Can I Use Marijuana Safely? An Examination of Distal Antecedents, Marijuana Protective Behavioral Strategies, and Marijuana Outcomes

ADRIAN J. BRAVO, Ph.D.,[a] MARK A. PRINCE, Ph.D.,[b] MATTHEW R. PEARSON, Ph.D.,[a],* &
THE MARIJUANA OUTCOMES STUDY TEAM[†]

[a]*Center on Alcoholism, Substance Abuse, and Addictions, University of New Mexico, Albuquerque, New Mexico*
[b]*Department of Psychology, Colorado State University, Fort Collins, Colorado*

ABSTRACT. Objective: Given the high prevalence of marijuana use among college students, it is imperative to determine the factors that may reduce risk of problematic marijuana use and/or the development of cannabis use disorder. We examined marijuana protective behavioral strategies (PBS) as a proximal predictor of marijuana-related outcomes and a mediator of the associations between other known risk/protective factors and marijuana-related outcomes. **Method:** Using data from a sample of 2,129 past-month marijuana users, collected from 11 universities in the United States, we examined marijuana PBS use as a mediator of the effects of sex, age at first use, impulsivity-like traits, and marijuana use motives on marijuana use frequency and marijuana-related consequences. **Results:** Marijuana PBS was identified as a robust negative predictor of marijuana use frequency and marijuana-related consequences. Further, Marijuana PBS use fully or partially mediated the effects of sex, premeditation, perseverance, coping motives, enhancement motives, conformity motives, and expansion motives on marijuana outcomes. **Conclusions:** Our results suggest that marijuana PBS use is a good candidate to be considered as a mechanism by which marijuana users moderate their marijuana use and attenuate their risk of experiencing marijuana-related consequences. (*J. Stud. Alcohol Drugs, 78,* 203–212, 2017)

RATES OF MARIJUANA USE AND cannabis use disorder peak during traditional college years (ages 18–25) in the U.S. (Farmer et al., 2015). In fact, about 30% of college students report past-year prevalence of marijuana use, and nearly 10% meet diagnostic criteria for cannabis use disorder (Caldeira et al., 2008; Johnston et al., 2015). In a recent study across 11 different U.S. universities, Pearson and colleagues (2017) found that between 15.5% and 38.7% (*M* = 26.2%) of college students report using marijuana in the past month. Further, marijuana-related negative consequences are prevalent with marijuana users experiencing approximately eight distinct negative consequences monthly (Pearson et al., 2017). Although there are several known risk (e.g., earlier age at first use and coping motives) and protective factors (e.g., self-regulation and female sex) of problematic marijuana use, research needs to go beyond examining only distal antecedents[1] and consider more proximal behaviors that may increase or decrease the negative consequences from using marijuana. Within the present study, we focus on marijuana protective behavioral strategies (PBS; Pedersen et al., 2016) as a proximal factor expected to a) relate to both frequency of marijuana use and marijuana-related negative consequences, and b) account for the effects of several known risk/protective factors of problematic marijuana use.

Stemming from a harm reduction focus in the alcohol field, much research has been conducted examining the use of alcohol PBS, defined as "behaviors that are used im-

[1]We refer to these variables as "distal antecedents" to marijuana-related outcomes to distinguish them from more "proximal antecedents," which tend to be variables that are less stable, more malleable, and presumed to be more proximal in a causal chain leading to marijuana-related outcomes.

mediately prior to, during, and/or after drinking that reduce alcohol use, intoxication, and/or alcohol-related harm" (Pearson, 2013, p. 1030). Examples of alcohol PBS identified in previous work (Protective Behavior Strategies Survey; Martens et al., 2005) include limiting/stopping drinking (e.g., "Stop drinking at a predetermined time"), manner of drinking (e.g., "Drink slowly, rather than gulp or chug"), and serious harm reduction (e.g., "Know where your drink has been at all times"). Within the college student alcohol literature, increasing evidence suggests that PBS use is a robust protective factor associated with lower alcohol-related consequences (Pearson, 2013; Prince et al., 2013). Moreover, alcohol PBS use has been found to mediate the effects of multiple interventions (i.e., increased PBS use was related to lower alcohol outcomes; Barnett et al., 2007; Dvorak et al., 2015, 2016; Larimer et al., 2007; Murphy et al., 2012), providing some evidence that PBS use is a proximal mechanism of changing one's alcohol use and related outcomes (Prince et al., 2013).

Recently, Pedersen and colleagues developed the Protective Behavioral Strategies for Marijuana (PBSM) scale to probe marijuana PBS use (Pedersen et al., 2016). Similar to alcohol PBS, marijuana PBS include strategies that are related to limiting marijuana intake by setting consumption limits (e.g., "Having a set amount of times you take a hit of a marijuana joint"), avoiding behaviors that lead to more intoxication than one would like (e.g., "Avoid using marijuana in concentrated form [e.g., hashish, hashish/honey oil, kief, marijuana butter/oil] to avoid getting too high"), and avoiding serious harm from impaired driving (e.g., "Use a designated driver [i.e., someone who has not used] after using marijuana"). In addition, marijuana PBS include behaviors that minimize potential problems in interpersonal relationships (e.g., "Avoid use while spending time with family"), reduce problems at work or school ("Avoid using marijuana before work or school"), and prevent legal troubles (e.g., "Avoid possibilities of legal repercussions [e.g., smoke in a safe place like home, avoiding having marijuana with you where you might get searched, etc.]"). Taken together, if individuals effectively use PBS, they could simultaneously decrease large amounts of marijuana use and reduce the likelihood of experiencing negative marijuana-related consequences. In support of this notion, the PBSM was found to have a simple, single-factor structure and correlate negatively with various indicators of marijuana involvement among past-month users (e.g., marijuana use frequency and consequences). Although this study provides preliminary evidence that marijuana PBS use is an important protective factor that reduces marijuana-related harms (e.g., social-impersonal consequences, impaired control, and risk behaviors), it is the only quantitative study to date that has examined marijuana PBS use and replication is warranted.

Beyond just examining the PBS use-alcohol outcomes link, multiple researchers have examined whether alcohol PBS use mediates the associations between more distal antecedents and alcohol-related outcomes (Pearson, 2013; Prince et al., 2013). Recently, Bravo and colleagues (2015, 2016) were able to replicate the protective effect of alcohol PBS use on alcohol outcomes, as well as most of the direct effects of antecedent variables on alcohol PBS use, including age at drinking onset (positive), drinking motives (negative), and impulsivity-like traits[2] (negative; Bravo et al., 2015, 2016). Similar to what has been found in the alcohol field, male sex (Johnston et al., 2015), earlier age at first use (Chen et al., 2009), impulsivity-like traits (Kaiser et al., 2012; Robinson et al., 2014; Wardell et al., 2016), and marijuana use motives (Simons et al., 1998; Zvolensky et al., 2007) have all been shown to be risk factors associated with increased marijuana use, consequences, and/or dependence. However, given the nascence of the marijuana PBS field, no studies have examined whether marijuana PBS use mediates the associations between these antecedents and marijuana-related outcomes.

Purpose of study

The purpose of the present study is to extend research on the associations between distal antecedents, marijuana PBS use, and marijuana outcomes among college student marijuana users. Although a large alcohol PBS field suggests that alcohol PBS use mediates the effects of a wide range of distal antecedents on alcohol-related outcomes, it is unknown whether marijuana PBS use would operate similarly. Based on mediation findings in the alcohol PBS literature (Bravo et al., 2015, 2016) and preliminary findings that marijuana PBS use is a protective factor associated with reduced marijuana-related harm (Pedersen et al., 2016), we expected that the associations between distal antecedents (i.e., sex, age at first use, impulsivity-like traits, and marijuana use motives) and marijuana outcomes (i.e., marijuana use frequency and consequences) would be mediated by marijuana PBS use. Generally, we expected that "protective" factors (e.g., female sex, premeditation, and perseverance) that are associated with greater marijuana PBS use would in turn be associated with less frequent marijuana use and fewer related consequences, whereas "risk" factors (e.g., younger age at first use, coping motives) associated with less marijuana PBS use would in turn be associated with greater marijuana use frequency and more related consequences.

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[2]Impulsivity-like traits are distinct constructs that contribute to impulsive behaviors: sensation seeking, urgency (positive and negative), planning, and persistence. These facets have been shown to be distinct traits of impulsivity and demonstrate different aspects of risky behaviors and clinical utility (Smith et al., 2007; Whiteside & Lynam, 2001).

Method

Participants and procedure

Participants were college students recruited from Psychology Department Participant Pools at 11 participating universities in the United States between fall 2015 and spring 2016. Participants completed an online survey examining the correlates of marijuana use among college students and received research participation credit on completion. For the present study, data only from students who consumed marijuana at least 1 day in the previous month ($n = 2,129$) were included in the final analysis from a larger sample ($n = 8,141$, 66.9% female; see Pearson et al., 2017, for more information about the larger sample). Among college student marijuana users, the majority of participants identified as being either White, non-Hispanic ($n = 1,285$; 60.4%), or of Hispanic/Latino ethnicity ($n = 390$; 18.3%), were female ($n = 1,260$; 59.2%), and reported a mean age at 19.95 ($SD = 3.66$) years. The study was approved by the institutional review boards at the participating institutions.

Measures

Age at first use. Age at first use was assessed with a single item: "How old were you the first time you used marijuana?"

Impulsivity-like traits. Impulsivity-like traits were assessed using the 59-item UPPS-P, which combines the 14-item Positive Urgency Measure (Cyders et al., 2007) with the 45-item Urgency Premeditation Perseverance Sensation Seeking Impulsive Behavior Scale (Whiteside & Lynam, 2001). The UPPS-P assesses five distinct impulsivity-like traits (each individually examined in our models): negative urgency (12 items; $\alpha = .87$), premeditation (11 items; $\alpha = .84$), perseverance (10 items; $\alpha = .79$), sensation seeking (12 items; $\alpha = .83$); and positive urgency (14 items; $\alpha = .92$). All items were measured on a 4-point response scale (1 = *strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree*). Items were averaged for each trait and higher scores on premeditation and perseverance represent less impulsivity, whereas higher scores on positive urgency, negative urgency, and sensation seeking represent more impulsivity. An examination of the psychometric properties of the measure revealed that the UPPS-P exhibited good psychometric properties and is an accurate and valid measure of impulsivity (Lynam et al., 2006).

Marijuana use motives. Marijuana use motives were assessed using the 25-item Marijuana Motives Questionnaire (MMQ; Simons et al., 1998). The MMQ assesses five distinct marijuana motives: enhancement (five items; $\alpha = .86$), conformity (five items; $\alpha = .89$), expansion (five items; $\alpha = .92$), coping (five items; $\alpha = .89$), and social motives (five items; $\alpha = .87$). Each item is rated on a 5-point Likert-type scale (1 = *almost never/never* to 5 = *almost always/always*). Items were averaged for each distinct motive so that higher scores indicate greater endorsement of a specific marijuana use motive. An examination of the psychometric properties of the measure revealed that the MMQ exhibited good psychometric properties and is an accurate and valid measure of marijuana use motives (Zvolensky et al., 2007).

Marijuana protective behavioral strategies. Marijuana PBS use was assessed using the 39-item version of the PBSM (Pedersen et al., 2016) scale. This measure consists of behaviors individuals report engaging in while using marijuana to reduce marijuana-related problems (e.g., "avoid using marijuana in public places"). Items are rated on a 6-point Likert-type scale (1 = *never* to 6 = *always*). Items were averaged so that a higher score indicates higher marijuana PBS use ($\alpha = .96$). Within their initial psychometric study, Pedersen and colleagues found support for criterion-related validity by finding moderate (negative) relationships between PBS and marijuana outcomes (e.g., cannabis use disorder symptoms) as well as convergent validity by finding moderate (positive) associations between the PBSM and the most widely used PBS measure (the Protective Behavior Strategies Survey; Martens et al., 2005) in the alcohol literature.

Marijuana use frequency. Marijuana use frequency was assessed using a high-definition measure patterned from the Daily Drinking Questionnaire (Collins et al., 1985). Specifically, each day of the week was broken down into six 4-hour blocks of time (midnight–4 A.M., 4 A.M.–8 A.M., 8 A.M.–noon, etc.), and participants were asked to report at which times they used marijuana during a "typical week" in the past 30 days. We calculated typical frequency of marijuana use by summing the total number of time blocks for which they reported using during the typical week (range: 0–42). The initial measure has shown adequate reliability and validity in previous research (Dvorak & Day, 2014).

Marijuana-related consequences. Marijuana-related consequences were assessed using a checklist version of the 50-item Marijuana Consequences Questionnaire (MACQ; Simons, et al., 2012). The MACQ assesses eight domains of marijuana consequences experienced in the past 30 days (0 = *no*, 1 = *yes*): social-interpersonal consequences (six items), impaired control (six items), negative self-perception (five items), self-care (nine items), risk behaviors (eight items), academic/occupational consequences (five items), physical dependence (four items), and blackout use (seven items). We summed all items to create a marijuana-related problems total score reflective of the number of distinct problems experienced in the past 30 days ($\alpha = .96$). Previous research supports the test-retest reliability, convergent, and discriminant validity of the MACQ as a measure of marijuana-related problems (Simons et al., 2012).

Statistical analysis

To determine which distal constructs uniquely (i.e., controlling for other distal antecedents) relate to marijuana PBS

TABLE 1.   Bivariate correlations among distal antecedents, marijuana PBS use, and marijuana outcomes in the comprehensive model

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	M or %	SD
1. Sex																60%	–
2. Age at first use	**.04**															16.45	5.99
3. Premeditation	.02	**.05**														2.87	0.40
4. Perseverance	-.02	**.04**	**.47**													2.89	0.40
5. Sensation seeking	**-.24**	-.03	-.04	**.21**												2.85	0.47
6. Positive urgency	**-.12**	-.02	**-.31**	**-.32**	**.19**											2.06	0.51
7. Negative urgency	.06	-.02	**-.25**	**-.35**	**.10**	**.66**										2.38	0.49
8. Social motives	.04	-.04	.03	.02	.06	**.18**	**.13**									2.67	1.05
9. Coping motives	.07	-.02	-.02	**-.09**	-.05	**.26**	**.30**	**.53**								2.20	1.05
10. Enhancement motives	-.04	-.05	.04	.05	**.18**	.02	.05	**.49**	**.28**							3.65	0.98
11. Conformity motives	**-.09**	-.02	**-.10**	**-.12**	-.05	**.31**	**.17**	**.33**	**.35**	-.07						1.48	0.77
12. Expansion motives	-.07	-.05	.01	-.04	**.09**	**.19**	**.13**	**.43**	**.50**	**.35**	**.29**					2.44	1.16
13. Marijuana PBS use	**.14**	**.10**	**.22**	**.19**	-.02	**-.14**	**-.11**	**-.13**	**-.22**	**-.14**	-.06	**-.21**				4.15	0.94
14. Marijuana use frequency	**-.13**	-.06	-.04	-.06	.03	.03	.02	**.16**	**.24**	**.23**	-.03	**.28**	**-.48**			5.76	6.92
15. Marijuana consequences	**-.14**	**-.10**	**-.16**	**-.17**	.02	**.21**	**.25**	**.15**	**.28**	**.11**	**.18**	**.21**	**-.40**	**.35**		8.91	7.83

Notes: Sex was coded 0 = *male,* 1 = *female.* Significant correlations are in **bold** typeface for emphasis and were determined by a 99% bias-corrected bootstrapped confidence interval (based on 10,000 bootstrapped samples) that does not contain zero.

use and marijuana outcomes, we conducted a comprehensive structural equation model (SEM) in which the proposed distal antecedents (i.e., age at first use, sex, impulsivity-like traits, and motives) were modeled as predictors of marijuana-related consequences via marijuana PBS use and marijuana use frequency (e.g., age at first use → marijuana PBS use → marijuana use frequency → marijuana-related consequences). To test the comprehensive model, structural equation modeling using Mplus 7.4 (Muthén & Muthén, 1998–2012) was conducted.

To evaluate overall model fit, we used model fit criteria suggested by Hu and Bentler (1999) including the comparative fit index (CFI) > .95, Tucker–Lewis index (TLI) > .95, root mean square error of approximation (RMSEA) < .06, and standardized root mean square residual (SRMR) < .08. To reduce the complexity of the model, we followed the item-to-construct balance approach described by Little and colleagues (2002) by creating parcels for impulsivity-like traits, marijuana PBS use, and marijuana-related consequences. We first confirmed and then extracted a single factor in exploratory factor analyses for each latent construct, sorted the items from highest to lowest factor loadings, and created three to five balanced parcels by pairing items with the highest factor loadings with items with the lowest factor loadings. A supplementary table of the correlations among the parcels and items used as indicators of the latent factors in the model are available from the authors on request.

We examined the total, direct, and indirect effects of each predictor variable on outcomes using bias-corrected bootstrapped estimates (Efron & Tibshirani, 1993) based on 10,000 bootstrapped samples, which provides a powerful test of mediation (Fritz & MacKinnon, 2007) and is robust to small departures from normality (Erceg-Hurn & Mirosevich, 2008). Parameters were estimated using maximum likelihood estimation, and missing data were handled using full information maximum likelihood, which is more efficient and has less bias than alternative procedures (Enders, 2001; Enders & Bandalos, 2001). Given our large sample size (i.e., large statistical power), statistical significance was determined by 99% bias-corrected bootstrapped confidence intervals that do not contain zero. Moreover, given our large statistical power we place emphasis on effect sizes of significant direct and indirect results.

Results

All bivariate correlations and descriptive statistics among distal antecedents, marijuana PBS use, and marijuana outcomes in the comprehensive model are summarized in Table 1. All total, direct, and indirect associations are shown in Table 2. After item parceling, the SEM provided an acceptable fit to the data based on most fit indices (CFI = .928; TLI = .919; RMSEA = .046, 90% CI [.045, .047], SRMR = .049). The significant model chi-square, $\chi^2(1, 223) = 6{,}746.04$, $p < .001$, would suggest poor model fit; however, the model chi-square is highly sensitive to sample size (Jöreskog & Sörbom, 1993; Kline, 1998).

Marijuana PBS use and marijuana-related outcomes

Marijuana PBS use was significantly negatively associated with marijuana use frequency ($\beta = -.47$) and marijuana-related consequences ($\beta = -.26$), and marijuana use frequency was significantly positively associated with marijuana-related consequences ($\beta = .19$). As expected by these direct associations, marijuana use frequency significantly mediated the associations between marijuana PBS use and marijuana related consequences (indirect $\beta = -.09$) accounting for 25.38% of the total effect.

Direct and indirect effects of sex on marijuana-related outcomes

Sex was significantly positively associated with marijuana PBS use ($\beta = .16$; women reported higher PBS use) and significantly negatively associated with both marijuana use frequency ($\beta = -.07$) and marijuana-related consequences ($\beta = -.10$; women reported lower marijuana use frequency and consequences). As could be expected by these direct associations, marijuana PBS use significantly mediated the associations between sex and marijuana use frequency (indirect $\beta = -.08$) accounting for 53.42% of the total effect, and the associations between sex and marijuana-related consequences (indirect $\beta = -.04$), accounting for 24.60% of the total effect. Further, the double-mediated association (i.e., sex → marijuana PBS use → marijuana use frequency → marijuana-related problems) was significant (indirect $\beta = -.01$), accounting for 8.38% of the total effect.

Direct and indirect effects of age at first use on marijuana-related outcomes

Despite significant (although weak) bivariate correlations, age at first use did not have a significant direct association with marijuana PBS use, marijuana use frequency, or marijuana-related consequences when examined in the comprehensive model.

Direct and indirect effects of impulsivity-like traits on marijuana-related outcomes

Of the five impulsivity-like traits, only premeditation ($\beta = .18$) and perseverance ($\beta = .11$) were significantly associated with marijuana PBS use; however, neither were directly significantly associated with marijuana outcomes. Marijuana PBS use significantly mediated the associations between premeditation and marijuana use frequency (indirect $\beta = -.08$; fully mediated) and the associations between premeditation and marijuana-related consequences (indirect $\beta = -.05$), accounting for 45.71% of the total effect. Further, the double-mediated association (i.e., premeditation → marijuana PBS use → marijuana use frequency → marijuana-related problems) was significant (indirect $\beta = -.02$), accounting for 15.67% of the total effect. Similarly, marijuana PBS use significantly mediated the associations between perseverance and marijuana use frequency (indirect $\beta = -.05$) accounting for 57.96% of the total effect, and the associations between perseverance and marijuana-related consequences (indirect $\beta = -.03$), accounting for 55.66% of the total effect. However, the double-mediated association (i.e., perseverance → marijuana PBS use → marijuana use frequency → marijuana-related problems) was not significant. The only significant direct association between impulsivity-like traits and marijuana outcomes

was found between negative urgency and marijuana-related consequences ($\beta = .23$). Positive urgency and sensation seeking did not have uniquely significant direct associations with marijuana PBS use, marijuana use frequency, or marijuana-related consequences (Table 2).

Marijuana use motives

Coping motives was significantly negatively associated with marijuana PBS use ($\beta = -.22$) and significantly positively associated with both marijuana use frequency ($\beta = .10$) and marijuana-related consequences ($\beta = .11$). Marijuana PBS use significantly mediated the associations between coping motives and marijuana use frequency (indirect $\beta = .10$) accounting for 49.83% of the total effect, and the associations between coping motives and marijuana-related consequences (indirect $\beta = .06$), accounting for 26.82% of the total effect. Further, the double-mediated association (i.e., coping motives → marijuana PBS use → marijuana use frequency → marijuana-related problems) was significant (indirect $\beta = .02$), accounting for 9.04% of the total effect.

Expansion motives was significantly negatively associated with marijuana PBS use ($\beta = -.13$) and significantly positively associated with marijuana use frequency ($\beta = .13$). Marijuana PBS use significantly mediated the associations between expansion motives and marijuana use frequency (indirect $\beta = .06$) accounting for 32.49% of the total effect, and the associations between expansion motives and marijuana-related consequences (indirect $\beta = .03$), accounting for 47.01% of the total effect. Further, the double-mediated association (i.e., expansion motives → marijuana PBS use → marijuana use frequency → marijuana-related problems) was significant (indirect $\beta = .01$), accounting for 16.42% of the total effect.

Counterintuitively, conformity motives were significantly positively associated with marijuana PBS use ($\beta = .10$) and marijuana-related consequences ($\beta = .12$) but significantly negatively associated with marijuana use frequency ($\beta = -.10$). Marijuana PBS use significantly mediated the associations between conformity motives and marijuana use frequency (indirect $\beta = -.05$) accounting for 32% of the total effect, and the associations between coping motives and marijuana-related consequences (indirect $\beta = -.03$), accounting for 42.62% of the total effect. However, the double-mediated association (i.e., conformity motives → marijuana PBS use → marijuana use frequency → marijuana-related problems) was not significant. Enhancement motives had a uniquely significant positive direct effect on marijuana use frequency ($\beta = .08$) but did not have uniquely significant direct associations with marijuana PBS use and marijuana-related consequences. Social motives did not have uniquely significant direct associations with marijuana PBS use, marijuana use frequency, and marijuana-related consequences.

TABLE 2.   Summary of total, indirect, and direct effects of distal antecedents and marijuana protective behavioral strategy (PBS) use on marijuana outcomes in a comprehensive model

| | Outcome variables | | | | | |
| | Marijuana PBS use | | Marijuana use frequency | | Marijuana related consequences | |
Predictor variable	β	[99% CI]	β	[99% CI]	β	[99% CI]
Sex						
Total	**.16**	**[.10, .22]**	**-.14**	**[-.20, -.08]**	**-.17**	**[-.23, -.11]**
Total indirect[a]	–	–	**-.08**	**[-.11, -.05]**	**-.07**	**[-.09, -.04]**
Marijuana PBS use	–	–	**-.08**	**[-.11, -.05]**	**-.04**	**[-.06, -.02]**
Marijuana use frequency	–	–	–	–	**-.01**	**[-.02, -.00]**
Marijuana PBS use – marijuana use frequency	–	–	–	–	**-.01**	**[-.02, -.01]**
Direct	**.16**	**[.10, .22]**	**-.07**	**[-.12, -.01]**	**-.10**	**[-.16, -.04]**
Age at first use						
Total	.07	[-.07, .21]	-.04	[-.15, .08]	-.08	[-.19, .03]
Total indirect[a]	–	–	-.03	[-.10, .03]	-.03	[-.08, .03]
Marijuana PBS use	–	–	-.03	[-.10, .03]	-.02	[-.05, .02]
Marijuana use frequency	–	–	–	–	-.00	[-.01, .01]
Marijuana PBS use – marijuana use frequency	–	–	–	–	-.01	[-.02, .01]
Direct	.07	[-.07, .21]	-.00	[-.06, .06]	-.06	[-.12, .01]
Premeditation						
Total	**.18**	**[.09, .27]**	-.04	[-.12, .05]	-.10	[-2.10, .10]
Total indirect[a]	–	–	**-.08**	**[-.13, -.04]**	**-.05**	**[-.01, -.02]**
Marijuana use frequency	–	–	–	–	.01	[-1.27, .37]
Marijuana PBS use – marijuana use frequency	–	–	–	–	**-.02**	**[-.03, -.01]**
Direct	**.18**	**[.09, .27]**	.05	[-.03, .12]	-.05	[-.15, .05]
Perseverance						
Total	**.11**	**[.01, .20]**	-.09	[-.18, .01]	-.05	[-.15, .05]
Total indirect[a]	–	–	**-.05**	**[-.10, -.00]**	**-.04**	**[-.08, -.01]**
Marijuana PBS use	–	–	**-.05**	**[-.10, -.00]**	**-.03**	**[-.05, -.00]**
Marijuana use frequency	–	–	–	–	-.01	[-.02, .01]
Marijuana PBS use – marijuana use frequency	–	–	–	–	-.01	[-.02, .00]
Direct	**.11**	**[.01, .20]**	-.04	[-.12, .05]	-.01	[-.10, .09]
Sensation seeking						
Total	.01	[-.06, .09]	-.01	[-.08, .07]	-.02	[-.11, .06]
Total indirect[a]	–	–	-.01	[-.04, .03]	-.01	[-.01, .01]
Marijuana PBS use	–	–	-.01	[-.04, .03]	.00	[-.02, .02]
Marijuana use frequency	–	–	–	–	-.00	[-.42, .34]
Marijuana PBS use – marijuana use frequency	–	–	–	–	-.00	[-.01, .01]
Direct	.01	[-.06, .09]	-.00	[-.07, .07]	-.02	[-.10, .06]
Positive urgency						
Total	-.02	[-.12, .09]	-.03	[-.13, .08]	-.08	[-.19, .03]
Total indirect[a]	–	–	.01	[-.04, .06]	.00	[-.04, .04]
Marijuana PBS use	–	–	.01	[-.04, .06]	.00	[-.02, .03]
Marijuana use frequency	–	–	–	–	-.01	[-.02, .01]
Marijuana PBS use – marijuana use frequency	–	–	–	–	.00	[-.01, .01]
Direct	-.02	[-.12, .09]	-.03	[-.12, .06]	-.08	[-.18, .03]
Negative urgency						
Total	.05	[-.05, .16]	-.06	[-.16, .04]	**.21**	**[.09, .32]**
Total indirect[a]	–	–	-.03	[-.07, .02]	-.02	[-.06, .02]
Marijuana PBS use	–	–	-.03	[-.07, .02]	-.01	[-.04, .01]
Marijuana use frequency	–	–	–	–	-.01	[-.02, .01]
Marijuana PBS use – marijuana use frequency	–	–	–	–	-.01	[-.01, .01]
Direct	.05	[-.05, .16]	-.03	[-.13, .06]	**.23**	**[.13, .33]**
Social motives						
Total	-.03	[-.11, .06]	.00	[-.09, .09]	-.02	[-.11, .07]
Total indirect[a]	–	–	.01	[-.03, .05]	.01	[-.04, .04]
Marijuana PBS use	–	–	.01	[-.03, .05]	.01	[-.02, .03]
Marijuana use frequency	–	–	–	–	-.00	[-.02, .01]
Marijuana PBS use – marijuana use frequency	–	–	–	–	.00	[-.01, .01]
Direct	-.03	[-.11, .06]	-.01	[-.09, .07]	-.03	[-.11, .05]

Table continued

TABLE 2. *Continued*

| | Outcome variables | | | | | |
| | Marijuana PBS use | | Marijuana use frequency | | Marijuana related consequences | |
Predictor variable	β	[99% CI]	β	[99% CI]	β	[99% CI]
Coping motives						
Total	**-.22**	**[-.30, -.14]**	**.20**	**[.12, .29]**	**.21**	**[.13, .29]**
Total indirect[a]	–	–	**.10**	**[.07, .14]**	**.09**	**[.06, .13]**
Marijuana PBS use	–	–	**.10**	**[.07, .14]**	**.06**	**[.03, .08]**
Marijuana use frequency	–	–	–	–	**.02**	**[.00, .04]**
Marijuana PBS use – marijuana use frequency	–	–	–	–	**.02**	**[.01, .03]**
Direct	**-.22**	**[-.30, -.14]**	**.10**	**[.03, .18]**	**.11**	**[.04, .19]**
Enhancement motives						
Total	-.06	[-.16, .03]	**.11**	**[.03, .19]**	.04	[-.05, .12]
Total indirect[a]	–	–	.03	[-.02, .08]	**.04**	**[.00, .07]**
Marijuana PBS use	–	–	.03	[-.02, .08]	.02	[-.01, .04]
Marijuana use frequency	–	–	–	–	.02	[-.00, .03]
Marijuana PBS use – marijuana use frequency	–	–	–	–	.01	[-.00, .01]
Direct	-.06	[-.16, .03]	**.08**	**[.01, .16]**	-.00	[-.08, .08]
Conformity motives						
Total	**.10**	**[.02, .19]**	**-.15**	**[-.23, -.07]**	.06	[-.04, .16]
Total indirect[a]	–	–	**-.05**	**[-.09, -.01]**	**-.05**	**[-.09, -.02]**
Marijuana PBS use	–	–	**-.05**	**[-.09, -.01]**	**-.03**	**[-.05, -.00]**
Marijuana use frequency	–	–	–	–	**-.02**	**[-.03, -.00]**
Marijuana PBS use – marijuana use frequency	–	–	–	–	-.01	[-.02, .00]
Direct	**.10**	**[.02, .19]**	**-.10**	**[-.18, -.03]**	**.12**	**[.03, .21]**
Expansion motives						
Total	**-.13**	**[-.19, -.06]**	**.19**	**[.11, .27]**	**.07**	**[.00, .14]**
Total indirect[a]	–	–	**.06**	**[.03, .10]**	**.07**	**[.04, .10]**
Marijuana PBS use	–	–	**.06**	**[.03, .10]**	**.03**	**[.01, .06]**
Marijuana use frequency	–	–	–	–	**.02**	**[.01, .04]**
Marijuana PBS use – marijuana use frequency	–	–	–	–	**.01**	**[.00, .02]**
Direct	**-.13**	**[-.19, -.06]**	**.13**	**[.06, .20]**	.00	[-.07, .07]
PBS use						
Total	–	–	**-.47**	**[-.53, -.41]**	**-.35**	**[-.41, -.28]**
Total indirect (marijuana use frequency)	–	–	–	–	**-.09**	**[-.13, -.05]**
Direct	–	–	**-.47**	**[.53, -.41]**	**-.26**	**[-.34, -.17]**

Notes: Significant associations are in **bold** typeface for emphasis and were determined by a 99% bias-corrected unstandardized bootstrapped confidence interval (based on 10,000 bootstrapped samples) that does not contain zero. [a]Reflects the combined indirect associations via marijuana PBS use, marijuana use frequency, marijuana PBS use via marijuana use frequency.

Discussion

The present study examined the direct effects of several risk and protective factors of marijuana related outcomes, and examined marijuana PBS use as a potential mediator of the associations between these risk/protective factors and marijuana-related outcomes. As the legal status of marijuana use has begun to shift, researchers have begun to question which scientific findings that have been explored with other substances will translate to marijuana. For example, there is a large body of literature establishing a robust negative relationship between PBS use and alcohol use and related consequences (Pearson, 2013; Prince et al., 2013); however, research on PBS use aimed at reducing marijuana outcomes is in its infancy. As such, it was an important first step to

establish that our findings are consistent with Pedersen et al. (2016) in that marijuana PBS use was associated with lower marijuana use frequency and experiencing fewer marijuana-related consequences.

Next, a principle aim of the present study was to examine whether certain risk and protective factors for alcohol outcomes serve the same function for marijuana outcomes through examining direct associations in the context of a comprehensive SEM. We found significant direct effects for (a) sex, coping motives, conformity motives, and marijuana PBS use for both marijuana use frequency and marijuana-related consequences; (b) enhancement motives and expansion motives for marijuana use frequency but not marijuana-related consequences; and (c) negative urgency for marijuana-related consequences but not marijuana use frequency.

For age at first use, premeditation, perseverance, sensation seeking, positive urgency, and social motives, neither the direct effects to marijuana use frequency nor marijuana-related consequences were significant. This pattern of findings could be explained, in part, by our implementation of a comprehensive model (Bravo et al., 2016). Indeed, for a direct effect to remain significant it would need to explain unique variance in the outcome over and above the other predictor variables. However, given our large sample size, we had sufficient power to run a comprehensive model, which has the advantage of testing many effects simultaneously and providing insights into the unique strength of each predictor variable while controlling for the other predictor variables.

To summarize our direct effects, nearly all effects were in the expected direction with risk factors being associated with greater marijuana use frequency and more marijuana-related consequences and protective factors being associated with less frequent marijuana use and fewer marijuana-related consequences. Consistent with previous research, conformity motives was actually associated with less marijuana use (Zvolensky et al., 2007). Moreover, we found that risk factors for marijuana use (e.g., coping motives) were associated with using fewer marijuana PBS and protective factors for marijuana use (e.g., premeditation) were associated with using more marijuana PBS.

Importantly, marijuana PBS use partially mediated the associations between several risk/protective factors and marijuana-related outcomes. Specifically, marijuana PBS fully or partially mediated the effects of sex, premeditation, perseverance, coping motives, enhancement motives, conformity motives, and expansion motives on marijuana outcomes. These results are consistent with recent replication attempts in the alcohol PBS literature demonstrating alcohol PBS use as a mediator between age at drinking onset, drinking motives, impulsivity-like traits, and alcohol outcomes (Bravo et al., 2015, 2016). Taken together, marijuana PBS is not only a robust predictor of marijuana use frequency and marijuana-related consequences but also a good candidate to be considered as a mechanism by which marijuana users moderate their marijuana use and attenuate their risk of experiencing marijuana-related consequences.

Clinical implications

The present study has a number of important clinical implications. Based on the current sample, we can identify certain characteristics that might be particularly good targets for marijuana PBS-based intervention efforts. For example, our results indicate that female college students tend to use marijuana less often, experience fewer marijuana-related consequences, and use more marijuana PBS. On the one hand, these results suggest that female college students seeking help for their marijuana use may be receptive to marijuana PBS in the context of a marijuana intervention. On

the other hand, it may be men who would benefit most from increasing their marijuana PBS use, given the strong negative association between marijuana PBS use and marijuana use and related consequences. Similarly, those who tend to use marijuana for coping motives or expansion motives may also benefit from an intervention targeting marijuana PBS use.

Limitations

The present study should be considered in light of its limitations. First, this was a cross-sectional study, which precludes any causal inferences to be drawn from the results. Second, the present sample, although large, may not be representative of all college student marijuana users nationwide as the sample was collected from participant pools from 11 universities. Third, unlike many alcohol studies, we looked at frequency of marijuana use but not quantity of marijuana use. This decision was made in part because of the challenges of standardizing the quantity of marijuana use. Last, marijuana PBS use as measured by the PBSM is focused more on avoidance strategies than the most common alcohol measure (i.e., the Protective Behavior Strategies Survey; Martens et al., 2005), which may weaken direct comparisons between marijuana PBS studies and alcohol PBS studies.

Conclusions

The present study identified marijuana PBS as a robust predictor of marijuana use frequency and marijuana-related consequences, as well as establishing preliminary evidence for marijuana PBS as a mediator of a variety of risk/protective factors of marijuana outcomes. These results have a variety of clinical implications, including supporting the potential benefit of a marijuana PBS-focused intervention for college student marijuana users. The present study identified that most (but not all) distal antecedents of marijuana outcomes were significant in the comprehensive model, suggesting that future studies should continue to elucidate total and unique effects of specific antecedents on marijuana-related outcomes. Although the present study provides some preliminary insights into the role of marijuana PBS use in the relationship between distal antecedents and marijuana use frequency and marijuana-related consequences, more research is needed to replicate and extend the current findings.

References

Barnett, N. P., Murphy, J. G., Colby, S. M., & Monti, P. M. (2007). Efficacy of counselor vs. computer-delivered intervention with mandated college students. *Addictive Behaviors, 32,* 2529–2548. doi:10.1016/j.addbeh.2007.06.017

Bravo, A. J., Prince, M. A., & Pearson, M. R. (2015). Does the how mediate the why? A multiple replication examination of drinking mo-

tives, alcohol protective behavioral strategies, and alcohol outcomes. *Journal of Studies on Alcohol and Drugs, 76,* 872–883. doi:10.15288/jsad.2015.76.872

Bravo, A. J., Prince, M. A., & Pearson, M. R. (2016). A multiple replication examination of distal antecedents to alcohol protective behavioral strategies. *Journal of Studies on Alcohol and Drugs, 77,* 958–967. doi:10.15288/jsad.2016.77.958

Caldeira, K. M., Arria, A. M., O'Grady, K. E., Vincent, K. B., & Wish, E. D. (2008). The occurrence of cannabis use disorders and other cannabis-related problems among first-year college students. *Addictive Behaviors, 33,* 397–411. doi:10.1016/j.addbeh.2007.10.001

Chen, C.-Y., Storr, C. L., & Anthony, J. C. (2009). Early-onset drug use and risk for drug dependence problems. *Addictive Behaviors, 34,* 319–322. doi:10.1016/j.addbeh.2008.10.021

Collins, R. L., Parks, G. A., & Marlatt, G. A. (1985). Social determinants of alcohol consumption: The effects of social interaction and model status on the self-administration of alcohol. *Journal of Consulting and Clinical Psychology, 53,* 189–200. doi:10.1037/0022-006X.53.2.189

Cyders, M. A., Smith, G. T., Spillane, N. S., Fischer, S., Annus, A. M., & Peterson, C. (2007). Integration of impulsivity and positive mood to predict risky behavior: Development and validation of a measure of positive urgency. *Psychological Assessment, 19,* 107–118. doi:10.1037/1040-3590.19.1.107

Dvorak, R. D., & Day, A. M. (2014). Marijuana and self-regulation: Examining likelihood and intensity of use and problems. *Addictive Behaviors, 39,* 709–712. doi:10.1016/j.addbeh.2013.11.001

Dvorak, R. D., Pearson, M. R., Neighbors, C., & Martens, M. P. (2015). Fitting in and standing out: Increasing the use of alcohol protective behavioral strategies with a deviance regulation intervention. *Journal of Consulting and Clinical Psychology, 83,* 482–493. doi:10.1037/a0038902

Dvorak, R. D., Pearson, M. R., Neighbors, C., Martens, M. P., Stevenson, B. L., & Kuvaas, N. J. (2016). A road paved with safe intentions: Increasing intentions to use alcohol protective behavioral strategies via Deviance Regulation Theory. *Health Psychology, 35,* 604–613. doi:10.1037/hea0000327

Efron, B., & Tibshirani, R. J. (1993). *An introduction to the bootstrap.* Boca Raton, FL: CRC Press.

Enders, C. K. (2001). The impact of nonnormality on full information maximum-likelihood estimation for structural equation models with missing data. *Psychological Methods, 6,* 352–370. doi:10.1037/1082-989X.6.4.352

Enders, C. K., & Bandalos, D. L. (2001). The relative performance of full information maximum likelihood estimation for missing data in structural equation models. *Structural Equation Modeling: A Multidisciplinary Journal, 8,* 430–457. doi:10.1207/S15328007SEM0803_5

Erceg-Hurn, D. M., & Mirosevich, V. M. (2008). Modern robust statistical methods: An easy way to maximize the accuracy and power of your research. *American Psychologist, 63,* 591–601. doi:10.1037/0003-066X.63.7.591

Farmer, R. F., Kosty, D. B., Seeley, J. R., Duncan, S. C., Lynskey, M. T., Rohde, P., . . . Lewinsohn, P. M. (2015). Natural course of cannabis use disorders. *Psychological Medicine, 45,* 63–72. doi:10.1017/S003329171400107X

Fritz, M. S., & Mackinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological Science, 18,* 233–239. doi:10.1111/j.1467-9280.2007.01882.x

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6,* 1–55. doi:10.1080/10705519909540118

Johnston, L. D., O'Malley, P. M., Bachman, J. G., Schulenberg, J. E., & Miech, R. A. (2015). *Monitoring the Future national survey results on drug use, 1975–2014: Volume 2, College students and adults ages 19–55.* Ann Arbor, MI: Institute for Social Research, The University of Michigan.

Jöreskog, K. G., & Sörbom, D. (1993). *LISREL 8: User's guide.* Chicago, IL: Scientific Software.

Kaiser, A. J., Milich, R., Lynam, D. R., & Charnigo, R. J. (2012). Negative urgency, distress tolerance, and substance abuse among college students. *Addictive Behaviors, 37,* 1075–1083. doi:10.1016/j.addbeh.2012.04.017

Kline, R. B. (1998). *Principles and practice of structural equation modeling.* New York, NY: Guilford Press.

Larimer, M. E., Lee, C. M., Kilmer, J. R., Fabiano, P. M., Stark, C. B., Geisner, I. M., . . . Neighbors, C. (2007). Personalized mailed feedback for college drinking prevention: A randomized clinical trial. *Journal of Consulting and Clinical Psychology, 75,* 285–293. doi:10.1037/0022-006X.75.2.285

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling: A Multidisciplinary Journal, 9,* 151–173. doi:10.1207/S15328007SEM0902_1

Lynam, D. R., Smith, G. T., Whiteside, S. P., & Cyders, M. A. (2006). *The UPPS-P: Assessing five personality pathways to impulsive behavior.* West Lafayette, IN: Purdue University.

Martens, M. P., Ferrier, A. G., Sheehy, M. J., Corbett, K., Anderson, D. A., & Simmons, A. (2005). Development of the Protective Behavioral Strategies Survey. *Journal of Studies on Alcohol, 66,* 698–705. doi:10.15288/jsa.2005.66.698

Murphy, J. G., Dennhardt, A. A., Skidmore, J. R., Borsari, B., Barnett, N. P., Colby, S. M., & Martens, M. P. (2012). A randomized controlled trial of a behavioral economic supplement to brief motivational interventions for college drinking. *Journal of Consulting and Clinical Psychology, 80,* 876–886. doi:10.1037/a0028763

Muthén, L. K., & Muthén, B. O. (1998–2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Authors.

Pearson, M. R. (2013). Use of alcohol protective behavioral strategies among college students: A critical review. *Clinical Psychology Review, 33,* 1025–1040. doi:10.1016/j.cpr.2013.08.006

Pearson, M. R., Liese, B. S., Dvorak, R. D., & Marijuana Outcomes Study Team. (2017). College student marijuana involvement: Perceptions, use, and consequences across 11 college campuses. *Addictive Behaviors, 66,* 83–89. doi:10.1016/j.addbeh.2016.10.019

Pedersen, E. R., Hummer, J. F., Rinker, D. V., Traylor, Z. K., & Neighbors, C. (2016). Measuring protective behavioral strategies for marijuana use among young adults. *Journal of Studies on Alcohol and Drugs, 77,* 441–450. doi:10.15288/jsad.2016.77.441

Prince, M. A., Carey, K. B., & Maisto, S. A. (2013). Protective behavioral strategies for reducing alcohol involvement: A review of the methodological issues. *Addictive Behaviors, 38,* 2343–2351. doi:10.1016/j.addbeh.2013.03.010

Robinson, J. M., Ladd, B. O., & Anderson, K. G. (2014). When you see it, let it be: Urgency, mindfulness and adolescent substance use. *Addictive Behaviors, 39,* 1038–1041. doi:10.1016/j.addbeh.2014.02.011

Simons, J., Correia, C. J., Carey, K. B., & Borsari, B. E. (1998). Validating a five-factor marijuana motives measure: Relations with use, problems, and alcohol motives. *Journal of Counseling Psychology, 45,* 265–273. doi:10.1037/0022-0167.45.3.265

Simons, J. S., Dvorak, R. D., Merrill, J. E., & Read, J. P. (2012). Dimensions and severity of marijuana consequences: Development and validation of the Marijuana Consequences Questionnaire (MACQ). *Addictive Behaviors, 37,* 613–621. doi:10.1016/j.addbeh.2012.01.008

Smith, G. T., Fischer, S., Cyders, M. A., Annus, A. M., Spillane, N. S., & McCarthy, D. M. (2007). On the validity and utility of discriminating among impulsivity-like traits. *Assessment, 14,* 155–170. doi:10.1177/1073191106295527

Wardell, J. D., Strang, N. M., & Hendershot, C. S. (2016). Negative urgency mediates the relationship between childhood maltreatment and problems with alcohol and cannabis in late adolescence. *Addictive Behaviors, 56,* 1–7. doi:10.1016/j.addbeh.2016.01.003

Whiteside, S. P., & Lynam, D. R. (2001). The Five Factor Model and impulsivity: Using a structural model of personality to understand impulsiv-ity. *Personality and Individual Differences, 30,* 669–689. doi:10.1016/S0191-8869(00)00064-7

Zvolensky, M. J., Vujanovic, A. A., Bernstein, A., Bonn-Miller, M. O., Marshall, E. C., & Leyro, T. M. (2007). Marijuana use motives: A confirmatory test and evaluation among young adult marijuana users. *Addictive Behaviors, 32,* 3122–3130. doi:10.1016/j.addbeh.2007.06.010