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Characteristics of clinically anxious versus non-anxious regular, heavy marijuana users

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ABSTRACT

Both the key mechanism of action for marijuana (the endocannabinoid system) and the symptoms associated with marijuana withdrawal suggest an important link to anxiety. Despite this link, there is a dearth of research on the characteristics of heavy marijuana users with clinical-level anxiety compared to those with heavy marijuana use alone. Over 10,000 participants (friends or affiliates of the National Organization for the Reform of Marijuana Laws) provided data via online survey. After careful, conservative screening, anxiety, other psychopathology, other drug use, and marijuana-related problems were examined in 2567 heavy marijuana users. Subsequently, 275 heavy users with clinical-level anxiety were compared to demographically-equivalent non-anxious heavy users on psychopathology, drug use, and cannabis-related problems. Among several psychological variables (including anxiety, depression, schizotypy, and impulsivity), anxiety was most strongly predictive of amount of marijuana used and marijuana-related problems. Group comparison ($n = 550$ total) revealed that clinically anxious heavy users exhibited more use, more non-anxiety psychopathological symptoms, and a greater number and severity of marijuana-related problems than their non-anxious peers. The findings reveal that anxiety shows an important relation to marijuana use and related problems among regular, heavy users. Further examinations of common and unique factors predisposing individuals for anxiety and marijuana abuse appear warranted.

1. Introduction

In contrast to extensive literature examining potential links between chronic marijuana use and psychosis (Malone, Hill, & Rubino, 2010; Moore et al., 2007) or depression(Degenhardt, Hall, & Lynskey, 2003; Harder, Stuart, & Anthony, 2008), much less is known about general clinical anxiety in heavy marijuana users (Cheung et al., 2010). Several studies have investigated marijuana problems in conjunction with social anxiety (e.g., Buckner, Bonn-Miller, Zvolensky, & Schmidt, 2007; Buckner, Silgado, & Schmidt, 2011; Buckner et al., 2008), symptoms of panic (e.g., Zvolensky et al., 2006a; Zvolensky, Cougle, Johnson, Bonn-Miller, & Bernstein, 2010; Zvolensky et al., 2008), post-traumatic stress disorder (PTSD; Bonn-Miller, Vujanovic, & Drescher, 2011; Cougle, Bonn-Miller, Vujanovic, Zvolensky, & Hawkins, 2011), and anxiety sensitivity (e.g., Zvolensky, et al., 2006b), but few focus on more general anxiety symptoms or the possible relationship between clinical levels of anxiety and marijuana use, though there are a few notable exceptions.

A recent study, in a very large nationally-representative sample, showed that clinical-level PTSD symptoms are associated with increased likelihood of daily cannabis use, even after controlling for other drug use (Cougle et al., 2011). Another exception is a cannabis problem prevalence and comorbidity study, which showed that rates of anxiety disorders are as high as 43.5% in 12-month and 50.0% in lifetime cannabis dependence (Stinson, Ruan, Pickering, & Grant, 2006). Among those with a diagnosis of abuse, 12-month and lifetime comorbidity with an anxiety disorder was 18.6% and 26.9%, respectively. Relationships to specific anxiety disorders, and comorbidity with anxiety disorders more generally, suggest the need for examination of characteristics of those who exhibit clinical anxiety and regularly use cannabis relative to those who regularly use cannabis, but do not have clinical anxiety. To our knowledge, no prior report has characterized features of regular, heavy marijuana smokers who exhibit clinical-level anxiety relative to heavy marijuana smokers who do not.

There are compelling reasons why such an investigation may prove fruitful. The endocannabinoid receptor type 1 (CB1), which mediates the positive rewarding effects of Δ^9-tetrahydrocannobinol

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(THC; the main psychoactive ingredient of marijuana; see Cooper & Haney, 2008), has also been implicated in anxiety-related processes (see Ruehle, Aparisi Rey, Remmers, & Lutz, 2011). Acutely, CB1 receptor agonists can decrease anxiety at low doses but increase it at high ones. Preclinical evidence has linked endocannabinoids and altered stress responses with dysregulation of the endocannaboid system, impairing adjustment to chronic stress (Gorzalka, Hill, & Hillard, 2008), and potentially increasing risk for anxiety. Thus, a subset of marijuana smokers might be at increased risk for anxiety, either because of pre-existing variability in the endocannabinoid system (predisposing them towards use of marijuana and anxiety-related psychopathology) or because chronic exposure to marijuana alters endocannabinoid system function. Such a possibility is supported by the overlap between the symptoms of marijuana withdrawal, which include anxiety, irritability, insomnia, and appetite disruptions (Budney & Hughes, 2006; Haney, 2005; Haney et al., 2004; Lazary, Juhasz, Hunyady, & Bagdy, 2011) and the symptoms of anxiety disorders (American Psychiatric Association, 2000).

Marijuana smokers with clinically-relevant anxiety may present particular challenges for treatment. Supporting this possibility, a clinical trial found that treatment-seeking marijuana smokers with anxiety exhibited more marijuana-related problems at baseline than did non-anxious users. Moreover, across different studies, reduced anxiety following treatment predicted lower levels of marijuana use at follow-up (Bonn-Miller et al., 2011; Buckner & Carroll, 2010). Consistent with these findings, anxiety symptoms at discharge from marijuana treatment predict marijuana relapse (Bonn-Miller & Moos, 2009), and level of anxiety reduction over treatment is associated with marijuana, but not necessarily other substance, use (Bonn-Miller et al., 2011).

Lack of information on clinical anxiety in marijuana users and the importance of anxiety in marijuana treatment inspired the current study, which aimed to compare marijuana users with clinical levels of anxiety to those with a comparable frequency of marijuana use but without clinically-relevant anxiety. Based on existing evidence (e.g., Buckner & Carroll, 2010; Cougle et al., 2011), we expected anxious heavy marijuana users to exhibit more psychopathological symptoms, more cannabis-associated problems, and heavier cannabis use than those low in anxiety.

2. Method

2.1. Procedure

Participants responded to an email request issued to NORML. At survey completion, participants were entered into a drawing for a $250 Amazon.com gift card or 1 of 5 4 GB iPods. Willing participants forwarded the email to others who might be interested. All procedures were approved by the University of Albany, SUNY Institutional Review Board.

2.2. Participants

A total of 10,304 participants responded to the request. Participant responses were screened for repeated Internet Protocol (IP) addresses and item completion rates of less than 95%, for which 501 and 2414 cases were excluded, respectively. We focused on daily or near-daily users who had smoked for at least a year. Participants had to report currently monthly use between 20 and 31 days and an age of first marijuana use at least one year less than current age. To ensure that the marijuana use criterion was valid, participants also had to report use in the last year, month, and week. 3753 individuals met these criteria.

2.3. Measures

Assessment included 1) anxiety symptoms; 2) other psychopathology including psychotic and depressive symptoms; 3) other drug use; and 4) marijuana problems. We focused on current heavy (daily or near daily) marijuana smokers given their elevated likelihood of anxiety diagnoses (e.g., Cougle et al., 2011), marijuana-related problems (Chen, Kandel, & Davies, 1997), and treatment-seeking (e.g., Levin et al., 2006). Data were obtained via web-based questionnaires completed by members or friends of members of a marijuana law reform group (National Organization for the Reform of Marijuana Laws; NORML). Internet-based approaches allow the collection of information from participants who might otherwise be hesitant to report illegal activity.

2.3.1. Cannabis-Associated Problems Questionnaire

The CAPQ (Lavender, Looby, & Earleywine, 2008), a 19-item questionnaire assessing psychological, social, occupational, and legal consequences of cannabis use, has participants endorse problems on a Likert-type scale from 0 (no problem) to 5 (serious problem). High scores (i.e. 4 or 5) on several of the individual CAPQ items align with DSM-IV criteria for Cannabis Abuse (American Psychiatric Association, 2000). Internal consistency of the CAPQ in this sample was Cronbach's $\alpha = .82$.

2.3.2. Center for Epidemiologic Studies Depression Scale — Revised

The CESD-R, an updated version of the CES-D (Radloff, 1977), contains 20 items that reflect DSM-IV criteria for depression (Eaton, Muntaner, Smith, Tien, & Ybarra, 2004). Each of the nine symptoms of a major depressive episode appear on at least 2 items, which participants rate from 0 (Not at all or less than 1 day/week) to 4 (nearly every day for the past 2 weeks). The CESD-R has excellent psychometric properties (Eaton et al., 2004; Van Dam & Earleywine, 2011). Internal consistency in the present sample was Cronbach's $\alpha = .91$.

2.3.3. Nicotine and Alcohol Use

Nicotine and alcohol use were assessed with a questionnaire used previously (see e.g., Van Dam, Earleywine, & DiGiacomo, 2008; Walden & Earleywine, 2008). Participants responded 'yes' or 'no' with regards to lifetime (and last year) use of cigarettes and alcohol. Participants reported whether they were current, regular cigarette smokers. They estimated the number of days of drinking within the last month and the number of standard drinks per drinking occasion, in standard drinks (a 12 oz beer, a 5 oz glass of wine, or a 1.5 oz shot of 80-proof liquor).

2.3.4. Illegal Drug Use

Participants answered 'yes' or 'no' to questions concerning lifetime, past year, past month, and past week use of 10 illicit drugs: amphetamine, cocaine (powder), cocaine (smoked), ecstasy, heroin, LSD, marijuana, methamphetamine, 'magic' mushrooms, and opium. Participants answered similar questions about 3 prescription drugs used for non-prescribed reasons and/or without a prescription, including prescription stimulants, opiates, and sedatives. They also reported the age they first used marijuana, current monthly and weekly use in days, how "high", on average, they get when using marijuana (from 1 — not at all high, to 6 — extremely high), and their weekly use of marijuana in grams (a standard unit for purchase and sale of marijuana). Weekly use of marijuana in grams has shown convergent validity with other relevant measures (Walden & Earleywine, 2008) and therefore served as a primary dependent variable.

2.3.5. Marlowe Crowne Social Desirability Scale

The MC (Crowne & Marlowe, 1960), a 33-item questionnaire assessing participants' desire to be perceived well (i.e. social desirability), uses a true/false response format. Eighteen items are worded so a response of "true" is socially desirable; fifteen items have "false" as the socially desirable response. The different directionality of wording likely represents an important method effect (DiStefano & Motl, 2006) and potentially reflects different sources of social desirability.

2.3.6. State-Trait Inventory for Cognitive and Somatic Anxiety

The STICSA, a 21-item questionnaire that differentiates cognitive from somatic components of anxiety, was developed as an alternative to other measures (e.g., State-Trait Anxiety Inventory), which co-vary more with depression than anxiety (Gros, Antony, Simms, & McCabe, 2007; Ree, French, MacLeod, & Locke, 2008). Participants endorse items on a scale of 1 (not at all) to 4 (very much so). The STICSA has excellent psychometric properties (Gros et al., 2007; Ree et al., 2008). Internal consistency in this sample was Cronbach's $\alpha = .89$.

2.3.7. Schizotypal Personality Questionnaire—Brief

The 22-item SPQ-B (Raine & Benishay, 1995), an abbreviation of the Schizotypal Personality Questionnaire, contains 22 true/false items assessing three main factors: Cognitive–Perceptual Deficits, Interpersonal Deficits, and Disorganization. An alternative approach focuses on three subscales of Positive, Negative, and Disorganized Symptoms (Vollema & Hoijtink, 2000). Previous studies reveal important distinctions among the different factors (Van Dam et al., 2008), for this reason the Cognitive–Perceptual (CP), Interpersonal (IP), Disorganized (D), Positive Symptom (Pos), and Negative Symptom (Neg) subscales were all computed in the present study. Total scale consistency was reasonable in the present sample (Cronbach's $\alpha = .79$).

2.3.8. Impulsive Sensation Seeking Scale

The 19-item Impulsive Sensation Seeking Scale (ImpSS) scale, part of the Zuckerman–Kuhlman Personality Questionnaire (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993) contains 19 true/false items. The ImpSS shows good psychometric properties including acceptable internal consistency (alphas above .80) across heterogeneous samples (McDaniel & Mahan, 2008; Zuckerman, 1994; though see De Leo, Van Dam, Hobkirk, & Earleywine, 2011). In this sample, internal consistency was Cronbach's $\alpha = .83$. The ImpSS was included primarily as means to control for extant findings that impulsivity may be an underlying risk-factor and complicating feature of substance-use disorders (Verdejo-García, Lawrence, & Clark, 2008).

2.4. Statistical Approach

We screened the data to remove potential bias associated with the sample (see Section 3.1). To determine whether anxiety was the primary contributing psychological symptom to marijuana use and problems, we regressed weekly marijuana use (in grams) and CAPQ total score on anxiety, depression, impulsive sensation seeking, schizotypy, and social desirability using backwards multiple regressions. Subsequently, we established clinically anxious and demographically equivalent non-anxious heavy marijuana user groups (see Section 3.3), and compared them on psychological and marijuana-related variables, legal and illicit drug use. Finally, we conducted logistic regression analyses on all 19 items of the CAPQ, setting the nominal p value to .05 using the False Discovery Rate (FDR; Benjamini & Hochberg, 1995). All statistics were conducted in IBM SPSS statistics 19.0.

3. Results

3.1. Data Screening

Due to concerns about data collection in a population (i.e. NORML members and associates) that may have had incentive to self-present in a positive fashion and who may have been impaired at the time (see Bedi, Van Dam, & Redman, 2010; Van Dam et al., 2008), conservative screening was undertaken to rule out careless and/or biased responding. Participants were asked, "Have you ever taken a drug that does not exist?" All participants who responded "yes" were excluded ($n = 123$). We additionally asked participants at the end of the questionnaire whether or not we should include their data. Participants were encouraged to notify us, without any penalty, if they were impaired or did not take the questionnaire seriously; 14 participants indicated that we should not include their data. We also embedded ten infrequency items, statements that have obvious answers (e.g., I breathe air every day, I can fly to other planets). Frequencies revealed that only 4.0% endorsed 2 or more of these statements, corresponding to a Z score of 2.45 (unidirectional $p = .007$); these participants were excluded ($n = 136$). Only individuals who completed the above screening measures were included, thus 223 additional individuals from the available sample of 3753 participants were excluded. The remaining sample contained 3257 individuals ($3753 - (123 + 14 + 136 + 223 = 496)$).

Forensic analyses suggest that MC scores ≤ 12 suggest a tendency to exaggerate pathology (Andrews & Meyer, 2003); these individuals may show positive endorsement biases. Individuals with MC scores ≥ 29 may be attempting to present themselves in a socially desirable fashion (Andrews & Meyer, 2003). Accordingly, data were limited to those who completed the MC ($n = 3086$). Participants with MC scores ≤ 12 were excluded from further analyses ($n = 519$). No participants scored ≥ 29 on the MC (maximum = 23). The final sample contained 2567 participants.

3.2. Regression analyses

To examine predictors of cannabis use and problems, multiple regression analyses were conducted in the entire screened sample ($n = 2567$). Weekly use in grams and total score on the CAPQ were regressed on anxiety, depression, impulsive sensation seeking, schizotypy, and social desirability. In a backward multiple regression, only anxiety significantly predicted weekly cannabis use in grams, $\beta = .105$, $t = 4.69$, $p < .001$. Since β is a standardized regression coefficient, this finding means that an increase of 8.3 points on the STICSA (anxiety) predicts an approximately 1 gram increase ($.11 * 9.15$) in weekly cannabis use. The zero-order correlation indicated that anxiety predicted approximately 1.0% of the variance of cannabis use. Anxiety ($\beta = .320$, $t = 12.73$, $p < .001$), impulsive sensation seeking ($\beta = .105$, $t = 4.86$, $p < .001$), social desirability ($\beta = .101$, $t = 4.77$, $p < .001$), and schizotypy ($\beta = .089$, $t = 3.52$, $p < .001$) were all significant predictors of cannabis-associated problems. This means that an increase of 8.3 points on the STICSA (anxiety), increase of 4.3 points on the ImpSS (impulsivity), increase of 2.1 points on the MC (social desirability), and increase of 4.4 points on the SPQ-B (schizotypy) predict increases of 2.7, .9, .8, and .7 points on the CAPQ (cannabis-associated problems), respectively. Semi-partial correlations, including all significantly related variables (i.e., anxiety, impulsive sensation seeking, social desirability, schizotypy, and cannabis-associated problems), revealed that anxiety predicted more unique variance (semi-partial $r^2 = .078$) in problems than impulsive sensation seeking (semi-partial $r^2 = .012$), schizotypy (semi-partial $r^2 = .006$), or social desirability (semi-partial $r^2 = .012$). These results suggest that anxiety is more strongly related to cannabis use and associated problems than are depression, impulsive sensation seeking, schizotypy, or social desirability.

3.3. Group Establishment

The 275 individuals scoring at or above the STICSA cut-score of 43, indicative of clinical anxiety (Van Dam, Gros, Earleywine, & Antony, in press), constituted the clinically anxious marijuana users. To minimize confounding variables that cannot be well controlled statistically (Miller & Chapman, 2001), 275 demographically equivalent (in age, gender, race/ethnicity, and education) individuals were selected from the remaining participants. To identify a subset of non-anxious regular users representative of the population, participants were pseudo-randomly sampled, matching at least 3 of the 4 demographic variables. Participants were then re-sampled until the group and the total sample were statistically equivalent on anxiety ($Z = .59$, $p > .5$), cannabis-associated problems ($Z = -.80$, $p > .4$), depression ($Z = 1.14$, $p > .2$), impulsive sensation seeking ($Z = .98$, $p > .3$), schizotypy ($Z = -1.14$,

$p > .2$), social desirability ($Z = -.91$, $p > .3$), and weekly marijuana use in grams ($Z = -1.40$, $p > .16$). The 275 demographically-equivalent, low anxiety individuals constituted the non-anxious marijuana users. As shown in Table 1, the clinically anxious and non-anxious marijuana users were not statistically different on any demographic variables.

3.4. Psychological Variables by Group

Group differences in psychological variables appear in Table 2. The clinically anxious group outscored the non-anxious group across all variables except the negative items of the MC. Clinically anxious users scored higher on the positive items of the MC (socially desirable responses obtained by affirming positive statements about oneself), but not on the negative ones (socially desirable responses obtained by rejecting negative statements about oneself). Clinically anxious users appear more likely than non-anxious users to endorse positive self-statements. The groups are equally likely to reject negative self-statements, suggesting a bias to *under-report*, rather than over-report, symptoms. The effect size for the cognitive subscale of the STICSA is approximately 1 standard deviation larger than the one for the somatic subscale. This finding deserves attention, given potential concerns about anxiety symptoms reflecting sub-acute drug effects (often somatic), in drug using populations (Bedi et al., 2010). Finally, the largest effect sizes for schizotypy appear in the interpersonal and negative subscales (unlike the positive symptoms of actively psychotic individuals, e.g., Van Dam et al., 2008).

3.5. Marijuana-Related Variables by Group

Group differences in marijuana-related variables appear in Table 3. The clinically anxious group exceeded the non-anxious group on self-reported quantity of marijuana used per week and marijuana-related problems. The clinically anxious group showed significantly higher rates of cannabis-related problems than the non-anxious group, as assessed by the CAPQ ($d = .73$; see Table 3). Marijuana withdrawal, which is similar in symptomatology to clinical anxiety, would seem to have particular relevance for those with clinical levels of anxiety (Lazary et al., 2011), thus we examined group differences on this single item. The clinically anxious group ($M = 1.61$, $SD = 1.08$) reported that withdrawal was significantly more of a problem relative to the non-anxious group ($M = 1.33$, $SD = .77$), $t(480.03) = 3.49$, $p = .001$, $d = .30$. The problems listed on the CAPQ reflect aspects of the four criteria for Cannabis Abuse as defined by the Diagnostic and Statistical Manual of Mental Disorders, Text Revision (American Psychiatric Association, 2000). To assess functional impairment regarding items on the CAPQ in a fashion consistent with the DSM cannabis abuse specification that problems must lead to significant distress, we recoded CAPQ responses into a binary format. The upper 2 response options (stating that the problem is serious) were coded as 1; all others were coded as 0. The non-anxious group predominantly endorsed no 'serious' problems; approximately 2/3 of the clinically anxious group endorsed 1 or more serious problems and approximately 1/3 of the clinically anxious group endorsed 3 or more serious problems (in comparison to approximately 1/8 of the non-anxious group).

To examine group differences on individual problems, we employed logistic regression analyses (response options were recoded into dichotomous categories — serious or not serious) using FDR correction because we were examining 19 items individually. The percentage of group members endorsing a serious problem is represented along the

Table 1
Demographics by marijuana group.

	NA (n = 275)	*CA (n = 275)*	NA vs. CA
	M (SD)	*M (SD)*	*t*
Age	28.25 (11.48)	28.15 (11.72)	.11
	%	%	χ^2
Gender			
Male	72.9	72.8	.01
Ethnicity			
White	90.4	90.9	.07
African American	1.1	1.1	
Asian	2.7	2.7	
Hispanic/Latino	3.8	3.4	
Native American	.4	.4	
Other	1.5	1.5	
Education			
Some HS	6.5	6.2	1.02
HS	13.5	13.5	
Some college	53.1	55.8	
Associates	9.8	9.9	
Bachelors	12.0	9.5	
Some advanced ed	1.8	1.8	
Advanced degree	3.3	3.3	

Note: No statistics reached significance at $p < .05$. All p values $> .9$. NA = non-anxious marijuana users; CA = clinically anxious marijuana users; HS = High School; t = t-test statistic with 548 degrees of freedom; χ^2 = chi-square statistic with 5 degrees of freedom for ethnicity and 6 degrees of freedom for education.

Table 2
Psychological variables by marijuana group.

	NA (n = 275)	*CA (n = 275)*	*t*	*Cohen's d*
	M (SD)	*M (SD)*		
CESD-R	8.52 (8.09)	28.2 (15.20)	18.32*	1.62
MC	15.75 (2.16)	16.51 (2.12)	4.21*	.36
Positive items	10.02 (1.88)	10.85 (1.79)	5.36*	.45
Negative items	5.73 (1.65)	5.65 (1.84)	.49	.05
STICSA	30.21 (5.17)	49.37 (6.47)	38.02*	3.27
Cognitive	15.64 (3.87)	27.20 (4.27)	33.10*	2.84
Somatic	14.65 (2.58)	22.18 (4.72)	23.15*	1.98
SPQ-B	7.11 (3.88)	12.49 (3.97)	15.66*	1.37
CP	2.70 (1.92)	4.24 (1.88)	9.46*	.81
IP	2.35 (1.97)	4.77 (2.14)	13.72*	1.18
D	2.09 (1.57)	3.40 (1.70)	9.29*	.80
VH Neg	3.72 (2.78)	7.56 (3.10)	15.14*	1.30
VH Pos	3.52 (2.31)	5.79 (2.45)	11.06*	.95
ImpSS	8.59 (3.97)	10.30 (4.14)	4.83*	.42

t = t-test statistic with 548 degrees of freedom; Cohen's d = effect size estimate in units of (pooled) standard deviations (≤.3 is considered a small effect, ≤.5 is considered a medium effect, ≥.8 is considered a large effect); NA = non-anxious marijuana users; CA = clinically anxious marijuana users; CESD-R = Center for Epidemiologic Studies Depression Scale — Revised; MC = Marlowe Crowne Social Desirability Scale (Positive = Positively-worded items; Negative = negatively-worded items); STICSA = State Trait Inventory for Cognitive and Somatic Anxiety (Cognitive = Cognitive Subscale; Somatic = Somatic subscale); SPQ-B = Schizotypal Personality Questionnaire Brief Version (CP = Cognitive Perceptual subscale; IP = Interpersonal subscale; D = Disorganized subscale; VH Neg = Vollema–Hoijtink Negative Symptom subscale; VH Pos = Vollema–Hoijtink Positive Symptom subscale); ImpSS = Impulsive Sensation Seeking subscale of Zuckerman–Kuhlman Personality Questionnaire.

* $p < .001$.

Table 3
Marijuana variables by marijuana group.

	NA (n = 275)	*CA (n = 275)*	*t*	*Cohen's d*
	M (SD)	*M (SD)*		
CAPQ	27.79 (7.43)	34.77 (11.24)	8.19**	.73
Grams per week	8.73 (7.72)	11.17 (11.02)	3.00*	.26
MJ first use	15.89 (2.97)	15.71 (2.94)	.71	.06
MJ avg high[a]	3.65 (1.21)	3.71 (1.32)	.55	.05
Length use	12.36 (11.14)	12.44 (11.61)	.08	.01

t = t-test statistic with 548 degrees of freedom; Cohen's d = effect size estimate in units of (pooled) standard deviations (≤.3 is considered a small effect, ≤.5 is considered a medium effect, ≥.8 is considered a large effect); NA = non-anxious marijuana users; CA = clinically anxious marijuana users; MJ = Marijuana.

[a] MJ Avg High = Subjective report of how high, on average, participants felt they got when using marijuana, ranging from 1 (not at all high) to 6 (extremely high).

* $p < .01$.

** $p < .001$.

x-axis and each problem along the y-axis of Fig. 1. Logistic regression analyses indicated that the clinically anxious group was more likely than the non-anxious group to report serious problems with self-confidence, procrastination, feeling bad about marijuana use, lower energy levels, financial difficulties, sleep troubles, memory loss, decreased productivity at work/school, and neglecting ones' family due to marijuana use.

3.6. Drug Use by Group

Cigarette use was equivalent between groups, $\chi^2_{(1)} = .12$, $p = .73$; 59.1% of non-anxious marijuana users and 60.8% of anxious marijuana users reported current, regular cigarette smoking. Alcohol use was also equivalent. Non-anxious users reported drinking an average of 6.87 ($SD = 7.89$) days per month; clinically-anxious users an average of 6.01 ($SD = 6.66$) days per month, $t(547) = 1.38$, $p = .17$. The same held for standard drinks per occasion (non-anxious: $M = 4.50$, $SD = 3.77$; clinically anxious: $M = 4.65$, $SD = 3.86$), $t(546) = .46$, $p = .65$. Statistics for lifetime and last year drug use appear in Table 4. The clinically anxious group was significantly more likely than the non-anxious group to have used prescription sedatives for reasons other than those prescribed during their lifetime. There were no other differences in illicit drug use.

Table 4
Lifetime and last year drug use by marijuana group and logistic regression statistics.

	NA ($n = 275$)	CA ($n = 275$)	NA ($n = 275$)	CA ($n = 275$)
	Lifetime		*Last year*	
	Wald χ^2	*OR (95% CI)*	*Wald* χ^2	*OR (95% CI)*
Cigarettes	.32	1.11 (.77, 1.61)	–	–
Amphetamine	.29	1.11 (.76, 1.63)	.01	1.05 (.40, 2.74)
Methamphetamine	.49	1.16 (.77, 1.75)	1.79	2.57 (.65, 10.22)
Cocaine	.08	1.05 (.75, 1.47)	1.67	1.38 (.85, 2.26)
Crack-cocaine	.03	.96 (.60, 1.53)	.84	.54 (.15, 2.01)
Ecstasy	.21	1.08 (.77, 1.53)	.22	1.14 (.66, 1.95)
Mushrooms	.63	.86 (.59, 1.25)	.36	.89 (.59, 1.32)
LSD	.66	.87 (.62, 1.22)	2.41	.67 (.40, 1.11)
Opium	.19	.93 (.65, 1.31)	.90	1.39 (.70, 2.75)
Heroin	.03	1.06 (.56, 2.00)	.00	1.00 (.13, 7.85)
Rx stimulant	.80	1.17 (.83, 1.65)	2.09	1.47 (.87, 2.50)
Rx opiate	.23	1.09 (.78, 1.52)	1.35	1.32 (.83, 2.13)
Rx sedative	7.44*	1.63 (1.15, 2.31)	1.04	1.33 (.77, 2.28)

Wald χ^2 = Wald's chi-square statistic; OR = odd's ratio; 95% CI = 95% confidence interval; NA = non-anxious marijuana users; CA = clinically anxious marijuana users. LSD = lysergic acid diethylamide; Rx = Prescription drug used for purposes other than prescribed or obtained without prescription.

* $p < .01$.

4. Discussion

Data from a large, near-daily marijuana-using sample ($n = 2567$) showed that anxiety (among other psychological variables) was the only significant predictor of self-reported quantity of marijuana used, and the strongest predictor of marijuana-associated functional problems. The relationship between anxiety and amount of marijuana consumed should be interpreted cautiously, since only 1% of the variance in use was predicted by anxiety. However, approximately 8% of variance in self-reported marijuana-related problems (i.e., problems with functionality) was predicted by anxiety. These findings suggest that anxiety may be more predictive of regular marijuana use and related problems than are other conditions, such as psychosis and depression, more commonly studied in marijuana users. Directionality should be considered cautiously, as the relationship between marijuana and anxiety could be due to overlapping predispositions, heavy marijuana use resulting in clinical anxiety, anxiety symptoms leading to increased marijuana use, or a reciprocally exacerbating situation.

Despite the prominence of anxiety as a predictor of marijuana use and related problems, group analyses of 275 demographically-matched anxious and 275 non-anxious heavy marijuana users showed that anxious participants were also more depressed, impulsive, and schizotypal than non-anxious respondents. Cognitive anxiety (e.g., worry, intrusive thoughts) exhibited a substantially larger effect ($d = 2.84$) than did somatic anxiety (e.g., palpitations, sweating; $d = 1.98$). Schizotypy-related interpersonal deficits and a negative symptom profile (rather than cognitive-perceptual deficits and the positive symptom profile more commonly associated with psychosis; Vollema & Hoijtink, 2000)

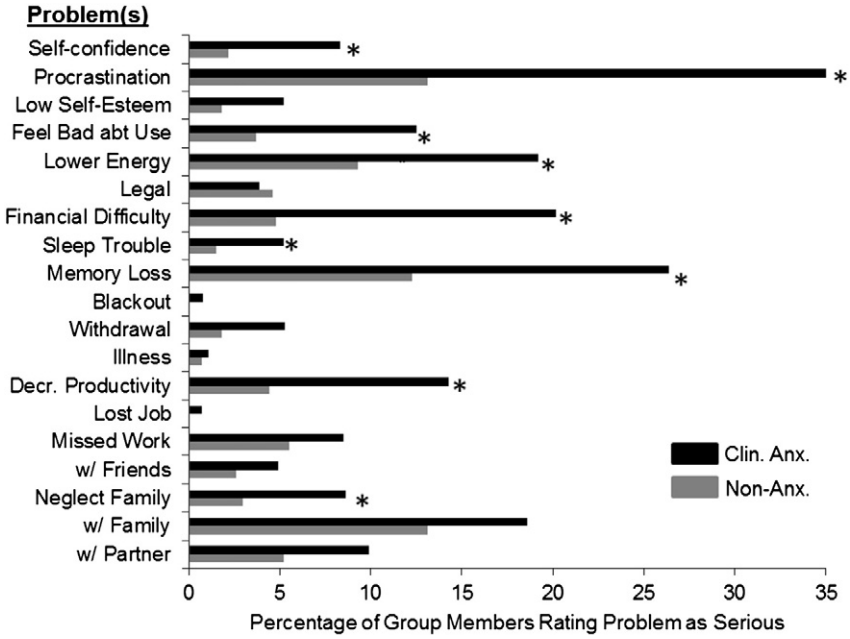

Fig. 1. Percentage of group members rating each cannabis-associated problem as serious. Each of 19 cannabis-associated problems is listed along the y-axis. Percentage of individuals in the clinically anxious marijuana group and non-anxious marijuana group are represented by black and gray bars, respectively. Percentages are based on the number of individuals selecting response options corresponding to identifying the problem as 'serious'. Asterisks indicate a significant difference based on logistic regression, corrected by sequential Bonferroni correction for multiple comparisons.

showed the largest effect sizes, although the anxious group was higher than the non-anxious group on all schizotypy dimensions assessed.

The clinically anxious group reported significantly greater quantities of marijuana smoked and more cannabis-associated problems than did the non-anxious group. The clinically anxious group experienced more severe problems with withdrawal ($d = .30$) as well as a pattern of concurrent marijuana-related problems that they rated as 'serious'. They were additionally more likely than the non-anxious group to rate 9 of the 19 cannabis-associated problems assessed as 'serious', whereas the opposite was not true of any item. Taken together, these findings indicate more severe marijuana-related problems across a range of functional domains, suggesting that the clinically anxious group were more likely to be experiencing marijuana abuse or dependence, which could be causally related to the anxiety. The only difference between the groups in use of drugs other than marijuana was an increased likelihood among the clinically anxious group for misuse of prescription sedatives. This difference was only apparent for lifetime, not last-year, use, perhaps suggesting that at some point the clinically anxious group used anxiolytics (or other prescription sedatives) in an attempt to manage symptoms, but that marijuana had become their preferred drug.

Limitations of this study include the use of cross-sectional data, excluding directional conclusions about the link between marijuana and anxiety, and lack of clinician-based assessment or diagnosis. A further limitation is that all participants were recruited from an organization supporting the legalization and market regulation of marijuana in adults (NORML). Involvement with NORML may have created bias to underreport symptoms in an effort to support the organization's cause. However, results from this sample closely approximate population prevalence estimates of anxiety (Van Dam et al., in press) and depression (Van Dam & Earleywine, 2011), suggesting that biased reporting of psychological symptomatology may not be a major contributor to results. An additional concern is that the clinically anxious group may simply represent a sample of individuals with a high symptom endorsement bias. Responses on the MC (Crowne & Marlowe, 1960) suggest that this is not the case. Very low scores on the MC often coincide with exaggeration of psychological symptoms (Andrews & Meyer, 2003). This possibility was attenuated by excluding individuals with scores below this cut-off. In addition, the anxious and non-anxious groups only differ on the positive items of the MC. Higher responding on positive items (e.g., "I have never intensely disliked anyone") is more consistent with *under*- rather than over-reporting distress (e.g. Andrews & Meyer, 2003), suggesting that observed differences are not primarily due to high symptom endorsement in the clinically anxious group.

Another limitation is the degree to which the sample recruited, as members or friends of members of a politically-active organization, is representative of the full scope of marijuana users. Members of such an organization are likely higher-functioning than some other cannabis users, for example those who do not have access to the internet or those with serious mental illnesses who might not be able to complete this type of survey. As such, we would expect the current results to be an under-estimate of psychopathology in marijuana users, more generally. Our sample does capture an interesting group of individuals that are not necessarily well-represented in research on marijuana use. Much research focuses on those who are able participate in time-intensive laboratory studies and/or those who are treatment-seeking, potentially over-representing a particular subgroup(s) of regular users. While work with treatment-seeking individuals and intensive laboratory-based approaches are extremely valuable, they likely do not represent marijuana users who view their use as not problematic enough to seek treatment and/or who do not have time/interest to participate in intensive laboratory-based studies. Thus, our sample potentially provides some insight into marijuana users who might not be captured using other recruitment approaches. Nevertheless, we cannot fully discount the possibility that our sample was unrepresentative in other ways that may have affected the outcomes.

Another consideration is the extent to which demographics of the sample assessed here are representative of the general population. Our sample was predominantly Caucasian and male, with at least some college education. As a result, our findings may not necessarily generalize to a wider population, particularly of greater ethnic diversity. However, it is important to note that our sample does not differ dramatically from epidemiological examination of those with cannabis use disorders (Stinson et al., 2006). So although our results may not be generalizable to ethnically diverse populations, they appear to be somewhat representative of those for whom marijuana use is potentially problematic.

These limitations notwithstanding, our findings provide important insight into the understudied relation between marijuana and anxiety. A subset of regular marijuana users show clinical levels of anxiety, other psychopathological symptoms, difficulties with withdrawal, and a host of serious marijuana-associated problems, yet use more marijuana than their non-anxious counterparts. Clinical trials reveal that anxiety symptoms have important implications for marijuana treatment (Bonn-Miller & Moos, 2009; Buckner & Carroll, 2010). Present results and previous findings may suggest that treatment-seeking marijuana users who also have anxiety should receive treatment for their primary psychopathology before, or concurrent with, marijuana-use treatment.

Together, these findings provide tentative support for the hypothesis that the clinically anxious group may represent a subgroup of high-risk marijuana smokers with a predisposition towards development of marijuana-use disorders, anxiety, and psychological distress. While the cross-sectional nature of our study cannot inform whether marijuana use preceded anxiety symptoms, previous findings suggest that onset of an emotional disorder commonly precedes onset of marijuana abuse and/or dependence (Agosti, Nunes, & Levin, 2002). Further, declines in anxiety often lead to declines in use, but not vice versa (Buckner & Carroll, 2010). Nevertheless, anxiety might have worsened with heavy marijuana use and associated problems. The nature of any predisposing vulnerabilities in this apparently high-risk group remains an empirical question. Such vulnerabilities might relate to variability in endocannabinoid system function, which is critically involved in both the positive reinforcing effects of marijuana (see Cooper & Haney, 2008) and regulation of stress-related processes (Gorzalka et al., 2008; Lazary et al., 2011; Ruehle et al., 2011). This possibility should be addressed in future work.

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Contributors

Authors N.T.V. and M.E. designed the study. Authors N.T.V. and M.E. collected the data. Authors N.T.V. and G.B. conducted the statistical analyses. Author N.T.V. wrote the first draft of the manuscript and all authors contributed to and approved the final version.

Conflict of interest

Author M.E. declares affiliation and involvement with several cannabis law reform groups. All other authors declare no conflicts of interest.

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