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Short communication

Expectancy of impairment attenuates marijuana-induced risk taking

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ABSTRACT

Background: Marijuana use has been associated with increased risk-taking and impulsive behavior. While pharmacologic effects of marijuana can lead to inhibitory impairment, expectancy of potential impairment may result in compensatory behavioral response by decreasing impulsive decisions and risky behaviors. With the increases in marijuana use and related problems, a better understanding of the individual characteristics associated with marijuana intoxication and risky behavior is needed. This study examined the role of impairment expectancies in marijuana's acute effects on behavioral measures of impulsivity and risk-taking.

Methods: Participants (N = 136) were regular marijuana users. A balanced placebo design (BPD) was used crossing marijuana administration (i.e., 0% Tetrahydrocannabinol (THC) vs. 2.8% THC) with stimulus expectancy (i.e., Told Placebo vs. Told THC). Marijuana outcome expectancies were measured by self-report and dependent measures included a number of behavioral impulsivity tasks and the balloon analogue risk task (BART).

Results: Among participants who received THC, higher expectancies for cognitive-behavioral impairment (CBI) were related to lower risk-taking on the BART. Among those who received placebo, there was no association between CBI expectancies and BART performance. CBI expectancies did not moderate the stimulus expectancy effect on the BART nor drug or stimulus expectancy effects on impulsivity measures.

Conclusions: Results provide initial evidence that expectancies of greater impairment are associated with compensatory behavior on a risk-taking task under acute marijuana intoxication. Future studies should examine the role of impairment expectancies on risk behaviors of substantial public health concern, such as driving while under the influence of marijuana.

1. Introduction

Ample evidence suggests that marijuana use is associated with increased likelihood of risk-taking behaviors, including intoxicated driving (Aston et al., 2016; Johnson et al., 2012), automobile accidents (Li et al., 2012; Ramaekers et al., 2004), and risky sexual behaviors (Simons et al., 2010). Laboratory studies suggest that acute marijuana administration is associated with poor inhibitory control on the Stop-signal task (Hart et al., 2001; McDonald et al., 2003; Metrik et al., 2012; Ramaekers et al., 2006) and the Stroop Task (Hooker and Jones, 1987; Metrik et al., 2012). Findings with marijuana's acute effects on risky decision-making are mixed, some studies showing increased risky decision-making on the Iowa Gambling Task (Lane et al., 2005), and others showing no effect (Ramaekers et al., 2006; Vadhan et al., 2007). Additionally, administration of marijuana is not acutely associated with increased impulsive decision-making during the delay discounting task (McDonald et al., 2003; Metrik et al., 2012).

Few studies have separated the effects of the drug from expectancies, which may also contribute to impulsive and risk-taking behaviors. Balanced placebo design (BPD) (Marlatt and Rohsenow, 1980) allows for the examination of the expectancy that marijuana was smoked independently from the pharmacological effect of delta-9-tetrahydrocannabinol (THC). This 2 × 2 factorial design crosses drug administration (THC or placebo) with instructions that THC was smoked (i.e., stimulus expectancy: Told THC or Told placebo) (Metrik et al., 2009).

Expectancy theory has helped elucidate the cognitive and motivational mechanisms for marijuana and other substance use (Abrams and Niaura 1987; Goldman et al., 1987; Schafer and Brown, 1991). Research and theory suggests that when stimulus expectancies are activated, outcome expectancies (the expected behavioral and affective response to the drug) are in turn initiated (Kirsch and Sapirstein, 1999;

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Metrik and Rohsenow, 2013). Outcome expectancies are strong determinants of marijuana use in youth and adults (Aarons et al., 2001; Gaher and Simons, 2007; Neighbors et al., 2008; Simons et al., 2009). More specifically, expectancies of cognitive-behavioral impairment (CBI) are inversely related to adolescent lifetime marijuana use and past 3-month use in adults (Kristjansson et al., 2012). Further, negative marijuana outcome expectancies are related to lower likelihood of risk-taking behavior, such as driving while intoxicated (Arterberry et al., 2013; Aston et al., 2016). In a BPD study, stimulus expectancy effects have decreased impulsive decision-making on a delay discounting task and increased perception of sexual risk among women, consistent with a compensatory effect (Metrik et al., 2012).

Few studies have examined the potential moderating effects of outcome expectancies on marijuana's pharmacological and stimulus expectancy effects. Metrik et al. (2011) found more salient CBI expectancies led to more anxiety under acute marijuana intoxication. In alcohol (Testa et al., 2006; Vogel-Sprott and Fillmore, 1999) and nicotine studies (Juliano and Brandon, 2002), negative outcome expectancies moderated pharmacological effects on behavioral tasks and negative affect. Overall, evidence suggests positive outcome expectancies amplify or increase the likelihood of behavior, whereas negative outcome expectancies result in reduction in behavior or compensation for the negative effects (Metrik and Rohsenow, 2013). No studies thus far have examined the effect of marijuana CBI expectancies on behavioral impulsivity and risk-taking behavior under acute administration. The present study is a secondary analysis of the Metrik et al. (2012) data testing the hypothesis that higher CBI expectancies would be associated with lower levels of impulsivity and risk taking among those who received THC and were told THC relative to participants without any THC or expectancy of THC.

2. Methods

2.1. Participants

Participants met the following inclusion criteria: native English speakers, 18–30 years of age, marijuana use at least once a week in the past month and at least ten times in the past 6 months, and self-reported ability to abstain from marijuana for 24 h without withdrawal. Exclusion criteria were: history of substance abuse treatment and intent to quit or receive treatment for marijuana abuse; use of other illicit drugs; pregnancy; nursing; past month affective disorder or history of panic attacks, psychotic, or suicidal state assessed by psychiatric interview; alcohol dependence; contraindicated medical issues by physical exam; 20+ tobacco cigarettes a day; and prior knowledge about the study procedures or contact with participants. The final sample (N = 136) had a mean age of 21.4 (SD = 3.1), was 64.7% female, 65.4% Caucasian non-Hispanic, and averaged 41.2% (SD = 24.4) marijuana use days at baseline. Further detail on demographic and substance use characteristics of the sample are presented in Metrik et al. (2012).

2.2. Procedures

Full details of procedures used in the current study have been previously outlined (Metrik et al., 2012). At baseline, participants completed questionnaires and impulsivity and risk taking tasks to provide within-subjects control for repeated measures. An alveolar carbon-monoxide (CO) of < 6 ppm was used to confirm no recent (past 12 h) smoking (Cooper and Haney, 2009; Metrik et al., 2012) with a Bedfont Scientific Smokelyzer®. Zero breath alcohol concentration was verified with an Alco-Sensor IV (Intoximeters, Inc., St Louis, MO., USA). Participants were then randomized to one of the four experimental BPD conditions: Told THC/Received THC, Told THC/Received Placebo, Told Placebo/Received THC, and Told Placebo/Received Placebo. At the second session, participants were instructed by a research assistant about which cigarette (THC or placebo) they were assigned to smoke (see Metrik et al., 2009 for full details of the instructional set manipulation procedures). Marijuana cigarettes (placebo or 2.8% THC) were provided by the National Institute on Drug Abuse, rolled at both ends, humidified, and smoked according to the standardized paced puffing procedure (Foltin et al., 1987). Participants were fully debriefed about the deception after completing the study. A previous report of the data examined here revealed successful manipulation of drug and expectancy effects (Metrik et al., 2012).

2.3. Measures

2.3.1. Baseline outcome expectancies

Beliefs about possible cognitive-behavioral consequences of smoking marijuana were assessed with the 10-item CBI subscale of the *Marijuana Effect Expectancy Questionnaire* (MEEQ; Schafer and Brown, 1991). The MEEQ is scored on a 5-point Likert scale.

2.3.2. Impulsive disinhibition

The *Stroop Color-Word task* (Stroop 1935) instructed participants to press as quickly as possible the designated key on the keyboard first in response to the color of a symbol string (e.g., XXXX) and then the color of the color-incongruent word. The primary dependent variable was response latency in milliseconds on color-incongruent trials. The *Stop Signal task* (Logan et al., 1997) measures inhibition of a prepotent response with two concurrent tasks: (1) the go task is a choice reaction–time task that requires participants to rapidly discriminate two symbols (maximum presentation 1250 ms) and (2) the stop task involves presentation of a tone (75 ms, 1000 Hz) that signals one to inhibit the response to the go task. The time in milliseconds required for the participant to stop the go response (stop signal reaction time, SSRT) was the primary dependent measure.

2.3.3. Impulsive decision-making

The *Delay Discounting Questionnaire* (DDQ; Richards et al., 1999) uses a computerized adjusting amount procedure to measure discounting of delayed monetary reinforcers (hypothetical choices between $10 available after a delay or a smaller amount available immediately). The primary dependent variable was area under the curve connecting indifference points and the x-axis, from 0.0 (steepest discounting) to 1.0 (no discounting) (Myerson et al., 2001). The *Experiential Discounting task* (EDT; Reynolds and Schiffbauer 2004) also assesses delayed-discounting. During a block of trials, participants chose between a standard amount ($0.30) that was probabilistic and an adjusting amount of money (initially set to $0.15) that was always delivered immediately and was certain. Participants were told that if they chose the standard 30 cents, the next adjusting choice would increase, while choosing the immediate amount caused the next adjusting choice to decrease. The primary dependent variable was the indifference point (i.e., an equal number of choices to both the standard and immediate options). The *Balloon Analogue Risk Task*, automatic response version (BART; Lejuez et al., 2002; Pleskac et al., 2008), is a computerized behavioral measure of risk taking. Thirty balloon images were presented one at a time with participants designating the number of pumps to have each balloon inflated. Each pump earned 1 cent, but money was lost if the balloon exploded (at 64 pumps on average). The primary dependent variable was the average number of pumps across trials.

2.4. Data analysis plan

ANOVA was conducted to test for differences in CBI expectancies between drug and stimulus expectancy manipulation groups at baseline. BPD groups did not differ on demographics, substance use characteristics, or baseline impulsivity measures in prior analyses (Metrik et al., 2012). Multiple regression analyses were used to examine the hypothesis that CBI expectancies would moderate drug manipulation

and stimulus expectancy effects on outcomes. Five separate models were run for each of the five outcome measures (Stroop, Stop-signal, BART, EDT, and DDQ). In each model, baseline task performance and task administration order were entered at step one as covariates, main effects of drug manipulation, stimulus expectancy and CBI expectancy MEEQ subscale were entered at step two, and two interactions of CBI expectancy with drug manipulation and stimulus expectancy were entered in the third and final step to test for moderation. Drug by stimulus expectancy interactions were not significant across all measures in prior analyses (Metrik et al., 2012).

3. Results

ANOVA revealed no significant difference in CBI expectancies at baseline between drug manipulation, F (1134) = 2.78, p = 0.10 nor stimulus expectancy groups, F(1134) = 0.904, p = 0.34. Multiple regression revealed non-significant interactions of CBI expectancies with drug manipulation or stimulus expectancy effects on the Stroop, Stop-Signal, EDT, or DDQ tasks after smoking. On the BART task, there was a significant interaction of CBI expectancies with drug manipulation, B = −0.190, SE = 0.08, p = 0.02, sr^2 = 0.04, but not with stimulus expectancies, B = −0.091, SE = 0.08, p = 0.27 sr^2 = 0.01 (Table 1). Post-hoc analyses without the CBI expectancy by stimulus expectancy interaction term in the model revealed higher expectancies of CBI were associated with less balloon pumps on the BART (lower levels of risk-taking) among participants who received THC, B = −0.16, SE = 0.08, p < 0.05 sr^2 = 0.06. Among those who received placebo, there was no significant association between CBI expectancies and pumps on the BART, B = 0.09, SE = 0.07, p = 0.22, sr^2 = 0.02 (Fig. 1).

4. Discussion

This study examined whether marijuana outcome expectancies of CBI would moderate the pharmacological and stimulus expectancy effects of marijuana on measures of impulsivity and risk-taking. Results suggested that CBI expectancies moderated the pharmacological, but not stimulus expectancy, effect of marijuana on the BART task. Among participants who received THC, higher expectancies for impairment were related to lower risk-taking (less balloon pumps). However, among those who received placebo, there was no association between impairment expectancies and performance on the BART task.

Consistent with previous research examining the relationship between negatively-valenced expectancies and behavior, results suggest a compensatory behavioral response for individuals who expect marijuana will impair thoughts and behaviors (Metrik and Rohsenow, 2013). These results build on previous findings on compensatory behavior observed in Metrik et al., 2012; in which THC stimulus expectancy reduced risky decision-making. Additionally, in alcohol studies, impairment expectancies among social drinkers are associated with less impairment on a stop-signal task (Fillmore and Vogel-Sprott, 1996). This response was also evident in an alcohol and caffeine study, in which social drinkers who were told that caffeine would counteract the effect of alcohol showed more impairment than those subjects who were not given this expectancy (Fillmore et al., 2002). Together with the current findings, this suggests that expecting impairment from a substance may operate as a protective factor against impulsive and risky behaviors when under the influence of that substance. Research also suggests negative marijuana outcome expectancies are associated with compensatory behaviors while driving (i.e., reduction in speed) (Bates and Blakeley, 1999). However, this study also found that this increased false perceptions of safety, highlighting the potential negative consequences of these expectancies.

Somewhat surprisingly, CBI expectancies did not moderate drug or stimulus expectancy effects on behavioral impulsivity measures. It is possible that marijuana expectancies are not as relevant to more automatic processes in impulsivity such as behavioral disinhibition. Indeed, there was no effect of stimulus expectancy on the Stroop or the Stop Signal tasks in the parent study (Metrik et al., 2012). Contrary to our expectation, CBI expectancies did not modulate marijuana's effects on delay-discounting measures, which assess impulsive decision-making involving a more deliberate process of evaluation of outcomes.

Table 1
Step-wise Multiple Regression Predicting post-smoking BART performance.

Predictor	β	S.E.	t	P	sr^2
Step 1					
BART(*BL*)	0.78	0.05	207.61	0.00	0.59
Task order	0.04	0.05	0.60	0.44	0.00
CBI Expect	−0.05	0.05	0.94	0.33	0.01
Step 2					
BART(*BL*)	0.79	0.06	203.81	0.00	0.61
Task order	0.04	0.06	0.64	0.43	0.01
CBI Expect	−0.05	0.06	0.68	0.41	0.01
Told (THC/Placebo)	−0.03	0.06	0.27	0.60	0.00
Received (THC/Placebo)	0.03	0.06	0.37	0.54	0.00
Step 3					
BART(*BL*)	0.78	0.05	207.54	0.00	0.62
Task order	0.05	0.05	0.98	0.32	0.01
CBI Expect	0.17	0.10	2.77	0.10	0.02
Told (THC/Placebo)	−0.05	0.06	0.70	0.41	0.01
Received (THC/Placebo)	0.03	0.06	0.30	0.59	0.00
CBI × Received	**−0.19**	**0.08**	**5.4**	**0.02**	**0.04**
CBI × Told	−0.09	0.08	1.21	0.27	0.01

Note: BART(BL) = Average number of pumps across balloon trials on the BART at baseline (centered) (Mean = 60.23, SD = 11.47); CBI Expect = Cognitive-Behavioral Impairment Expectancies (centered) (M = 2.73, SD = 0.72); Told (coded 0 = placebo, 1 = THC); and Received (coded 0 = placebo, 1 = THC), CBI × Received = CBI Expectancies by drug (Received THC or placebo) interaction term, CBI × Told = CBI Expectancies by stimulus expectancy (Told THC or placebo) interaction term. sr^2 = squared semipartial correlation.

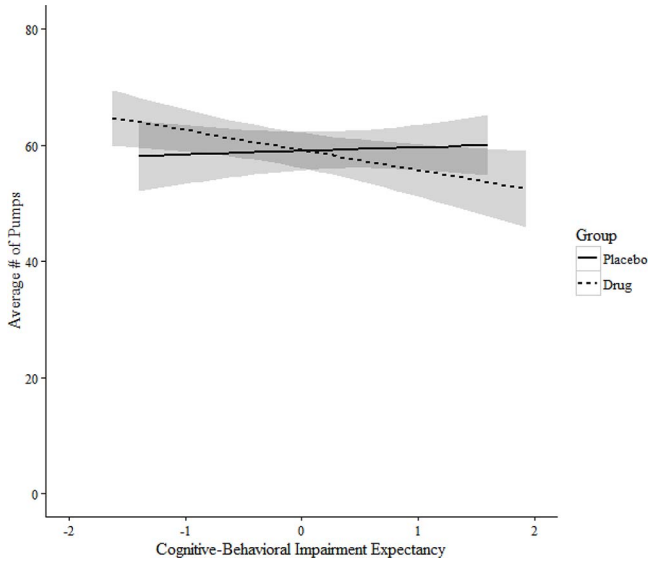

Fig. 1. Interaction of CBI Expectancies and Drug Effect on BART.
Note: Interaction effect from post-hoc regression analysis examining Marijuana Cognitive-Behavioral Impairment Expectancies (centered) by Received (THC/Placebo) on Average number of pumps on the BART post-smoking. Variance displayed using 95% confidence intervals.

5. Conclusions

The findings provide further evidence towards the value of carefully targeting outcome expectancies for intervention. Results suggest that expectancies about the impairing effects of marijuana lead to lower levels of risk-taking among users when under the influence of the drug.

The present study also suggests that this moderating effect may be unique to risk-taking behavior, given impairment expectancies did not moderate drug or expectancy effects on other measures of impulsive decision making or disinhibition. Given the BART was the only measure of risk-taking in the present study, it is unknown whether such compensatory action would be observed with marijuana's acute effects on other measures of risk-taking. Future controlled studies should investigate the potential moderating role of impairment expectancies on other measures that are of significant public health concern, such as driving under the influence of marijuana.

Conflict of interest

All of the listed authors declare that they have no conflicts of interests.

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Contributors

Dr. Metrik designed the project that collected the data for the current study. Ms. Gunn conducted literature searches and provided summaries of previous research studies under the guidance of Dr. Metrik. Ms. Gunn conducted the analyses under the guidance of Dr. Metrik. Ms. Gunn wrote the first draft of the manuscript with significant contribution from Dr. Skalski and all authors contributed to and have approved the final manuscript.

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