Initiated EMA Sessions**	**User-Initiated EMA Sessions: Before Engaging in Use**	**Signal-Initiated EMA Sessions: After Engaging in Use**
Demographic Questions and Assessment of Past Use (including CUDIT-R)	Momentary Assessment of Use	Momentary Assessment of Use	Momentary Assessment of Use
Affect (PANAS)	Affect (PANAS)	Affect (PANAS)	Affect (PANAS)
Psychiatric Symptoms (PHQ-9; GAD-7)	Psychiatric Symptoms (PHQ-2; GAD-2)	Psychiatric Symptoms (PHQ-2; GAD-2)	Psychiatric Symptoms (PHQ-2; GAD-2)
Motives for Use (MMM)		Momentary Motives for Use (MMM Checklist)	

Note. GAD = Generalized Anxiety Disorder Screener; MMM = Marijuana Motives Measure; PANAS = Positive and Negative Affect Schedule; PHQ = Patient Health Questionnaire.

Table 3

Participant Demographics

Characteristic	*M*	*SD*
Age (*n* =84)	21.8	3.2
Alcohol Frequency (drinks per week)	1.5	1.4
Average Amount (drinks per occasion)	4.1	2.7
	n	%
Sex		
Women	56	66.7
Men	28	33.3
Gender		
Female	53	63.1
Male	29	34.5
Ethnicity		
First Nations	4	4.8
Asian	8	9.5
White	59	70.2
Multiple Ethnicities	8	9.5
Other	5	6.0
Psychiatric Diagnosis		
No	53	63.1
Yes	30	35.7
Prescribed Psychiatric Medication		
No	57	67.9
Yes	26	31.0
Cannabis Use (past month)		
No	0	0.0
Yes	84	100.0
Alcohol Use (lifetime)		
No	0	0.0
Yes	84	100.0
Nicotine Use (past month)		
No	49	58.3
Yes	29	34.5
Illicit Substance Use (lifetime)		
No	38	45.2
Yes	42	50.0

Note. Totals may not add to 100% due to missing data or participants choosing “prefer not to answer”.

Table 4

Descriptive Statistics for Baseline Measures (n = 84)

	M	*SD*	*α*
CUDIT-R			
Total	13.26	5.78	.76
MMM			
Expansion	9.04	5.25	.88
Social	9.38	5.64	.86
Enhancement	12.65	3.98	.78
Conformity	1.12	1.99	.73
Coping	7.85	3.68	.79
PANAS			
Positive Affect	21.67	8.03	.90
Negative Affect	13.48	7.76	.86
PHQ-9			
Item 1: Anhedonia	0.86	0.88	
Item 2: Depressed Mood/Hopelessness	1.07	0.93	
Item 3: Sleep Difficulties	1.58	1.10	
Item 4: Fatigue	1.49	1.00	
Item 5: Appetite Difficulties	1.30	1.13	
Item 6: Self-Criticalness	0.95	0.96	
Item 7: Difficulties Concentrating	0.98	1.09	
Item 8: Psychomotor Changes	0.27	0.70	
Item 9: Suicidality	0.26	0.58	
Total	8.77	5.92	.87
GAD-7			
Item 1: Anxious mood/Nervousness	1.39	0.99	
Item 2: Uncontrollable Worry	1.28	1.11	
Item 3: Excessive Worry	1.39	1.05	
Item 4: Difficulty Relaxing	1.20	1.05	
Item 5: Restlessness	0.81	1.09	
Item 6: Irritability	0.95	1.00	
Item 7: Fear	0.73	0.92	
Total	7.76	5.54	.88

Note. CUDIT-R = Cannabis Use Disorder Identification Test – Revised; MMM = Marijuana Motives Measure; PANAS = Positive and Negative Affect Scale; PHQ-9 = Patient Health Questionnaire-9; GAD-7 = Generalized Anxiety Disorder Questionnaire-7.

Table 5

Baseline Cannabis Use Statistics

	M	*SD*
Age of Onset	15.82	2.30
Frequency of Use (per week)	9.10	13.62
Average Amount of Use (grams per occasion)	2.42	5.68
	N	%
Mode of Consumption		
Smoking – Joint	36	42.9
Smoking - Water Pipe or Bong	44	52.4
Smoking – Pipe	26	31.0
Smoking - Vaporizer	16	19.0
Oral - Edibles (e.g., candy, baking)	29	34.5
Oral – Capsules	3	3.6
Other	4	4.8
Type of Smoked Cannabis		
Flower	77	91.7
Extracts	10	11.9
THC Concentration		
Low (0-10%)	6	7.1
Medium (11-19%)	9	10.7
High (20% +)	34	40.5
Varies	1	1.2
Unknown	28	33.3
CBD Concentration		
Low (0-10%)	27	32.1
Medium (11-19%)	8	9.5
High (20% +)	6	7.1
Varies	1	1.2
Unknown	33	39.3
Medicinal Cannabis Use		
No	74	88.1
Yes	5	6.0
Associated Medical Conditions		
Pain (e.g., fibromyalgia)	2	2.4
Anxiety	4	4.8
Depression	1	1.2
Other (e.g., insomnia)	2	2.4

Note. THC = Tetrahydrocannabinol; CBD = Cannabidiol. Totals may not add to 100% due to missing data, participants indicating "prefer not to answer" or due to multiple responses where appropriate.

Table 6

Descriptive Statistics for Episode of Use EMA Sessions

	Random Before Use (Time = -1; *n* = 185)		Before Cannabis Use (Time = 0; *n* = 489)		After Cannabis Use – 5 minutes (Time = 1; *n* = 347)	
Scale	*M*	*SD*	*M*	*SD*	*M*	*SD*
PANAS						
Positive Affect	13.48	5.16	14.53	5.34	14.55	5.06
Negative Affect	9.10	4.10	8.30	3.52	7.42	2.24
GAD-2						
Item 1	0.85	0.86	0.66	0.52	0.37	0.64
Item 2	0.72	0.88	0.52	0.81	0.27	0.55
Total	1.57	1.64	1.19	1.56	0.63	1.07
PHQ-2						
Item 1	0.58	0.90	0.44	0.77	0.24	0.58
Item 2	0.55	0.80	0.54	0.80	0.31	0.61
Total	1.15	1.49	0.98	1.38	0.55	1.03

Note. GAD-2 = Generalized Anxiety Disorder Screener -2; PANAS = Positive and Negative Affect Scale; PHQ-2 = Patient Health Questionnaire-2.

Table 7

Momentary Cannabis Use Motives

	n	%
MMM (*n* = 509 episodes)		
Enhancement	313	61.5
Social	25	4.9
Coping - Anxiety	94	18.5
Coping – Depression	36	7.1
Conformity	3	0.6
Expansion	38	7.5

Notes. MMM = Marijuana Motives Measure.

Table 8

Fixed Effects for Positive Affect by CUD Symptoms Before Use

	F	*df1*	*df2*	*p*
Corrected Model	2.857	5	747	**0.015**
Time	0.062	1	747	0.803
Gender	6.903	1	747	**0.009**
Age of Onset	3.246	1	747	0.072
CUDIT-R	4.554	1	747	**0.033**
CUDIT-R*Time	0.060	1	747	0.806

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised.

Table 9

Fixed Coefficients for Positive Affect by CUD Symptoms Before Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	2.378	10.783	0.2036	11.677	**<0.001**	1.978	2.777
Time	-0.016	0.984	0.0648	-0.250	0.803	-0.143	0.111
Male	0.145	1.156	0.0553	2.627	**0.009**	0.037	0.254
Female	0[a]						
Age of Onset	0.021	1.021	0.0115	1.802	0.072	-0.002	0.043
CUDIT-R	-0.010	0.990	0.0046	-2.134	**0.033**	-0.019	-0.001
CUDIT-R*Time	0.001	1.001	0.0045	0.246	0.806	-0.008	0.010

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 10

Fixed Effects for Positive Affect by CUD Symptoms After Use

	F	*df1*	*df2*	*p*
Corrected Model	4.940	5	1484	**<0.001**
Time	0.021	1	1484	0.884
Gender	10.120	1	1484	**0.001**
Age of Onset	4.884	1	1484	**0.027**
CUDIT-R	10.575	1	1484	**0.001**
CUDIT-R*Time	0.016	1	1484	0.899

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised.

Table 11

Fixed Coefficients for Positive Affect by CUD Symptoms After Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	2.412	11.156	0.1732	13.927	**<0.001**	2.072	2.752
Time	-0.007	0.993	0.0460	-0.146	0.884	-0.097	0.084
Male	0.150	1.162	0.0470	3.181	**0.001**	0.057	0.242
Female	0[a]						
Age of Onset	0.022	1.022	0.0098	2.210	**0.027**	0.002	0.041
CUDIT-R	-0.013	0.987	0.0039	-3.252	**0.001**	-0.020	-0.005
CUDIT-R*Time	0.000	1.000	0.0031	0.127	0.899	-0.006	0.007

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 12

Fixed Effects for Negative Affect by CUD Symptoms Before Use

	F	*df1*	*df2*	*p*
Corrected Model	1.805	5	748	0.110
Time	0.170	1	748	0.680
Gender	4.792	1	748	**0.029**
Age of Onset	3.016	1	748	0.083
CUDIT-R	0.925	1	748	0.336
CUDIT-R*Time	0.011	1	748	0.917

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised.

Table 13

Fixed Coefficients for Negative Affect by CUD Symptoms Before Use

						95% CI	
Model Term	β	Exp(β)	*SE*	*t*	*p*	Lower	Upper
Intercept	1.817	6.153	0.1866	9.737	**<0.001**	1.450	2.183
Time	0.024	1.024	0.0585	0.412	0.680	-0.091	0.139
Male	-0.111	0.895	0.0507	-2.189	**0.029**	-0.211	-0.011
Female	0[a]						
Age of Onset	0.018	0.982	0.0106	1.737	0.083	-0.002	0.039
CUDIT-R	0.004	0.996	0.0042	0.962	0.336	-0.004	0.012
CUDIT-R*Time	0.000	1.000	0.0041	-0.105	0.917	-0.008	0.008

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 14

Fixed Effects for Negative Affect by CUD Symptoms After Use

	F	*df1*	*df2*	*p*
Corrected Model	2.544	5	1488	**0.027**
Time	0.259	1	1488	0.611
Gender	8.190	1	1488	**0.004**
Age of Onset	2.236	1	1488	0.135
CUDIT-R	1.306	1	1488	0.253
CUDIT-R*Time	0.003	1	1488	0.959

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised.

Table 15

Fixed Coefficients for Negative Affect by CUD Symptoms After Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	1.879	6.547	0.1497	12.556	**<0.001**	1.586	2.173
Time	-0.019	0.981	0.0377	-0.509	0.611	-0.093	0.055
Male	-0.116	0.890	0.0405	-2.862	**0.004**	-0.195	-0.036
Female	0[a]						
Age of Onset	0.013	1.013	0.0084	1.495	0.135	-0.004	0.029
CUDIT-R	0.004	1.004	0.0034	1.143	0.253	-0.003	0.010
CUDIT-R*Time	0.000	1.000	0.0026	0.052	0.959	-0.005	0.005

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 16

Fixed Effects for Anxiety by CUD Symptoms Before Use

	F	*df1*	*df2*	*p*
Corrected Model	2.704	5	751	**0.020**
Time	0.029	1	751	0.866
Gender	11.227	1	751	**0.001**
Age of Onset	0.657	1	751	0.418
CUDIT-R	0.091	1	751	0.763
CUDIT-R*Time	0.164	1	751	0.686

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised.

Table 17

Fixed Coefficients for Anxiety Symptoms by CUD Symptoms Before Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*T*	*p*	Lower	Upper
Intercept	0.653	1.921	0.3384	1.929	0.054	-0.012	1.317
Time	-0.019	0.981	0.1117	-0.169	0.866	-0.238	0.200
Male	-0.308	0.735	0.0920	-3.351	**0.001**	-0.489	-0.128
Female	0[a]						
Age of Onset	0.015	1.015	0.0191	0.810	0.418	-0.022	0.053
CUDIT-R	-0.002	0.998	0.0076	-0.302	0.763	-0.017	0.013
CUDIT-R*Time	0.003	1.003	0.0078	0.404	0.686	-0.012	0.018

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 18

Fixed Effects for Anxiety Symptoms by CUD Symptoms After Use

	F	*df1*	*df2*	*p*
Corrected Model	4.764	5	1498	**<0.001**
Time	3.585	1	1498	0.058
Gender	13.085	1	1498	**<0.001**
Age of Onset	0.974	1	1498	0.324
CUDIT-R	0.296	1	1498	0.586
CUDIT-R*Time	0.805	1	1498	0.370

Note. CUDIT-R = Cannabis Use Disorder Identification Test – Revised.

Table 19

Fixed Coefficients for Anxiety Symptoms by CUD Symptoms After Use

						95% CI	
Model Term	β	Exp(β)	*SE*	*T*	*p*	Lower	Upper
Intercept	0.620	1.859	0.3006	2.063	**0.039**	0.030	1.210
Time	-0.160	0.852	0.0845	-1.893	0.058	-0.326	0.006
Male	-0.295	0.745	0.0815	-3.617	**<0.001**	-0.455	-0.135
Female	0[a]						
Age of Onset	0.017	1.017	0.0170	0.987	0.324	-0.017	0.050
CUDIT-R	-0.004	0.996	0.0067	-0.544	0.586	-0.017	0.010
CUDIT-R*Time	0.005	1.005	0.0058	0.897	0.370	-0.006	0.016

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 20

Fixed Effects for Depression by CUD Symptoms Before Use

	F	*df1*	*df2*	*p*
Corrected Model	0.786	5	752	0.560
Time	0.023	1	752	0.879
Gender	1.337	1	752	0.248
Age of Onset	1.572	1	752	0.210
CUDIT-R	0.040	1	752	0.842
CUDIT-R * Time	0.051	1	752	0.821

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised.

Table 21

Fixed Coefficients for Depression Symptoms by CUD Symptoms Before Use

						95% CI	
Model Term	β	Exp(β)	*SE*	*t*	*p*	Lower	Upper
Intercept	0.285	1.330	0.3368	0.847	0.398	-0.376	0.946
Time	0.017	1.017	0.1111	0.153	0.879	-0.201	0.235
Male	-0.106	0.899	0.0915	-1.156	0.248	-0.285	0.074
Female	0[a]						
Age of Onset	0.024	1.024	0.0190	1.254	0.210	-0.013	0.061
CUDIT-R	0.002	1.002	0.0076	0.199	0.842	-0.013	0.016
CUDIT-R*Time	0.002	1.002	0.0078	0.226	0.821	-0.013	0.017

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 22

Fixed Effects for Depression Symptoms by CUD Symptoms After Use

	F	*df1*	*df2*	*p*
Corrected Model	1.488	5	1500	0.191
Time	1.881	1	1500	0.170
Gender	0.935	1	1500	0.334
Age of Onset	1.614	1	1500	0.204
CUDIT-R	0.002	1	1500	0.962
CUDIT-R*Time	0.353	1	1500	0.552

Note. CUDIT-R = Cannabis Use Disorder Identification Test – Revised.

Table 23

Fixed Coefficients for Depression Symptoms by CUD Symptoms After Use

						95% CI	
Model Term	β	Exp(β)	*SE*	*T*	*p*	Lower	Upper
Intercept	0.319	1.376	0.2950	1.083	0.279	-0.259	0.898
Time	-0.112	0.894	0.0818	-1.372	0.170	-0.273	0.048
Male	-0.077	0.926	0.0799	-0.967	0.334	-0.234	0.080
Female	0[a]						
Age of Onset	0.021	1.021	0.0166	1.271	0.204	-0.012	0.054
CUDIT-R	0.000	1.000	0.0066	0.048	0.962	-0.013	0.013
CUDIT-R*Time	0.003	1.003	0.0056	0.594	0.552	-0.008	0.014

Note. CUDIT-R = Cannabis Use Disorder Identification Test - Revised; CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 24

Fixed Effects for Positive Affect by Coping Motives Before Use

	F	*df1*	*df2*	*p*
Corrected Model	3.670	5	770	**0.003**
Time	0.098	1	770	0.754
Gender	3.978	1	770	**0.046**
Age of Onset	4.423	1	770	**0.036**
Coping Motives	9.312	1	770	**0.002**
Coping Motives*Time	0.016	1	770	0.898

Table 25

Fixed Coefficients for Positive Affect by Coping Motives Before Use

						95% CI	
Model Term	β	Exp(β)	*SE*	*t*	*p*	Lower	Upper
Intercept	2.213	9.143	0.1853	11.944	**<0.001**	1.849	2.577
Time	-0.008	0.992	0.0261	-0.314	0.754	-0.059	0.043
Male	0.110	1.116	0.0552	1.995	**0.046**	0.002	0.218
Female	0[a]						
Age of Onset	0.024	1.024	0.0115	2.103	**0.036**	0.002	0.047
Coping Motives	-0.108	0.898	0.0355	-3.052	**0.002**	-0.178	-0.039
Coping Motives*Time	0.004	1.004	0.0321	0.128	0.898	-0.059	0.067

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 26

Fixed Effects for Positive Affect by Coping Motives After Use

	F	*df1*	*df2*	*p*
Corrected Model	4.794	5	1535	**<0.001**
Time	0.006	1	1535	0.940
Gender	5.792	1	1535	**0.016**
Age of Onset	5.529	1	1535	**0.019**
Coping Motives	11.834	1	1535	**0.001**
Coping Motives*Time	0.496	1	1535	0.481

Table 27

Fixed Coefficients for Positive Affect by Coping Motives After Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	2.228	9.281	0.1628	13.687	**<0.001**	1.909	2.548
Time	0.001	1.001	0.0196	0.075	0.940	-0.037	0.040
Male	0.117	1.124	0.0484	2.407	**0.016**	0.022	0.211
Female	0[a]						
Age of Onset	0.024	1.024	0.0101	2.351	**0.019**	0.004	0.044
Coping Motives	-0.119	0.888	0.0346	-3.440	**0.001**	-0.187	-0.051
Coping Motives*Time	0.008	1.008	0.0121	0.704	0.481	-0.015	0.032

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 28

Fixed Effects for Negative Affect by Coping Motives Before Use

	F	*df1*	*df2*	*p*
Corrected Model	11.866	5	771	**<0.001**
Time	0.988	1	771	0.321
Gender	5.646	1	771	**0.018**
Age of Onset	2.594	1	771	0.108
Coping Motives	48.266	1	771	**<0.001**
Coping Motives*Time	13.536	1	771	**<0.001**

Table 29

Fixed Coefficients for Negative Affect by Motives Before Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	1.905	6.719	0.1640	11.621	**<0.001**	1.583	2.227
Time	0.023	1.023	0.0231	0.994	0.321	-0.022	0.068
Male	-0.116	0.890	0.0488	-2.376	**0.018**	-0.212	-0.020
Female	0[a]						
Age of Onset	0.016	1.016	0.0102	1.611	0.108	-0.004	0.036
Coping Motives	0.246	1.279	0.0354	6.947	**<0.001**	0.176	0.315
Coping Motives*Time	0.121	1.129	0.0328	3.679	**<0.001**	0.056	0.185

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 30

Fixed Effects for Negative Affect by Coping Motives After Use

	F	*df1*	*df2*	*p*
Corrected Model	11.066	5	1538	**<0.001**
Time	1.490	1	1538	0.222
Gender	9.812	1	1538	**0.002**
Age of Onset	1.716	1	1538	0.190
Coping Motives	41.068	1	1538	**<0.001**
Coping Motives * Time	14.252	1	1538	**<0.001**

Table 31

Fixed Coefficients for Negative Affect by Coping Motives After Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	1.962	7.114	0.1296	15.137	**<0.001**	1.708	2.217
Time	-0.018	0.982	0.0146	-1.221	0.222	-0.046	0.011
Male	-0.120	0.887	0.0384	-3.132	**0.002**	-0.195	-0.045
Female	0[a]						
Age of Onset	0.010	1.010	0.0080	1.310	0.190	-0.005	0.026
Coping Motives	0.207	1.230	0.0323	6.408	**<0.001**	0.144	0.270
Coping Motives*Time	-0.041	0.960	0.0110	-3.775	**<0.001**	-0.063	-0.020

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 32

Fixed Effects for Anxiety by Coping Motives Before Use

	F	*df1*	*df2*	*p*
Corrected Model	17.268	5	775	**<0.001**
Time	0.384	1	775	0.536
Gender	14.821	1	775	**<0.001**
Age of Onset	0.469	1	775	0.494
Coping Motives	68.375	1	775	**<0.001**
Coping Motives*Time	28.684	1	775	**<0.001**

Table 33

Fixed Coefficients for Anxiety Symptoms by Coping Motives Before Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	0.661	1.937	0.3001	2.203	**0.028**	0.072	1.250
Time	0.027	1.027	0.0443	0.619	0.536	-0.059	0.114
Male	-0.345	0.708	0.0895	-3.850	**<0.001**	-0.520	-0.169
Female	0[a]						
Age of Onset	0.013	1.013	0.0186	0.685	0.494	-0.024	0.049
Coping Motive	0.477	1.611	0.0576	8.269	**<0.001**	0.363	0.590
Coping Motive*Time	0.323	1.381	0.0603	5.356	**<0.001**	0.205	0.441

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 34

Fixed Effects for Anxiety by Coping Motives After Use

	F	*df1*	*df2*	*p*
Corrected Model	20.134	5	1548	**<0.001**
Time	7.509	1	1548	**0.006**
Gender	17.451	1	1548	**<0.001**
Age of Onset	0.857	1	1548	0.355
Coping Motives	67.066	1	1548	**<0.001**
Coping Motives*Time	13.586	1	1548	**<0.001**

Table 35

Fixed Coefficients for Anxiety Symptoms by Coping Motives After Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	0.589	1.802	0.2664	2.209	**0.027**	0.066	1.111
Time	-0.091	0.913	0.0334	-2.740	**0.006**	-0.157	-0.026
Male	-0.331	0.718	0.0793	-4.177	**<0.001**	-0.487	-0.176
Female	0[a]						
Age of Onset	0.015	1.015	0.0165	0.926	0.355	-0.017	0.048
Coping Motives	0.431	1.539	0.0526	8.189	**<0.001**	0.327	0.534
Coping Motives*Time	-0.084	0.919	0.0227	-3.686	**<0.001**	-0.128	-0.039

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 36

Fixed Effects for Depression by Coping Motives Before Use

	F	*df1*	*df2*	*p*
Corrected Model	7.514	5	775	**<0.001**
Time	1.737	1	775	0.188
Gender	1.226	1	775	0.269
Age of Onset	1.756	1	775	0.186
Coping Motives	30.862	1	775	**<0.001**
Coping Motives*Time	14.517	1	775	**<0.001**

Table 37

Fixed Coefficients for Depression Symptoms by Motives Before Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	0.291	1.338	0.2939	0.989	0.323	-0.286	0.868
Time	0.057	1.059	0.0430	1.318	0.188	-0.028	0.141
Male	-0.097	0.908	0.0876	-1.107	0.269	-0.269	0.075
Female	0[a]						
Age of Onset	0.024	1.024	0.0182	1.325	0.186	-0.012	0.060
Coping Motives	0.325	1.384	0.0586	5.555	**<0.001**	0.210	0.440
Coping Motives*Time	0.229	1.257	0.0601	3.810	**<0.001**	0.111	0.347

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Table 38

Fixed Effects for Depression by Coping Motives After Use

	F	*df1*	*df2*	*p*
Corrected Model	8.777	5	1549	**<0.001**
Time	4.852	1	1549	**0.028**
Gender	0.938	1	1549	0.333
Age of Onset	2.093	1	1549	0.148
Coping Motives	34.676	1	1549	**<0.001**
Coping Motives*Time	10.622	1	1549	**0.001**

Table 39

Fixed Coefficients for Depression Symptoms by Coping Motives After Use

						95% CI	
Model Term	*β*	Exp(*β*)	*SE*	*t*	*p*	Lower	Upper
Intercept	0.279	1.321	0.2577	1.084	0.278	-0.226	0.785
Time	-0.070	0.932	0.0316	-2.203	**0.028**	-0.132	-0.008
Male	-0.074	0.929	0.0766	-0.968	0.333	-0.224	0.076
Female	0[a]						
Age of Onset	0.023	1.023	0.0160	1.447	0.148	-0.008	0.054
Coping Motives	0.325	1.384	0.0552	5.889	**<0.001**	0.217	0.433
Coping Motives*Time	-0.077	0.926	0.0237	-3.259	**0.001**	-0.124	-0.031

Note. CI = Confidence Interval; SE = Standard Error.
[a]This coefficient is set to zero because it is redundant.

Appendix 2: Measures

Worksheet 3.1 The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988)

PANAS Questionnaire

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. **Indicate to what extent you feel this way right now, that is, at the present moment *OR* indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure)**

1	2	3	4	5
Very Slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely

_____ 1. Interested	_____ 11. Irritable
_____ 2. Distressed	_____ 12. Alert
_____ 3. Excited	_____ 13. Ashamed
_____ 4. Upset	_____ 14. Inspired
_____ 5. Strong	_____ 15. Nervous
_____ 6. Guilty	_____ 16. Determined
_____ 7. Scared	_____ 17. Attentive
_____ 8. Hostile	_____ 18. Jittery
_____ 9. Enthusiastic	_____ 19. Active
_____ 10. Proud	_____ 20. Afraid

Scoring Instructions:

Positive Affect Score: Add the scores on items 1, 3, 5, 9, 10, 12, 14, 16, 17, and 19. Scores can range from 10 – 50, with higher scores representing higher levels of positive affect. Mean Scores: Momentary = 29.7 (*SD* = 7.9); Weekly = 33.3 (*SD* = *7.2)*

Negative Affect Score: Add the scores on items 2, 4, 6, 7, 8, 11, 13, 15, 18, and 20. Scores can range from 10 – 50, with lower scores representing lower levels of negative affect. Mean Score: Momentary = 14.8 (*SD* = 5.4); Weekly = 17.4 (*SD* = 6.2)

Generalized Anxiety Disorder 7-item (GAD-7) scale

Over the last 2 weeks, how often have you been bothered by the following problems?	Not at all sure	Several days	Over half the days	Nearly every day
1. Feeling nervous, anxious, or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it's hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3
Add the score for each column	+	+	+	
Total Score *(add your column scores)* =				

GAD-7.pd

The Patient Health Questionnaire (PHQ-9)

Patient Name _____ Date of Visit _____

Over the past 2 weeks, how often have you been bothered by any of the following problems?	Not At all	Several Days	More Than Half the Days	Nearly Every Day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed or hopeless	0	1	2	3
3. Trouble falling asleep, staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself - or that you're a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or, the opposite - being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

Column Totals _____ + _____ + _____

Add Totals Together _____

PHQ-4: THE FOUR-ITEM PATIENT HEALTH QUESTIONNAIRE FOR ANXIETY AND DEPRESSION

Over the last two weeks, how often have you been bothered by the following problems?	Not at all	Several days	More than half the days	Nearly every day
Feeling nervous, anxious or on edge	0	1	2	3
Not being able to stop or control worrying	0	1	2	3
Feeling down, depressed or hopeless	0	1	2	3
Little interest or pleasure in doing things	0	1	2	3
TOTALS				

Total score is determined by adding together the scores of each of the 4 items.
Scores are rated as normal (0-2), mild (3-5), moderate (6-8), and severe (9-12).
Total score ≥3 for first 2 questions suggests anxiety.
Total score ≥3 for last 2 questions suggests depression.

Reprinted with permission from Kroenke K, Spitzer RL, Williams JB, Löwe B. An ultra-brief screening scale for anxiety and depression: the PHQ-4. Psychosomatics. 2009;50(6):613-21. From Principles of Neuropathic Pain Assessment and Management, November 2011.

Marijuana Motives Measure (MMM)

The following is a list of reasons people sometimes give for using cannabis. Thinking of all the times you use cannabis, **how often** would you say that you use it for each of the following reasons? (Please circle your answer).

Please respond based on how you usually have felt or behaved **over the past several years**.

I use marijuana …	Never/ Almost never				Always/ Almost always
1. To forget my worries.	1	2	3	4	5
2. Because my friends pressure me to use marijuana.	1	2	3	4	5
3. Because it helps me enjoy a party.	1	2	3	4	5
4. Because it helps me when I feel depressed or nervous.	1	2	3	4	5
5. To be sociable.	1	2	3	4	5
6. To cheer up when I am in a bad mood.	1	2	3	4	5
7. Because I like the feeling.	1	2	3	4	5
8. So that others won't kid me about not using marijuana.	1	2	3	4	5
9. Because it's exciting.	1	2	3	4	5
10. To get high.	1	2	3	4	5
11. Because it makes social gatherings more fun.	1	2	3	4	5
12. To fit in with the group I like.	1	2	3	4	5
13. Because it gives me a pleasant feeling.	1	2	3	4	5
14. Because it improves parties and celebrations.	1	2	3	4	5
15. Because I feel more confident and sure of myself.	1	2	3	4	5
16. To celebrate a special occasion with friends.	1	2	3	4	5
17. To forget about my problems.	1	2	3	4	5
18. Because it's fun.	1	2	3	4	5
19. To be liked.	1	2	3	4	5
20. So I won't feel left out.	1	2	3	4	5
21. To know myself better.	1	2	3	4	5
22. Because it helps me be more creative and original.	1	2	3	4	5
23. To understand things differently.	1	2	3	4	5
24. To expand my awareness.	1	2	3	4	5
25. To be more open to experiences.	1	2	3	4	5

The Cannabis Use Disorder Identification Test - Revised (CUDIT-R)

Have you used any cannabis over the past six months? YES / NO

If YES, please answer the following questions about your cannabis use. Circle the response that is most correct for you in relation to your cannabis use *over the past six months*

1. How often do you use cannabis?

Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week
0	1	2	3	4

2. How many hours were you "stoned" on a typical day when you had been using cannabis?

Less than 1	1 or 2	3 or 4	5 or 6	7 or more
0	1	2	3	4

3. How often during the past 6 months did you find that you were not able to stop using cannabis once you had started?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily
0	1	2	3	4

4. How often during the past 6 months did you fail to do what was normally expected from you because of using cannabis?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily
0	1	2	3	4

5. How often in the past 6 months have you devoted a great deal of your time to getting, using, or recovering from cannabis?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily
0	1	2	3	4

6. How often in the past 6 months have you had a problem with your memory or concentration after using cannabis?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily
0	1	2	3	4

7. How often do you use cannabis in situations that could be physically hazardous, such as driving, operating machinery, or caring for children:

Never	Less than monthly	Monthly	Weekly	Daily or almost daily
0	1	2	3	4

8. Have you ever thought about cutting down, or stopping, your use of cannabis?

Never	Yes, but not in the past 6 months	Yes, during the past 6 months
0	2	4

This scale is in the public domain and is free to use with appropriate citation:

Adamson SJ, Kay-Lambkin FJ, Baker AL, Lewin TJ, Thornton L, Kelly BJ, and Sellman JD. (2010). An Improved Brief Measure of Cannabis Misuse: The Cannabis Use Disorders Identification Test – Revised (CUDIT-R). *Drug and Alcohol Dependence* 110:137-143.