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Working Memory and Impulsivity Predict Marijuana-Related Problems Among Frequent Users

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Abstract

Background—Although marijuana is the most commonly used illicit substance in the US, only a small portion of users go on to develop dependence, suggesting that there are substantial individual differences in vulnerability to marijuana-related problems among users. Deficits in working memory and high trait impulsivity are two factors that may place marijuana users at increased risk for experiencing related problems.

Methods—Using baseline data from an experimental study that recruited 104 frequent marijuana users (*M*=71.86% of prior 60 days, *SD*=22%), we examined the associations of working memory and trait impulsivity with marijuana-related problems.

Results—Lower working memory, as measured by Trail Making Test B, but not short-term memory capacity, predicted more marijuana-related problems. Higher trait impulsivity scores were independently associated with greater number of problems.

Conclusions—Results suggest that marijuana users with reduced executive cognitive ability are more susceptible to developing problems related to their use. Trait impulsivity and executive working memory appear to be independent risk factors for experiencing marijuana-related problems.

Keywords

marijuana; working memory; problems; executive functioning; impulsivity

1. INTRODUCTION

Although marijuana is the most used illicit drug in the U.S. and the world (Substance Abuse and Mental Health Services Administration, 2010), only about nine percent of those who

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Contributors

Authors Day and Metrik designed this study and author Metrik designed, wrote the protocol, and collected the data for the laboratory study. Authors Metrik, Spillane, and Kahler undertook the statistical analysis, and authors Day, Metrik, and Spillane drafted the manuscript with editing by all authors. All authors contributed to and have approved the final manuscript.

Conflict of Interest

The authors have no conflicts of interest to report.

have ever used become dependent (Anthony, 2006), indicating substantial individual differences in risk of progression to problem use (Anthony et al., 1994; Kendler and Prescott, 1998; Kleinman et al., 1998). Executive functioning deficits have been linked to the experience of behavioral (Wahlstedt et al., 2008) and emotional problems (Knouse et al., 2012), and play a critical role in the development and maintenance of drug addiction (Hester et al., 2010). These disturbances in prefrontally-mediated processes can represent both a pre-existing vulnerability to and a consequence of drug use (Yücel and Lubman, 2007).

Two facets of executive functioning that may have particular relevance to the development of marijuana problems are working memory and impulsivity. These constructs are inversely related and independently predict problem behaviors (Romer et al., 2011), including drug use (Albein-Urios et al., 2012). Those lower in working memory may have limited capacity to maintain task-relevant information during complex tasks, restricting ability to exert behavioral control when needed. Likewise, those high in impulsivity may be more likely to act upon maladaptive behavioral impulses without considering consequences. There is mixed evidence regarding whether marijuana use leads to deficits in working memory (Solowij and Pesa, 2010), and a dearth of information on the role of working memory in the experience of marijuana-related problems. By contrast, impulsivity has demonstrated a robust and consistent association with increased substance use (Littlefield and Sher, 2010), including marijuana use (Hale et al., 2003; Jaffe and Archer, 1987; Kollins, 2003; Satinder and Black, 1984; Vangsness, et al., 2005). Furthermore, trait impulsivity is positively associated with marijuana-related problems (Hayaki et al., 2011; Simons and Carey, 2002), although studies have been mostly limited to college samples with low levels of marijuana use (e.g., Simons et al., 2006).

The current study explored the association between working memory, impulsivity and marijuana-related problems among frequent users. We hypothesized that greater trait impulsivity and poorer working memory (but not short-term memory capacity) would independently predict greater number of marijuana-related problems.

2. METHODS

2.1. Participants

Data were drawn from a study investigating cannabinoid-related genetic variation and variability in marijuana's acute and cue-elicited effects (Metrik et al., 2012a). The Institutional Review Board of Brown University approved the study. Participants were 104 marijuana smokers recruited through newspaper advertisements, flyers, and social media websites who met the following inclusion criteria: native English speakers, 18 to 44 years of age, non-Hispanic Caucasian (due to genetic aims of the parent study), marijuana use at least 2 days a week in the past month and at least weekly in the past 6 months, and self-reported ability to abstain from marijuana for 24 hours without withdrawal. Exclusion criteria were: intent to quit or receive treatment for cannabis abuse, use of other illicit drugs, pregnancy, nursing, past month affective or panic disorder, psychotic or suicidal state assessed by psychiatric interview, contraindicated medical issues by physical exam and BMI > 30, and smoking more than 20 tobacco cigarettes per day.

The sample was 36.5% female with a mean age of 21.29 (SD = 4.30, range = 18–42), with 64.3% of the sample reporting having completed college at least one year of, or being currently enrolled in, college (M=13.6 years of education, SD=1.7). Participants reported using marijuana a mean of 2.03 (SD = 1.22) times a day on 71.86% (SD = 22.02%) of the past 60 days (about 5 days per week). There were 44 tobacco cigarette smokers (42.3%), who smoked 4.08 cigarettes (SD = 3.77) per day. The 100 current drinkers drank 8.5

(*SD*=7.88) drinks per week consuming an average of 4.34 drinks (*SD*=2.44) on a drinking day.

2.2. Procedure

Participants completed self-report assessments and research assistants administered two executive functioning tests (Trail-Making Test and Digit Span). Participants abstained from marijuana and tobacco smoking for 12 hours before the session. Alveolar carbon-monoxide (CO) of ≤ 6 ppm was used to confirm no recent smoking (Cooper and Haney, 2009; Metrik et al., 2012b) with a Bedfont Scientific Smokelyzer and zero breath alcohol concentration was verified with an Alco-Sensor IV (Intoximeters, Inc., St Louis, MO, USA). Smokers smoked one cigarette after CO confirmation to prevent effects of nicotine withdrawal on task performance.

2.3. Measures

The well-validated calendar-assisted *Timeline Follow-Back* interview (TLFB; Dennis et al., 2004) was used to assess past 60-day marijuana use.

Trait impulsivity was measured with the mean composite score for the Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995), a reliable and valid 30-item self-report measure of motor, attentional, and future planning impulsivity, scored on Likert scales, from 1 (rarely/never) to 4 (almost always).

Working memory was assessed with the Trails B (Sánchez-Cubillo et al., 2009) portion of the Trail-Making Test (TMT; Reitan and Wolfson, 1995). T-scores (Weaver et al., 2002; Reitan and Wolfson, 1995) adjusted for age, gender, and education were used.

Short-term memory capacity was measured with Digit Span subtests (forward and backward) of the WAIS-III (Wechsler, 1997) and was used as an indicator of the discriminant validity of working memory in the prediction of marijuana-related problems.

Marijuana-related problems were assessed with the 22-item Marijuana Problems Scale (MPS; Stephens, 2000), a reliable and valid measure of the number and severity of marijuana problems during the past 90 days. Total count of combined minor and serious problems was used. Internal validity for the BIS and MPS were fair (α=.68 and .76, respectively).

2.4. Data Analysis Plan

We first examined correlations among gender, age of onset of regular use of marijuana, marijuana use frequency, Digit Span Forward and Backward, Trails B, BIS, and marijuana-related problems. In a linear regression model, we tested the association of each variable with marijuana-related problems. Variables were centered to aid in interpretation of results. Age of initiation of regular marijuana use was included in the model as a covariate because it has been linked to negative outcomes including progression to cannabis dependence (Substance Abuse and Mental Health Services Administration, 2010). This variable was dichotomized (under 16/16 and over; Gruber et al., 2012).

3. RESULTS

3.1. Marijuana-Related Problems

All participants reported at least one marijuana-related problem. The median number of problems was 3, with a range between 1 and 13 problems. Participants most frequently reported that marijuana caused them “to procrastinate” (53% of the sample) and “to have a

lower energy level" (42.6%). No participants reported that marijuana had caused them to lose a job, and 1% reported experiencing medical problems as a result of marijuana. The remaining 18 problems were reported by between 2 and 37% of participants.

Means and standard deviations of variables, along with correlations, are listed in Table 1. As expected, number of marijuana problems was negatively correlated with age of initiation of regular use, Trails B, and BIS, but was uncorrelated with frequency of use or scores on both subtests of Digit Span. We found a nonsignificant relationship between gender and number of marijuana problems (p>.60), so gender was excluded from further analyses.

3.2. Predicting Marijuana-Related Problems

Use frequency, age of initiation of regular use, and both subtests of Digit Span were not significantly associated with marijuana problems, while lower working memory (Trails B) and higher impulsivity (BIS) were significantly related to marijuana problems, predicting 6% and 4% of the variance, respectively (see Table 2). (The following interactions were all nonsignificant (ps>.45): use X BIS, use X Trails B, BIS X Trails B.)

4. DISCUSSION

As predicted, lower working memory was associated with the experience of more marijuana-related problems, such as procrastination, lower energy and lower productivity, independent of frequency of use. Poor working memory has been implicated in difficulty limiting consumption of substances (Hofman et al., 2011), and in this sample, use and working memory were negatively correlated, indicating that those with greater use frequency performed more poorly on Trails B. Previous research indicates that marijuana users do perform worse than non-users on tests of executive functioning (Pope and Yurgelun-Todd, 1996; Solowij et al., 2002), although not necessarily worse on tasks of working memory (Bolla et al., 2002; Jager et al., 2006). Because of the cross-sectional nature of the study, it is impossible to tell whether frequency of use contributed to deficits in working memory, which then led to marijuana-related problems, or if pre-existing deficits in working memory led to greater marijuana use and marijuana-related problems. It is also possible that an underlying psychological variable (e.g., anxiety) that was not measured in the current study might have predicted both greater frequency of use and a greater number of problems.

Performance on Digit Span subtests was not predictive of problems associated with marijuana use. Digit Span Forward measures only short-term memory capacity, which reflects ability to store information for a short period of time (Conway et al., 2005). Digit Span Backward measures capacity to complete a transformation in short-term memory, which is a more complicated cognitive activity, but nonetheless does not assess working memory, which is utilized when an individual actively maintains task-relevant information in the face of ongoing distraction (Conway et al., 2005). Working memory and short-term memory capacity were correlated in this study, but working memory was uniquely related to the experience of problems, providing evidence that working memory and short-term memory capacity are indeed distinct.

Consistent with other studies (Hayaki et al., 2011; Simons and Carey, 2006), we found that trait impulsivity was related to marijuana-related problems. Future research might consider measuring impulsivity with behavioral tasks or completing prospective research to provide additional support for the direction of causality between impulsivity and the experience of marijuana-related problems.

In prior studies, frequent and intense use of marijuana has predicted negative academic and social outcomes (Brook et al., 2003, 2008). The present study may not have replicated these findings because participants were slightly older (M=22 years) than adolescents previously studied (ages 14 –15). We also had a restricted range of marijuana use in our sample, with participants using five days a week on average. At this level of use, other variables, such as facets of personality and executive function, may play a more critical role in the experience of problems.

One strength of this study is the community sample of regular marijuana users which reflects the age group (18–25 years) that has the highest rates of marijuana use (Substance Abuse and Mental Health Services Administration, 2010). Another strength was measuring different elements of cognitive functioning (working memory and short-term memory capacity) and testing their independent effects. Other studies have utilized composite executive function scores (e.g., Glass et al., 2009; Thoma et al., 2011), which may fail to delineate which elements of executive control create a vulnerability to experiencing marijuana-related problems.

A limitation of these findings is the use of only one measure for short-term memory capacity and for working memory. Having a more comprehensive evaluation of each construct and other elements of executive functioning might further elucidate the links between executive functioning and marijuana-related problems.

The current study did not examine motives or expectancies related to marijuana use, which have been shown to mediate the relation between use and subsequent problems (Mirin, 1971; Patrick et al., 2011; Simons et al., 1998), and between other psychological risk factors and and problems (Buckner and Schmidt, 2008, 2009). In addition, negative expectancies about marijuana use have been shown to mediate the link between impulsivity and marijuana use (Vangsness et al., 2005), and as such, future studies might examine the role of motives expectancies in determining the link between impulsivity, executive functioning, use, and problems. Clinically, the results of the current study are valuable. Knowing that those high in impulsivity and low in working memory are at risk for developing negative consequences of marijuana use can guide efforts to develop targeted prevention and interventions efforts.

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Table 1

Correlations Among Executive Control and Marijuana Use Variables

	Mean (SD)	1	2	3	4	5	6	7
1. MJ Use Frequency	71.86% (22.02)	--						
2. Age of Regular		−.19	--					
3. Trails B	49.55 (10.21)	−.22**	.08	--				
4. BIS	59.95 (8.21)	.38**	−.30**	−.26**	--			
5. DS Forward	11.45 (2.06)	−.03	.10	.36**	−.03	--		
6. DS Backward	7.99 (2.4)	−.11	.20*	.30**	−.18	.30**	--	
7. MJ Problems	3.64 (2.94)	.13	−.19*	−.22**	.34**	−.01	−.003	--

Note. MJ = Marijuana; BIS = Barratt Impulsiveness Scale; DS = Digit Span. Use frequency is percent of days used in the past 60 days. Spearman's rank correlation coefficients reported for correlations for the dichotomous age of regular use variable; all other correlation statistics are based on Pearson's Product-Moment correlation coefficients.

* $p < .05$,

** $p < .01$.

Table 2

Linear Regression Predicting Marijuana-Related Problems (N=104)

Predictor	B	SE (B)	sr^2	*p*
MJ Use Frequency	−.01	.01	.001	.71
Age of Initiation	−.1.21	.73	.27	.10
Digit Span Forward	.01	.14	.005	.50
Digit Span Backward	.16	.12	.02	.18
Trails B	−.08	.03	.07	.009
BIS	.09	.04	.06	.016

Note. MJ = Marijuana. BIS = Barratt Impulsiveness Scale. MJ Use Frequency, Trails B and BIS are centered. Total R^2=.154.