The Social Context of Cannabis Use: Relationship to Cannabis Use Disorders and Depressive Symptoms among College Students

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Abstract

Few studies have investigated the association between the social context of cannabis use and cannabis use disorder (CUD). This longitudinal study of college students aimed to: develop a social context measure of cannabis use; examine the degree to which social context is associated with the transition from non-problematic cannabis use to CUD; and, examine the association between social context of cannabis use and depressive symptoms. The analytic sample consisted of 322 past-year cannabis users at baseline. Four distinct and internally consistent social context scales were found (i.e., social facilitation, emotional pain, sex-seeking, and peer acceptance). Persistent CUD (meeting DSM-IV criteria for CUD at baseline and twelve months later) was associated with using cannabis in social facilitation or emotional pain contexts, controlling for frequency of cannabis use and alcohol use quantity. Students with higher levels of depressive symptoms were more likely to use cannabis in an emotional pain or sex-seeking context. These findings highlight the importance of examining the social contextual factors relating to substance use among college students.

Keywords

cannabis; marijuana; drug abuse liability; drug addiction; college students; mental health

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1. Introduction

Cannabis use among college students is widespread, with past-year use estimated at approximately 30% (Johnston, O'Malley, Bachman, & Schulenberg, 2007; Mohler-Kuo, Lee, & Wechsler, 2003). Overall, young adults have a higher prevalence of cannabis use than other age groups [Substance Abuse and Mental Health Services Administration (SAMHSA), 2006], with college students comparable to their non-college attending peers (Johnston, O'Malley, Bachman, & Schulenberg, 2006).

Cannabis use disorders (CUD) are defined as meeting DSM-IV diagnostic criteria for either abuse or dependence, which includes experiencing problems such as loss of major role functions and repeated legal problems [American Psychiatric Association (APA), 1994]. Recent epidemiologic evidence suggests that approximately one in three past-year cannabis users in the general population meet criteria for CUD (Compton, Grant, Colliver, Glantz, & Stinson, 2004). The prevalence of CUD among one sample of first-year college students was estimated to be 9%, with almost 25% of past-year users meeting criteria for CUD (Caldeira, Arria, O'Grady, Vincent, & Wish, 2008).

While there are a number of studies documenting cannabis-related problems among college students (e.g., Caldeira et al., 2008; Everett, Lowry, Cohen, & Dellinger, 1999; Hammersley & Leon, 2006; Shillington & Clapp, 2001; Tullis, Dupont, Frost-Pineda, & Gold, 2003; White, Labouvie, & Papadaratsakis, 2005), few studies have focused on the social and psychological factors that might contribute to cannabis use or cannabis-related problems. Social context refers to the immediate situational, temporal, and motivational factors that influence substance use behavior (Beck, Thombs, Mahoney, & Fingar, 1995; Thombs, Beck, & Mahoney, 1993; Thombs, Wolcott, & Farkash, 1997). Recently, the social context of drinking in a first-year college population was described and related to a variety of alcohol-specific problems. In that study, the Social Context of Drinking Scales–College Version (Beck et al., 1995) was used to derive six distinct social contexts of drinking: 1) social facilitation (e.g., drinking for purposes of conviviality and social enhancement); 2) peer acceptance (e.g., drinking as part of a group or to gain peer approval); 3) emotional pain (e.g., drinking to alleviate a negative emotional state); 4) drinking in the context of family celebrations or rituals; 5) sex-seeking (e.g., drinking to initiate sexual contact with someone); and, 6) drinking in the context of motor vehicles (e.g., while sitting in a parked car or driving around). Drinking in the context of motor vehicles was associated with DSM-IV criteria for alcohol use disorders, and drinking in the context of emotional pain was associated with the presence of depression (Beck et al., 2008).

The first purpose of the present study was to develop a Social Context of Cannabis Use Scale for college students, based on the prior work with the Social Context of Drinking Scales. Secondly, we aimed to understand the relationship between social context and CUD, including whether or not social context measures were predictive of transitioning from non-problematic to problematic use one year later. Lastly, we explored the association between social context and depressive symptoms. Knowing where, why, and when college students use cannabis might help identify important targets for intervention and CUD prevention.

2. Methods

2.1 Study Design

The data for this study were derived from the College Life Study (CLS), a longitudinal study of a cohort of 1253 undergraduate college students, with a focus on understanding the natural history and course of substance use and other health behaviors during the transition to adulthood. Sampling occurred in two stages. First, a screening instrument was administered to 3401 incoming freshman students, ages 17 to 19, who attended new student orientation sessions

in the summer of 2004 at one large, public university in the mid-Atlantic region. Next, a sample of the screening participants was invited to participate in the longitudinal study, with oversampling of participants who had used illicit drugs in high school. A personal interview and self-report questionnaires were administered at some point during the first year of college ("baseline") that lasted approximately two hours and covered a wide range of topics, including demographics, family and peer variables, drug use, and mental health. Six months later, students were sent a self-report questionnaire (including the Social Context of Cannabis Use Scale, see below), either electronically as a web-based survey, or if they preferred, by regular mail. At 12 months post-baseline, which corresponded to sometime during the sophomore year for the vast majority who were still enrolled in school, another personal interview was administered, covering similar topics as the baseline assessment. Respondents received $5 for participating in the screening survey, $50 for completing personal interviews, and $20 for completing the 6-month follow-up assessment. The response rates were 72% at 6 months (n=897) and 91% at 12 months (n=1142). Informed consent was obtained under IRB-approved protocols for participation in all phases of the longitudinal study and a federal Certificate of Confidentiality was obtained. Additional information on sampling, recruitment, and assessment methods have been described in detail elsewhere (Arria et al., 2008).

2.2 Analytic Sample

To be included in the general analytic sample, participants had to meet the following two inclusion criteria: 1) they had to have completed both the 6- and 12-month follow-up assessments; 2) they had to be cannabis users. Specifically, from the larger sample of 1253 students, 322 students (169 males and 153 females) completed both assessments, had used cannabis more than five times in the last year, and at the 6-month assessment, had used cannabis at least once a month during the past six months. The remaining participants were excluded because either they did not complete both assessments (n=357), they had not used cannabis at baseline (n=61), their cannabis use was deemed too infrequent to demonstrate a reliable social context (n=481), or they had partially missing data on cannabis use at one or both assessments (n=32). The majority of the sample self-identified as being White (78.1%).

2.3 Measures

2.3.1 Social Context of Cannabis Use—The 6-month assessment contained 24 new items to capture the variety of situations and reasons for using cannabis. These items were guided by the Social Context of Drinking Scales—College Version (Beck et al., 1995). Each item was followed by the response options of "never" (scored as 0), "seldom" (scored as 1), "occasionally" (scored as 2) and "frequently" (scored as 3). The wording of the items can be found in Table 1.

2.3.2 Cannabis Use and CUD—Cannabis use and CUD were assessed in-person at baseline and during the 12-month follow-up interview. Past-month and past-year frequency of use were assessed with separate questions by asking "During the [(past 30 days) or (past 12 months)], on how many days did you use cannabis?". The assessment of CUD was taken from the National Survey on Drug Use and Health (SAMHSA, 2003), which consists of a series of questions that ask about problems experienced during the past 12 months as a result of cannabis use. These problems correspond to the ten DSM-IV criteria for cannabis abuse and dependence. Based on the combination of criteria endorsed, four mutually exclusive categories were defined: dependence, abuse, diagnostic orphans, and non-problematic use. Consistent with the DSM-IV guidelines (APA, 1994), dependence cases were defined by the endorsement of three or more of the following six criteria as a result of their cannabis use: tolerance, using more than intended, being unable to cut down, spending a lot of time obtaining or using, giving up important activities, or continuing to use despite problems with physical or mental health. Abuse cases were defined as non-dependent individuals who endorsed one or more of the

following four problems resulting from their cannabis use: having serious problems at home, work, or school; regularly putting oneself in physical danger; repeatedly getting into trouble with the law; or continuing use despite problems with family or friends. Diagnostic orphans were defined as individuals who endorsed one or two dependence criteria and no abuse criteria, and therefore escaped both diagnoses. Non-problematic cases were defined as the group of individuals who endorsed none of the ten DSM-IV criteria for CUD. A similar classification has been previously used (Caldeira et al., 2008; Degenhardt, Lynskey, Coffey, & Patton, 2002).

2.3.3. Alcohol Use—The question, "During the past 12 months, on days when you drank alcohol, how many drinks did you typically have in a single day?" measured alcohol use involvement at baseline and at 12 months.

2.3.4. Depression—The Center for Epidemiologic Studies Depression scale (CES-D) was self-administered at the 6-month assessment. The CES-D assesses the presence of depressive symptoms (Radloff, 1977). The median score was nine (M=10.81, SD=7.72). A cutoff score of 23 was used to define students at high risk for depression (Audrain-McGovern, Lerman, Wileyto, Rodriguez, & Shields, 2004). Non-depressed students were defined by a CES-D score of nine or less. The Beck Depression Inventory (BDI) (Beck, Rush, Shaw, & Emery, 1979) was also administered as an alternative measure of depressive symptoms. Students scoring 0-4 on the BDI were defined as being at low-risk for depression, and a score of 12 or above was defined as high-risk.

2.4 Analytic Strategy, by Aim

2.4.1 Aim 1: Development of the Social Context of Cannabis Use Scale—This analysis used data from the subset of 249 cannabis users who had non-missing data on all the social context questions. The aim of the analysis was to identify subscales and examine their psychometric properties. The social context of cannabis use items were subjected to a principle components analysis, followed by a varimax rotation. After inspecting the resultant eigenvalues and scree plot, four factors were identified. Individual items were assigned to each factor if they loaded >.5 on that factor and <.4 on any non-selected factor.

2.4.2 Aim 2: Social Context and CUD—From the original 322 cannabis users, 293 had non-missing data on at least one social context scale, and on the assessment of CUD (at both baseline and 12 months). Given the modest number of cases in the separate dependence and abuse categories, they were combined into one category labeled CUD. To focus the analyses on cannabis users who did and did not transition between non-problematic use and CUD between baseline and 12 months, analyses were restricted to the subset of individuals (n=182) in the following three groups. First, consistent non-problematic users (n=75) were defined as meeting the definition of a non-problematic user at both the baseline and 12-month assessments. Second, consistent problem users (n=72) met CUD criteria at both assessments. Third, converters (n=35) were defined as individuals who were non-problematic users at baseline, but met the definition of CUD at 12 months. Excluded from these analyses were an additional 17 individuals who met CUD criteria at baseline but not at 12 months, and 94 individuals who were classified as diagnostic orphans at either assessment.

An initial series of analyses of covariance (ANCOVA) were conducted, using each social context subscale score as a dependent variable. Three separate ANCOVAs were conducted for pairwise comparisons of the groups. Consistent non-problematic users were compared first to consistent problem users, and then secondly to converters. In these analyses, gender, frequency of cannabis use, and alcohol use (quantity consumed per drinking day) at baseline and 12

months were held constant. The first-order interaction of gender*CUD transition category was also tested to determine if gender differences in conversion to CUD over time existed.

2.4.3 Aim 3: Social Context and Depressive Symptoms—This analysis compared the social context subscale scores of the 22 students at high-risk for depression (defined as a score on the CES-D of 23 or higher at baseline) with 159 non-depressed students (defined as a score of 9 or lower) with respect to social context subscale scores. The remaining individuals had either missing data (*n*=25) or had scores on the CES-D that would place them in the middle of the continuum between high- and low-risk for depression (*n*=116). Gender, baseline frequency of cannabis use, and alcohol use were held constant, and the first-order interaction of gender*depression group was also tested.

3. Results

3.1 Aim 1: Development of the Social Context of Cannabis Use Scale

Items that were assigned to each factor were then subjected to a frequency analysis (Table 1) and summed to produce separate composite subscales. As can be seen, using cannabis in a context of social facilitation was most common.

These subscales, labeled social facilitation, peer acceptance, emotional pain, and sex-seeking, were internally consistent, comparable across gender, and modestly intercorrelated (Table 2).

3.2 Aim 2: Social Context and CUD

Table 3 presents the unadjusted means and standard deviations on the social context subscales for males and females by CUD category. The ANCOVA results revealed a main effect for social facilitation, $F(1, 138)=13.99$, $p<.001$, and emotional pain, $F(1, 137)=4.87$, $p<.05$, even holding constant the effects of gender, cannabis use frequency, and alcohol use at baseline and 12 months. Consistent problem users were more likely to report using cannabis in contexts of social facilitation and emotional pain than consistent non-problematic users.

There was also a significant difference between converters and non-converters (i.e., consistent non-problematic users), $F(1, 100)=6.06$, $p<.02$, with converters more likely to use cannabis in a context of social facilitation than consistent non-problematic users. There were no other main effects for gender or gender*CUD category interactions in any of these analyses.

3.3 Aim 3: Social Context and Depressive Symptoms

The ANCOVA results revealed main effects for emotional pain, $F(1, 180)=6.23$, $p<.02$ and sex seeking, $F(1, 182)=4.26$, $p<.05$, holding constant gender, baseline cannabis use frequency, and alcohol use. Students at high risk for depression were more likely to use cannabis in a context of emotional pain (M_{adj}=5.47, SD=2.93 *vs*. M_{adj}=4.40, SD=2.04) and sex seeking (M_{adj}=4.17, SD=1.61 *vs*. M_{adj}=3.55, SD=1.27) than non-depressed students. There was also a main effect for peer acceptance, $F(1, 131)=5.89$, $p<.02$, but more importantly there was a gender*depression group interaction, $F(1, 131)=4.87$, $p<.05$. A simple main effects analysis revealed that depressed males (M_{adj}=9.35 SD=5.79) were more likely to use cannabis in a context of peer acceptance than non-depressed males (M_{adj}=6.24, SD=2.72). There was no difference between depressed (M_{adj}=6.25, SD=1.73) or non-depressed females (M_{adj}=6.11, SD=1.80).

A *post-hoc* linear regression analysis revealed that using cannabis in an emotional pain context was a significant predictor of depression scores (treated continuously) both at 6 and 12 months (Table 4), independent of gender, cannabis use frequency, or alcohol use. A separate analysis revealed that using cannabis in a sex-seeking context predicted depression only at 6 months

(β=.192, $p<.01$), however when both of the emotional pain and sex seeking contexts were simultaneously considered, only emotional pain remained significant (β=.183, $p<.02$).

Finally, although our original aim was to investigate the association between social context of cannabis use and CUD or depressive symptoms as two distinct dependent variables, a *post-hoc* analysis was conducted to understand the association between these two outcomes. In the original analytic sample of 322 cannabis users, no significant differences were found on CES-D scores between students who met criteria for CUD and non-problematic users at either baseline or 12 months. Moreover, the prevalence of CUD was similar for individuals with and without high levels of depressive symptoms. All of these results were replicated using the BDI as a measure of depressive symptoms.

4. Discussion

This study showed that there are a variety of social contexts in which college students use cannabis. Similar to alcohol, the main reasons for using cannabis relate to social facilitation, meaning to enhance feelings of well being, conviviality and social interaction (Beck et al., 2008). The three other distinct contexts identified here were peer acceptance (to fit in or be accepted by significant others); emotional pain (to forget about personal or academic problems and depression); and sex-seeking (where use occurs with a need for interpersonal intimacy). The reliability and construct validity of these four new subscales were established. Further, this investigation demonstrated that these separate contexts of cannabis use exist in a college population; they do not seem to differ across gender, and at least two of these contexts are related to DSM-IV criteria for CUD (i.e., abuse and/or dependence). Further analyses will be devoted to examining the relationship of these scales to sub-clinical indices of cannabis problem behaviors (e.g., high risk sexual behavior, interpersonal problems, injuries) not included in the DSM-IV criteria.

As we acknowledged earlier (Beck et al., 2008), this investigation was confined to students from a single university, and thus the findings may not be generalizable to students at other smaller, private or rural institutions. Also, the relatively small number of students that were used in the various analyses could have hampered our ability to detect significant differences. This was especially so for the number of students who were screened at-risk for depression. While considerable care was taken to define the comparison groups conservatively in order to avoid including false positives (i.e., we dropped the diagnostic orphans and excluded students with depression scores greater than 9 and less than 23), this gain in precision entailed a substantial loss in statistical power. Therefore, these findings should be taken as preliminary until more robust estimates can be produced with larger samples.

Social facilitation bore the most consistent relation with CUD. Consistent problem users were significantly more likely to use cannabis in the contexts of social facilitation and emotional pain than consistent non-problematic users. It is important to note that this significant relationship was found after adjusting for cannabis use frequency and alcohol use. This demonstrates that social context is not just an artifact of consumption. Students with CUD may use cannabis, as well as alcohol, more often, but they also appear to be using it for different social and psychological reasons. Further substantiation of the notion that using cannabis in a context of social facilitation is associated with CUD was demonstrated in analyses examining the conversion from non-problematic use to CUD. Many students who attend college are living away from home for the first time in their lives, and they are free from direct parental supervision and control. They are also faced with the challenges of making new friends and acquaintances, establishing new living arrangements, and negotiating their way around a college campus (Beck et al., 2008). It is understandable that cannabis is used in the context of social facilitation, to make friends more easily and to form relationships with others. However,

the study results point out that this context may not be as innocuous as many assume, in that the risk of problematic use is higher for those who frequently use cannabis in the context of social facilitation. Our previous investigation of the social contexts of drinking found that while social facilitation was not significantly related to alcohol abuse or dependence, it was related to drinking and driving.

However, drinking in a context of a motor vehicle (while sitting in or driving around in a car) was related to both alcohol abuse and dependence (Beck et al., 2008). The cannabis versions of these items did not load on a separate scale in the current investigation. Instead they were included in the social facilitation scale. This may account, in part, for why this scale discriminated problematic from non-problematic cannabis users, in that more serious and riskier forms of behavior (i.e., using cannabis while in a car or driving) are associated with aspects of social facilitation (i.e., using with friends, to have a good time, etc.).

We controlled for alcohol use in the analyses because alcohol and cannabis use are likely to co-occur (Barrett, Darredeau, & Pihl, 2006). Future studies should examine the specific transition patterns from alcohol use and abuse to CUD, as well as determine the contextual nature of this transition.

Although there was some evidence that depressed students were more likely to use cannabis in a context of sex-seeking and peer acceptance, using cannabis in a context of emotional pain was most consistently related to both CUD and depression. This is consistent with our previous examination of alcohol-specific contexts, and demonstrates that, just as depressed drinkers may be more prone to relief drinking (Beck et al., 2008), so too may depressed cannabis users be prone to relying on cannabis to relieve depressive symptoms. This is also consistent with other lines of evidence showing an association between CUD and depression, however recent evidence does not support a causal relationship (Fleming, Mason, Mazza, Abbott, & Catalano, 2008; Harder, Stuart, & Anthony, 2008; Moore et al., 2007). Although we did not find differences on the CES-D between cannabis users who did and did not meet criteria for a CUD, we cannot rule out the possibility that some depressive symptoms may be attributable to the pharmacological effects of cannabis use. Further study is underway with this cohort to understand the association between different levels of cannabis use and the onset of depressive symptoms.

Early identification and treatment of depressed students who are also using cannabis is a critical challenge for college mental health professionals. One implication of these findings is that these scales may be useful as a screening tool for identifying students who may be at risk for CUD as well as those likely to become at risk for developing a problem in the future.

Acknowledgements

Abbreviations

APA, American Psychiatric Association; BDI, Beck Depression Inventory; CES-D, Center for Epidemiologic Studies Depression Scale; CLS, College Life Study; CUD, Cannabis Use Disorder (DSM-IV); SAMHSA, Substance Abuse and Mental Health Services Administration.

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Table 1

Social Context of Cannabis Use Scale items, among 322 cannabis-using first-year college students[a]

How often do you use cannabis:	Never %	Seldom %	Occasionally %	Frequently %
Social Facilitation (*n*=310)				
with a small group of friends?	2.2	23.8	38.7	35.3
to have a good time?	4.5	25.3	37.9	32.3
on a college campus (e.g., at parties, in dormitories, at fraternities or sororities)?	12.9	31.2	30.9	25.0
on weekend nights?	2.8	37.6	35.7	23.9
when you have no class or obligations the next morning?	15.7	36.1	27.5	20.7
at a party with friends?	6.7	42.5	31.8	19.0
while driving around?	33.8	25.4	23.2	17.6
on week nights?	20.2	39.5	24.1	16.2
when a friend from home visits for the weekend?	25.3	36.2	22.8	15.7
in a parked car?	22.9	35.2	29.6	12.3
with a large group of friends?	19.0	47.1	23.5	10.4
before "going out" (i.e., to a party or bar)?	49.6	29.4	11.2	9.8
while driving or riding in a car to another night spot?	48.6	28.4	14.0	9.0
Peer Acceptance (*n*=249)				
because it's cool?	80.7	13.4	2.0	3.9
to be part of a group (e.g., to be accepted, fit in and not feel left out)?	73.9	18.2	5.3	2.5
to get someone's approval (e.g., a close friend, a boyfriend or girlfriend)?	84.8	11.2	2.8	1.1
to maintain your image?	85.4	8.7	4.8	1.1
to act older and/or feel more grown up?	90.4	7.1	1.8	0.7
Emotional Pain (*n*=315)				
to get rid of depression?	64.4	20.3	11.3	4.0
to forget about personal problems?	58.1	26.4	11.5	3.9
to forget about academic problems?	64.5	23.7	8.7	3.1
Sex-Seeking (*n*=320)				
to reduce inhibitions?	70.9	19.9	7.6	1.7
to make it easier to go to bed with someone?	90.2	6.7	2.2	0.8
to build up courage to talk to someone of the opposite sex?	85.7	11.2	2.5	0.6

[a]Sample sizes vary due to missing data on individual scale items.

Table 2

Intercorrelations, Cronbach's Alpha (α), means (*M*) and standard deviations (*SD*) for Social Context of Cannabis Use Scales, among 249 cannabis-using first-year college students

	Social Facilitation (13 items)	Peer Acceptance (5 items)	Emotional Pain (3 items)	Sex Seeking (3 items)
Peer Acceptance	.313[a]			
Emotional Pain	.623[a]	.415[a]		
Sex Seeking	.416[a]	.548[a]	.546[a]	
Total α	.945	.843	.893	.762
Males α	.955	.852	.886	.788
Females α	.933	.830	.901	.715
M (*SD*)	32.36 (9.51)	6.25 (2.40)	4.66 (2.25)	3.71 (1.38)

[a] Correlations significant *p*<.01

Table 3

Comparison of male and female problem and non-problematic cannabis users on social context subscale scores[a]

	Consistent Non-Problematic Users M(SD)		Consistent Problem Users M(SD)		Non-Problematic to Problem Converters M(SD)	
	Females (n=43)	Males (n=32)	Females (n=37)	Males (n=35)	Females (n=16)	Males (n=19)
Social Facilitation	25.95 (7.13)	24.47 (5.57)	40.78 (8.44)	41.91 (8.67)	31.53 (5.48)	32.89 (8.18)
Peer Acceptance	6.00 (1.96)	5.70 (1.32)	6.95 (3.12)	6.89 (3.45)	6.14 (2.71)	6.53 (1.68)
Emotional Pain	3.63 (1.42)	3.56 (1.11)	6.49 (2.68)	5.85 (2.57)	4.87 (2.33)	4.44 (1.86)
Sex Seeking	3.37 (0.93)	3.57 (0.97)	4.11 (1.63)	4.00 (1.75)	3.56 (0.89)	3.68 (1.20)

[a]Sample sizes vary slightly due to missing data on individual scale items; cases were excluded if they were missing an item from a scale. "Problem" and "non-problematic" users were defined by the presence or absence of cannabis use disorder (CUD) at baseline and 12 months. Not depicted in this table were an additional 17 individuals who converted from CUD at baseline to non-problematic at 12 months, and 94 who experienced some cannabis-related problems but did not meet criteria for CUD.

Table 4

Standardized and unstandardized regression coefficients of hypothesized predictors of depressive symptoms as measured by the CES-D

Predictor Variable	Depressive Symptoms Measured at:			
	6 Months (*n*=300)		12 Months (*n*=282)	
	B	β	B	β
Gender	−.896	−.057	−1.041	−.071
Frequency of cannabis use at 6 months[c]	−.117	−.129	−.063	−.076
Alcohol use quantity at baseline[d]	−.529[b]	−.174	−.246	−.087
Frequency of cannabis use at 12 months[c]		n/a	.048	.057
Alcohol use quantity at 12 months[d]			.013	.005
Emotional pain subscale at 6 months	.919[b]	.264	.639[b]	.189
R^2		.089[b]		.050[a]

B=unstandardized regression coefficient

β=standardized regression coefficient

[a]
$p<.05$

[b]
$p<.01$

[c]
Frequency of cannabis use was defined as the number of days cannabis was used in a typical month during the past six months or the past year.

[d]
Alcohol use quantity was defined as the average number of drinks per drinking day in that last 12 months. All effects shown were held constant simultaneously.