Impulsivity, Sensation Seeking, and Decision-Making in Long-Term Abstinent Cannabis Dependent Patients

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ABSTRACT

Introduction: In contrast to several studies that examined different domains of neurocognitive functions in long-term abstinent cannabis users, there are few studies examined impulsivity in cannabis users with prolonged abstinence. The aim of this study was to test whether impulsivity and sensation seeking traits and impulsive decision-making are transient or enduring in patients with cannabis dependence who were abstinent for at least 1 month.

Methods: The study included 30 patients with cannabis dependence (CDP) who had been abstinent for at least 1 month and 30 healthy controls. All the participants were male and the two groups were matched for age and duration of education.

Results: As a result of Iowa Gambling Task (IGT) evaluation, there was no significant group (CDP vs. control) by block interaction in

IGT performance ($p=0.680$). CDP showed significantly higher Barratt Impulsiveness Scale-11 (BIS-11) total ($p=0.006$), BIS-11 non-planning ($p=0.006$) and Zuckerman Sensation Seeking Scale experience seeking subscale ($p=0.001$) scores compared with controls.

Conclusions: This is the first study to investigate decision-making, self-report impulsivity and sensation seeking in long-term abstinent CDP. Our findings suggest that both self-report impulsivity and experience seeking may reflect a stable trait in CDP but not deficits on decision-making. This suggestion is consistent with the hypothesis that elevated impulsivity and sensation seeking traits may lead to addiction when they occur together rather than alone.

Keywords: Cannabis, decision-making, sensation seeking, impulsivity, abstinence

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INTRODUCTION

Impulsivity and sensation seeking are core components of addiction, prominent across all phases of the illness (1-3). Longitudinal studies have identified impulsivity in children as a high-risk factor for early substance use and later substance abuse (4). Furthermore, impulsivity is an important predictor of treatment outcome and relapse into drug use (5, 6). In addition, drug use itself may increase maladaptive behaviors, either through their direct, acute effects, or because of long-term sequelae of drug use (7). Like impulsivity, sensation seeking is also associated with initiation and maintenance of drug addiction (8, 9). Impulsivity and sensation seeking are different but partially overlapping concepts (10). Sensation seeking has been found to be predict vulnerability to initiation of drug use, whereas impulsivity has been found to predict vulnerability to transition from controlled to compulsive drug use and dependence in both animal and human studies (11, 12).

Impulsivity has been assessed with various measures including self-report scales (e.g. the Barratt Impulsiveness Scale), a measure of trait-like impulsivity, that reliant on an individual's insight into their own behavior and behavioral measures like decision-making tests, which are considered to be a more objective (13). However, self-report and behavioral measures are generally not correlated with each other which suggests these measures are different dimensions of impulsivity (14).

Decision-making involves the outcome of cognitive processes leading to a choice between alternative courses of action. Poor decision-making has been described as "deciding against one's best interests and inability to learn from previous mistakes, with repeated decisions leading to negative consequences" (15). A commonly used measure of decision-making is the Iowa Gambling Task (IGT) (16). The IGT simulates real-life decision-making with uncertainty concerning premises and outcome as well as reward and punishment. The IGT was specifically developed to measure decision-making in patients with lesions of the ventromedial prefrontal cortex. Such patients often take part in risky behaviors that are immediately gratifying while ignoring negative future outcomes. Similarly, drug and alcohol abusers persist in behaviors that have short-term benefits despite long-term major negative consequences. In line with this, studies have shown that alcohol (17), MDMA (18), heroin and cocaine (19) users exhibit impaired decision-making on the IGT.

Cannabis is clearly the most popular illicit drug in North America, Europe and in other parts of the world (20). Cannabis use have an acute negative impact on neurocognitive functions like executive functions or impulsivity (21, 22). Cannabis contains a number of chemical compounds collectively known as cannabinoids. The documented psychoactive properties and neurocognitive effects of cannabis are thought to be mainly due to one

of these cannabinoids, delta-9 tetrahydrocannabinol (THC), via the central cannabinoid receptors (23). Several previous studies found higher impulsivity rates in cannabis users both using self-report measures like Barratt Impulsiveness Scale-11 (BIS-11) (24–26) or behavioral measures like decision-making tests (27, 28). However, these studies were performed in frequent cannabis users who were active users or recently abstinent users. Therefore, it is difficult to determine whether such deficits, observed after recent abstinence, are temporary or long-lasting after a longer duration of abstinence. Findings of these studies might be due to sedative effects of cannabis, residual effects of cannabinoids in the brain or acute withdrawal effects from cannabis. Meta-analyses of 13 studies among cannabis users with at least 25 days of abstinence found no significant differences between cannabis users and healthy controls on neurocognitive performance (29). Interestingly, in contrast to several studies that examined different domains of neurocognitive functions in long-term abstinent cannabis users, there are few studies examined impulsivity in cannabis users with prolonged abstinence (30, 31). Continued poorer decision-making performance on the IGT was found in adult cannabis users with a 25 days' abstinence than controls (32). Similarly, another study found poorer decision-making performance on the Balloon Analogue Risk Task in adolescent cannabis users with a mean 53 days' abstinence compared to controls (33). However, 25 or 53 days of abstinence may not be sufficient to observe any improvement in decision-making deficits. For example, a study that evaluated the delay discounting performance, a similar construct to decision-making, did not found any difference between cannabis users with at least a year abstinence and healthy controls (34).

The aim of this study was to assess the long-term effects of cannabis on impulsivity and sensation seeking traits and decision-making.

METHODS

Participants

The study included 30 patients with cannabis dependence (CDP) according to DSM-IV criteria and who had been abstinent for at least 1 month, and 30 healthy controls. All the participants were male, and the two groups were matched for age and duration of education. CDP were applied by probation. They were typically enrolled in the study after 1 month in treatment. Abstinence from cannabis and other drugs monitored by clinical observation and urine drug screening for amphetamines, benzodiazepines, cannabis, cocaine, and opiates at the 15th and 30th days (time of testing) of the treatment. Control subjects were recruited by means of local advertisements and snowball communication among adult people from the community.

Exclusion criteria for cannabis dependent group were: 1) more than 15 lifetime uses of any category of illicit drugs or positive urine screen for any illicit drug or more than 12 alcoholic drinks/week, 2) history of DSM-IV Axis I psychiatric disorders or use of psychoactive medications, 3) history of loss of consciousness more than 10 min, 4) any severe hepatic, endocrine, renal disease, 5) current or past history of any significant neurological disorders, and 6) visual impairment, colorblindness, or hearing impairments.

Control subjects met the same criteria as patients, except for the history of cannabis dependence. All subjects were interviewed using the Structured Clinical Interview for DSM-IV Axis I Disorders (35) to exclude participants with past or current comorbid Axis I diagnosis and to confirm the diagnosis of cannabis dependence in the CDP group. Cannabis dependent group was interviewed in order to determine the age of the onset of cannabis use, duration of cannabis use, the frequency of weekly cannabis use, number of joints smoked per week prior to the period of abstinence, and the time since the last cannabis use.

All of the participants were medication-free. We did not specifically test the subjects for alcohol use, Hep-C, and other medical conditions. Our data were based on subjects' self-report, clinical examination, and available medical records. All subjects gave written informed consent to participate in the study. The study was approved by local ethics committees.

Measures

Zuckerman Sensation Seeking Scale (form V) (SSS-V) (36): It is a scale which evaluates the sensation seeking with 40 items. There are four different subscales composing from the 10 items; thrill/adventure seeking, experience seeking, disinhibition and boredom susceptibility. 1 point were rewarded for each positive respond to SSS-V items. The top score is 40. There are total five different scores consisting of four scores for subscales and as well as a total score. A higher score indicates more sensation seeking.

Barratt Impulsiveness Scale-11 (BIS-11) (37): It is a scale consisting of 30 items and 3 subscales to evaluate the impulsivity. Subscales are constitutes of attention, motor and non-planning. It is a Likert type scale. Each question is scored with minimum 1 and maximum 4 points. Maximum score is 120 and minimum score is 40. There are a total of 4 different scores consisting of 3 points for subscale and 1 point for total score.

Iowa Gambling Task (IGT) (16): Briefly, subjects sit in front of four decks (A, B, C and D) of cards equal in appearance and size; the goal is to win as much money as possible. The subjects are told that the game requires a long series of card selections, one card at a time, from any of the four decks, until they are told to stop. Each deck consisted of 40 cards but participants did not know that the amount, and probability of punishment varied across decks. Two of the four decks give high rewards, but also high losses, and result in a net loss in the long run (disadvantageous decks A and B). The two other decks result in low rewards, but also render lower losses, and result in a net gain in the long run (advantageous decks C and D). The task ends when the participant has selected a total of 100 cards. In scoring for the IGT, 100 choices were divided into five blocks of 20 choices each. A net score is calculated within each block by subtracting the number cards selected from the two disadvantageous decks (A+B) from the number selected from the two advantageous decks (C+D). Higher scores reflect more advantageous decision-making performance on the task.

Statistical Analyses

The data were analyzed with the Statistical Package for the Social Sciences for Windows, Version 16.0 (SPSS Inc., Chicago, IL). BIS-11 scores, SSS-V scores, IGT total score and age were checked for normality of their distribution using Kolmogorov-Smirnov normality test. In normally distributed data, independent t-test was performed to assess group differences. When variables were not normally distributed, nonparametric Mann-Whitney U test was used to identify statistical differences. Comparisons across categories of nominal variables were made with Chi-square test. We conducted a mixed-design analysis of variance (ANOVA) (two-group: CDP versus controls $\times$ 5-IGT blocks) to examine possible differences between groups on their IGT performance. Pearson correlation analysis was conducted to determine the direction and level of relation between variables. In all analyses, the p-value was set to <0.05.

RESULTS

The groups were matched for age and educational level. Table 1 shows the demographic and cannabis use variables for CDP and controls. The CDP had a wide range of abstinence duration (1–36 months) with a mean duration of 7.1 months.

Table 1. Group means (SD) for participants' demographics and drug use

	CDP (n=30)	Controls (n=30)	t	p
Age	28.1 (6.6)	26.4 (5.4)	t=1.086	0.282
Years of education	9.5 (1.8)	9.1 (1.5)	t=1.016	0.314
Duration of cannabis use (month)	83.1 (50.9)			
Frequency of weekly cannabis use	5.5 (2.1)			
Number of joints smoked per week	18.9 (22.1)			
Months since last use of cannabis	7.1 (7.5)			

CDP, cannabis dependent patients.

Table 2. IGT net scores of long-term abstinent CDP and healthy controls

	IGT Block 1	IGT Block 2	IGT Block 3	IGT Block 4	IGT Block 5	IGT Total	t	p
CDP (n=30)	-2.8 (6.3)	-0.9 (7.3)	0.5 (7.6)	-1.1 (9.0)	0.1 (10.2)	-4.3 (24.4)	-1.003	0.320
Controls (n=30)	-2.8 (5.1)	-0.3 (6.0)	1.1 (8.6)	2.1 (10.1)	2.5 (9.6)	2.5 (27.5)		

IGT, Iowa gambling task; CDP, cannabis dependent patients.
Data are expressed as mean (standard deviation).

As a result of IGT evaluation, all subjects had aimed to draw cards from advantageous decks ($F=3.179$, $df=4$, $p=0.014$) as they drew cards, however there was no significant group (CDP vs. control) by block interaction in IGT performance ($F=0.576$, $df=4$, $p=0.680$). Total IGT score of CDP and control group was calculated as -4.3 ± 24.4 and 2.5 ± 27.5 respectively. There was no statistically significant difference between two groups ($t=-1.003$, $p=0.320$) (Table 2).

As displayed in Table 2, CDP showed significantly higher BIS-11 total ($t=2.8$, $p=0.006$), BIS-11 nonplanning ($t=2.9$, $p=0.006$) and SSS-V experience seeking subscale ($U=236.500$, $p=0.001$) scores compared with controls.

Within the CDP group, we performed correlation analyses of cannabis use variables with the BIS-11, SSS-V and IGT total scores. There was a significant negative correlation between IGT total score and duration of cannabis use ($r=-0.402$, $p=0.028$). We also found a significant negative correlation between SSS-V total score and time since the last cannabis use ($r=-0.384$, $p=0.036$).

DISCUSSION

The main finding of this study was the presence of higher self-report measures of impulsivity and experience seeking subscale of sensation seeking in CDP during long-term abstinence. In contrast, our sample of long-term abstinent CDP did not show any evidence of deficits in decision-making on the IGT. However, we found a significant negative correlation between IGT scores and duration of cannabis use. Our findings indicate that higher self-report measures of impulsivity and experience seeking are still detectable in long-term abstinent CDP, and do not improve quickly with abstinence (an average of 7.1 months). In contrast, decision-making deficits seem to improve with long-term abstinence.

Chronic exposure to cannabis seems to impair decision-making process in the active or recently abstinent users (30), however, as we mentioned above, whether these deficits continue in long-term abstinence is unclear. In our study, control group selected more cards from the disadvantageous decks in the first trials, and switched to the advantageous decks to receive a higher reward in the last 40 trials. In contrast, the long-term abstinent

CDP group showed less improvement from the first to the last trials when compared with the control group. However, this difference was not statistically significant. But we found a significant negative correlation between IGT total score and duration of cannabis use. Both of these findings suggest that decision-making deficits found in CDP seem to be a state dependent rather than a stable trait. Our result of no difference in decision-making between groups is not consistent with two previous studies that found persisting decision-making deficits among cannabis users in spite of mean 25 and 53 days of abstinence (32, 33). Length of abstinence might be an important factor to explain the differences in findings between studies. In our study, the mean duration of abstinence was 7.1 months, and this may have allowed CDP for recovery of decision-making deficits like other neurocognitive domains that seem to recover after prolonged abstinence (29). In line with our suggestion, one previous study found persisting behavioral impulsivity in alcohol dependent patients with mean 6 months' abstinence (38), while another study did not find differences in behavioral impulsivity between alcohol dependent patients with mean 15 months' abstinence and controls (39). However, due to our cross-sectional design, we are unable to establish a clear temporal relationship between cannabis use, long-term abstinence and decision-making. For example, an alternative explanation is that maintaining abstinence in the face of decision-making impairment is more difficult. A recent study showed decision-making performance on the IGT significantly predicted short-term relapse in substance dependent patients (40). Also, a recent review reported that out of the seven studies, six showed a significant relationship between impulsive/risky decision-making and abstinence/relapse in substance users (41). That is, those who had greater decision-making impairment may have been more likely to relapse, and thus were not included in this study. Another possible reason may be inadequate power due to small sample size.

To the best of our knowledge, this is the first study to examine both self-report impulsivity and sensation seeking in CDP with long-term abstinence. BIS-11 total and non-planning subscale scores were significantly higher in long-term abstinent CDP group compared with controls, consistent with previous studies that found elevated BIS-11 total and non-planning subscale scores in the current cannabis users, relative to healthy controls (24, 26, 42). These findings suggest that elevated self-report impulsivity that has been found in current cannabis users is still persisting in long-term abstinent CDP, similar to previous studies showing

Table 3. Self-report impulsivity and sensation-seeking in CDP and controls

	CDP (n=30)	Controls (n=30)	t or U	p
BIS-11 motor	20.6 (4.4)	18.7 (3.9)	t=1.817	0.074
BIS-11 attention	16.2 (3.7)	15.5 (4.4)	t=0.737	0.464
BIS-11 nonplanning	25.6 (4.3)	22.5 (4.0)	t=2.834	0.006
BIS-11 total	62.8 (9.6)	56.3 (7.6)	t=2.854	0.006
SSS-V thrill/adventure seeking	5.5 (2.3)	6.4 (2.6)	U=341.5	0.105
SSS-V experience seeking	4.0 (1.8)	2.6 (1.3)	U=236.5	0.001
SSS-V disinhibition	2.6 (1.8)	2.4 (2.2)	U=403.0	0.480
SSS-V boredom susceptibility	2.8 (1.7)	2.1 (1.7)	t=1.535	0.130
SSS-V total	14.9 (5.5)	13.5 (4.5)	t=1.112	0.271

BIS-11, scores on Barratt Impulsiveness Scale-11; SSS-V, scores on Sensation-Seeking Scale-V; CDP, cannabis dependent patients. Data are expressed as mean (standard deviation).

enduring elevated impulsivity as measured by the BIS-11 in the long-term abstinent cocaine (43) and heroin (44) users. Our research extends the findings of these studies to CDP.

Of all SSS-V total and subscale scores, we only found significant differences for experience seeking subscale. Higher experience seeking that we found in this study may be a risk factor for initiation drug use. For example, in a sample of monozygotic twins discordant for cannabis use, cannabis users scored higher on experience seeking subscale than their non-user co-twins (45). In addition, a longitudinal study in a sample of 553 adolescents reported an association between experience seeking and cannabis use in males (46). Our results are at least partly in line with the previous studies that have reported higher sensation seeking scores among long-term abstinent substance users. In a recent study, long-term abstinent cocaine users showed higher scores on the sensation seeking scale than healthy controls (43). Similarly, another recent study reported higher SSS-V total score in long-term abstinent heroin users, relative to controls (44).

An important limitation of this study is its cross-sectional nature. Thus, we are unable to establish a clear temporal relationship between cannabis use, long-term abstinence, and our findings on impulsivity and sensation seeking. Longitudinal studies are needed to clarify this issue. Another limitation of the study is that it included only males. Therefore, we were unable to generalize our findings. Third limitation of the study is the wide range of abstinence duration, which might have influenced our results. In addition, we recruited healthy control subjects who were matched with the using group for age and sex. However, the CDP may have had other premorbid psychosocial factors such as personality disorders or attention deficit hyperactivity disorder, which may have affected the results. Finally, the data on the duration of abstinence and previous substance use other than cannabis, except the last 1 month, were based on self-reports. Thus, we do not know exactly whether the CDP were completely abstained from cannabis before treatment.

In conclusion, this is the first study to investigate decision-making, self-report impulsivity and sensation seeking in long-term abstinent CDP. Our findings suggest that both self-report impulsivity and experience seeking may reflect a stable trait in CDP but not deficits on decision-making. This suggestion is consistent with the hypothesis that elevated impulsivity and sensation seeking traits may lead to addiction when they occur together rather than alone (3, 11).

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