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Factor analysis of a short form of the Protective Behavioral Strategies for Marijuana scale

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Abstract

Objective: The Protective Behavioral Strategies for Marijuana Scale (PBSM), a 17-item scale targeting strategies for mitigating the negative consequences of cannabis use, highlights a range of behaviors that can reduce harm beyond straightforward decreases in quantity or frequency. The 17-item scale's factor structure remains under-examined but could reveal meaningful distinctions among strategies. This study aimed to confirm the factor structure of the short form of the PBSM.

Methods: This study recruited cannabis-using undergraduates ($N = 454$, $M_{age} = 19.6$, 68.8% female, 39% White), who reported using cannabis approximately 2.3 days per week with mild cannabis-related consequences (CAPQ; $M = 9.74$).

Results: A confirmatory factor analysis demonstrated poor fit for the one-factor model of the PBSM, prompting an exploratory factor analysis. Analyses revealed two internally reliable factors: a "Quantity" factor, strategies specific to mitigating overuse and limiting amounts consumed and an "Context" factor loosely related to troubles with others. This two-factor model accounted for over half of the total variance; invariance testing indicated reduced fit as models became more restrictive. Though each of the factors covaried negatively with both days of use and problems, Context had a stronger relation to both variables compared to Quantity. Only Context predicted fewer cannabis problems and use.

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All authors significantly contributed to and approved the final version of this manuscript for publication.

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Declaration of Competing Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Conclusions: The two-factor solution suggests further work on the psychometric properties of the scale could provide heuristic information to allow for more nuanced approaches in clinical and research settings. Theoretically, each factor might have novel links to some constructs but not others in ways that could assist harm-reduction strategies and treatment.

Keywords

Cannabis; Marijuana; Protective behavioral strategies; Cannabis problems

1. Introduction

In the United States, approximately 43.5 million individuals used cannabis in 2018, over 40% of which were emerging adults (Substance Abuse and Mental Health Services Administration, 2019). Ten percent of these individuals endorse problematic use consistent with cannabis use disorder (CUD). Heavy, frequent cannabis use increases with both mental and physical health concerns, and covaries with occupational, academic, and interpersonal impairments (Caldeira et al., 2008; Volkow et al., 2014).

Despite negative consequences related to cannabis use, not all use leads to problems (Pardini et al., 2015; White et al., 2015). Furthermore, many users report improvements with sleep problems, chronic pain and illness, and anxiety (Altman et al., 2019; Fischer et al., 2015; Webb & Webb, 2014). Several factors influence cannabis consumption and outcomes, including the use of protective behavioral strategies (PBS). PBS are intentional strategies that can mitigate negative consequences of substance use. PBS are noted to decrease alcohol-induced troubles and negative use-related consequences; PBS are similarly related to cannabis use and problems (Araas & Adams, 2008; Martens et al., 2005, 2007; Pearson, 2013; Pedersen et al., 2016; Prince et al., 2013). Several studies target PBS among college students in an effort to develop harm reduction interventions for safer substance use (Pearson, 2013).

The development of the Protective Behavioral Strategies for Marijuana scale provided a method for examining cannabis-specific harm reduction strategies (PBSM; Pedersen et al., 2016). Researchers initially began with 50 items drawn from a review of protective strategies used by young adult cannabis users. Following an iterative principal component analysis, a final 39-item unidimensional scale of best fit accounted for 34% of the total variance with high internal reliability (Cronbach’s alpha = 0.95). This scale negatively associated with cannabis use and consequences, and covaried positively with alcohol PBS.

The 50-item PBSM was further validated in a diverse, multi-state sample of college students (Pedersen et al., 2017). An exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) warranted the removal of six and eight items, respectively, due to poor loadings and overlapping content wording. Examination of the factor structure of the longer forms of the scale indicated a one-factor solution to be the best fit. Initial item response theory (IRT) analyses supported an underlying latent construct with acceptable internal consistency for the 36-item scale. Differential item functioning (DIF) analyses led to a 17-item short form invariant across gender, race, ethnicity, and recreational cannabis legal status. This short form negatively covaried with cannabis use and problems, consistent with previous findings for the longer scales.

Several forms of PBSM appear helpful in college and community samples, for both research queries and clinical interventions (Bravo et al., 2017; Prince et al., 2019, 2019b; Wong et al., 2019). Variations of this scale, such as the short form, might prove to be especially helpful for specific populations. Relatedly, particular protective behavioral strategies could be useful for targeting different kinds of cannabis users or patterns of harm. Given the unidimensional nature of the present short form, less is known about the utility of specific PBS or their unique relation to certain cannabis outcomes. In this study, we sought to confirm and explore the factor structure of the 17-item short form PBSM in young adult cannabis users.

2. Method

2.1. Participants

Participants were drawn from two samples of undergraduate students enrolled at a public university in the Northeast, where medical cannabis is legalized, but recreational cannabis is not. Both samples were recruited through an undergraduate research pool; interested students opted-in to complete brief web-based surveys anonymously. Both surveys queried participants about demographics, cannabis use, PBS, and problems. Surveys were hosted on Qualtrics, an online survey platform. Two hundred and twenty-seven participants (M_{age} = 19.9, 70.6% Female) and 253 participants (M_{age} = 19.2, 67.1% Female) consented and completed the study. We excluded participants who endorsed no lifetime cannabis use, and used pairwise deletion to remove one case that failed to complete more than three items in the PBSM; no participants failed to complete more than three items on the CAPQ. We examined a final sample of 454 (M_{age} = 19.6, SD = 3). No differences in cannabis problems, cannabis use, or PBS were observed between samples (t_{use} = 0.92, df = 448, t_{prob} = 0.09, df = 453, t_{PBS} = 1.03, df = 433, $p > .05$). Our sample was largely female (68.8%). Approximately 39% of our sample identified as White, followed by 26.7% as Asian, 12.9% as Black, 8.7% as multiracial, 7.3% as Hispanic/Latinx, 4.2% as other, and 1.1% as Native-American. All procedures were in accordance with and approved by the Institutional Review Board.

3. Measures

3.1. Demographics and cannabis use

Participants provided demographic information on age, gender, and race/ethnicity. Individuals who endorsed lifetime cannabis use reported weekly cannabis use (0–7).

3.2. Cannabis problems

Participants completed the Cannabis-Associated Problems Questionnaire (CAPQ) to assess for cannabis-related consequences. The CAPQ is a 19-item, self-report measure cannabis-related problems, adapted for lifetime use (Lavender et al., 2008) across several domains (Stephens et al., 2000, 1994). Participants respond on a 0–5 Likert scale (0 = “No” to 5 = “Yes, very many times, or a very serious problem”), which is summed to calculate a global score. The CAPQ demonstrated high internal reliability in our sample (Cronbach's alpha = 0.92).

3.3. Protective behavioral strategies

Participants endorsed cannabis-specific protective behaviors with the Protective Behaviors for Marijuana Scale (PBSM; Pedersen et al., 2016). This 17-item, self-report measure asks participants to indicate strategies used to mitigate problematic cannabis use or negative consequences. Participants can provide the extent to which they endorse the behavior while using cannabis (0 = "Never" to 5 = "Always"), which is totaled for a global score. Among respondents, the PBSM had high internal reliability (Cronbach's alpha = 0.92). Item endorsements for this scale can be found in Table 1.

3.4. Data analysis

Descriptive analyses were performed on all variables to test assumptions prior to factor analyses. We determined our sample size to be appropriate following sampling guidelines of 300 or more for factor analyses recommended by Tabachnick and Fidell (2013). The CAPQ's positive skew (2.32) decreased meaningfully (−0.1) after a Box-Cox transformation (Osborne, 2013). First, we performed a CFA to replicate previous work that revealed a unidimensional structure (Pedersen et al., 2016). We then used an EFA to further examine the scale. Parallel analysis suggested that a two-factor solution could be appropriate (Horn, 1965). Factor 2's negative skew (−1.47), reduced to an acceptable level with the removal of outliers that fell more than three standard deviations away from the mean ($n = 9$; skew = −1.04). Finally, we examined relations between factors and cannabis problems and use, and differences by gender and race. Prior work indicates gender differences on cannabis outcomes and interactions between PBSM and cannabis outcomes; thus, we included gender as a covariate for our analyses (Bravo et al., 2017; Khan et al., 2013). Two hierarchical linear regression models predicted cannabis use and problems from both factors, with gender as a covariate for both, and use as a covariate for cannabis problems. For cannabis use, step 1 included gender (male), step 2 added Quantity (factor 1), and step 3 added Context (factor 2). For cannabis problems, step 1 included gender (male), step 2 added cannabis use, step 3 added Quantity (factor 1) and step 4 added Context (factor 2). Finally, we examined measurement invariance by gender and race/ethnicity separately on each factor using goodness-of-fit indices (GFI) through multigroup confirmatory factor analysis (MGCFA). We first freely estimated parameters among groups (for gender and race/ethnicity), then examined consistency in the underlying factor structure through a configural invariance model, followed by increasingly restrictive models that included equal factor loadings (metric invariance), equal item intercepts (scalar invariance), and item uniqueness (strict factorial invariance). Invariance was supported if both the restrictive model and less restrictive model fit, evidenced by nonsignificant $\Delta\chi^2$ and comparative fit index (ΔCFI) < 0.002 (Cheung & Rensvold, 1999). Descriptively, race/ethnicity was examined by individual categories (White, Black, Asian, Hispanic/Latinx, Native American, multiracial); for further comparisons, race was collapsed into a binary variable (White and ethnic minority). The CFA was completed on SAS University Edition, invariance testing was performed using the lavaan package in R, and all other analyses were completed on SPSS 25.0.

4. Results

4.1. Sample characteristics

On average, participants used cannabis 2.3 days a week ($SD = 2.7$). Our sample endorsed mild cannabis-related problems on average ($M = 9.74$, $SD = 12.6$, range: 0–72) and moderate degrees of PBSM ($M = 56.3$, $SD = 19$, range: 0–85). Weekly use, problems, and PSBM were comparable across race ($t = 0.52$, $df = 444$; $t = -0.42$, $df = 444$; $t = -0.24$, $df = 429$, respectively, $p > .05$). Weekly use and problems were comparable between men and women ($t = 1.1$, $df = 447$; $t = 1.8$, $df = 448$, respectively, $p > .05$); women endorsed a higher degree of PBSM ($t = -3.1$ $df = 432$, $p < .01$).

4.2. Confirmatory factor analysis

This analysis was executed with the PROC CALIS command on SAS. We examined the fit of the one-factor model, by dividing the absolute chi-square value by its degrees of freedom (chi-square/df). Following Kline's recommendation, a good fit for this statistic would include a value less than or equal to 3 (Kline, 2015). Our fit statistic indicated the model to be a poor fit for this sample, as the chi-square was nearly seven times greater than the degrees of freedom ($\chi^2 = 716.71$, $df = 119$, $p < .001$). Alternative measures of fit also suggested problems. Generally, indices of good fit include: RMSEA < 0.08, SRMR < 0.08, CFI > 0.90, NFI > 0.90, and NNFI > 0.95 (Tabachnick & Fidell, 2013; Kline, 2015). While SRMR indicated good fit (SRMR = 0.07), remaining indices demonstrated a poor fit (RMSEA = 0.108, CFI = 0.827, NNFI = 0.80, NFI = 0.80). All factor loadings in our model were significant at $p < .0001$; t-values ranged from 11.81 to 32.38 (Table 2). Wald tests and Lagrange Multiplier failed to suggest meaningful improvements from simple addition or subtraction of paths; thus, the model was not respecified. Given the poor fit of the one-factor model and the lack of obvious ways to improve the fit via deletion or addition of paths, we explored the factor structure of the PBSM.

4.3. Exploratory factor analysis

The first level of extraction was completed with a principal axis factor extraction with the 17 items of the PBSM. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.93 and the Bartlett's test of sphericity was significant ($\chi^2 = 3538.3$, $df = 136$, $p < .001$), demonstrating adequate factorability to proceed with further analyses. Three factors were detected with eigenvalues factor loadings greater than or equal to 1 (eigenvalues = 7.51, 1.40, 1.41). Further examination of the scree plot in conjunction with a parallel analysis comparison eliminated factor 3, demonstrating a two-factor extraction was most appropriate (Hayton et al., 2004; Horn, 1965). We re-specified our analysis to extract two factors. Both the KMO and Bartlett's test demonstrated acceptability for factor extraction (KMO = 0.93; Bartlett's test of sphericity, $\chi^2 = 3538.3$, $df = 136$, $p < .001$). A two-factor model was appropriate (eigenvalues = 7.51, 1.40), accounting for 52.4% of the variance in this measure. Examination of correlations (0.73) demonstrated considerable associations between factors, suggesting a promax (oblique) rotation was appropriate.

Applying a promax rotation to the two-factor model revealed that six unique items mapped on to Factor 1, with seven unique items mapped on to Factor 2, and four items mapped on to both factors. Items shared between both factors failed to demonstrate a margin>0.20, indicating they should be dropped from both factors. All loadings were>0.30. A final analysis with the four shared items removed demonstrated that Factor 1 accounted for 42.96% of the total variance, and factor loadings ranged from 0.409 to 0.824 (Table 2). Items included “set frequency of hits,” and “limiting amount of marijuana in one sitting.” These items generally related to “Quantity” PBS. This factor demonstrated good internal reliability (Cronbach’s alpha = 0.85). Factor 2 accounted for 10.69% of the total variance, with factor loadings ranging from 0.403 to 0.767 (Table 2). Items included, “avoiding use with family,” and “avoiding using marijuana in public.” This factor was best characterized as “Context” PBS. Context demonstrated acceptable internal inconsistency (Cronbach’s alpha = 0.81).

4.4. Factor relations with demographics, use, and problems

Factor scores were examined across gender and race. Quantity and Context were more strongly endorsed by women compared to men ($t = -2.7$, $df = 430$; $t = -3.3$, $df = 429$, respectively, $p < .01$). Both factors were comparable between White and ethnic minority participants (Quantity: $t = -0.66$, $df = 427$; Context: $t = 0.15$, $df = 426$, $p > .05$). Quantity and Context had moderate-to-strong negative associations with weekly use ($r = -0.29$, $r = -0.40$, $p < .001$). Additionally, both factors negatively covaried with problems ($r = -0.27$, $r = -0.38$, $p < .001$). As scores increased on both Quantity and Context PBS, cannabis use and problems decreased. We followed the procedure for comparing correlated correlation coefficients by Meng, Rosenthal, and Rubin (1992), which determined that Context had a significant stronger relation to fewer overall problems and less use than Quantity ($t_{use} = 13.11$, $t_{problems} = 12.87$, $p < .001$). The statistical significance of this find requires cautious interpretation given the large sample size. The 27.5% absolute difference of 0.11 accounts for less than 1/5 of 1% of the variance. We further examined these associations for men and women separately. General trends between both genders appear comparable to the overall sample, though men demonstrate a stronger association between each factor and cannabis use ($r_{Quantity} = -0.45$, $r_{context} = -0.52$, $p < .001$), compared to women ($r_{Quantity} = -0.21$, $r_{context} = -0.35$, $p < .001$). Additionally, women appear to have a slightly stronger association between Context and cannabis problems ($r = -0.42$, $p < .001$), compared to Quantity and cannabis problems ($r = -0.25$, $p < .001$), about a 40% difference in magnitude of association. The first association appears to account for 17.6% of the variance, while the second accounts for 6.3%. These associations do not appear to differ for men ($r = -0.28$, and -0.30, $p < .001$, respectively). All correlations can be found in Table 3.

Hierarchical regression models examined both factors in predicting cannabis problems and use, with gender as a covariate for both, and cannabis use an additional covariate for predicting problems. The three-step model was not significant at step 1 (gender), but was significant at step 2 (gender and Quantity), with Quantity significantly predicting less cannabis use ($\beta_{Quantity} = -0.31$; $F_{(2, 409)} = 22.0$, $p < .001$, $R^2 = 0.09$). At step 3, only context ($\beta_{Context} = -0.37$; $p < .\ 001$) and gender ($\beta_{males} = -0.10$, $p < .05$;) significantly predicted less cannabis use ($F_{(3, 408)} = 31.0$, $p < .001$; $R^2 = 0.18$) at the final step of the model. A four-step model predicting cannabis problems was significant at step 1, finding that identifying as male significantly predicted more problems ($\beta = 0.10$; $F_{(1, 409)} = 4.08$, $p < .05$, $R^2 = 0.01$).

The model was significant at step 2 ($F_{(2, 408)}$ = 14.41, $p < .001$, $R^2 = 0.06$), with both gender and cannabis use predicting more problems ($\beta_{male} = 0.11$; $p < .05$; $\beta_{use} = 0.24$, $p < .001$). Step 3 was also significant ($F_{(3, 407)}$ = 15.65, $p < .001$, $R^2 = 0.10$). Gender was no longer a significant predictor, but cannabis use predicted more problems ($\beta_{use} = 0.17$, $p < .05$), while Quantity predicted less problems ($\beta_{Quantity} = -0.21$, $p < .001$). Finally, the model was significant at step 4 ($F_{(4, 406)}$ = 20.28, $p < .001$, $R^2 = 0.16$), with Context as the sole predictor of fewer cannabis problems ($\beta_{Context} = -0.33$, $p < .001$). Full results appear in Tables 4 and 5.

4.5. Invariance testing

Multigroup confirmatory factor analyses were performed to examine if the 2-factor model of the PBSM was invariant across gender and race. We first examined the model fit across gender. The 2-factor model adequately fit for both men and women based on CFI (men = 0.889; women = 0.894), RMSEA (men = 0.088, p < .01; women = 0.08, p < .001), and SRMR (men = 0.068, women = 0.06) indices, with TLI indicated marginal fit (TLI_{men} = 0.865, TLI_{women} = 0.871; see Table 6). We found that the acceptable fit for the configural model across gender for most indices, with TLI again demonstrating marginal fit. The metric model indicated similarly invariance across gender based on the nonsignificant $\Delta\chi^2$ test, but not the ΔCFI criterion (0.004). The scalar model again demonstrated a non-significant$\Delta\chi^2$ test but failed to find a ΔCFI less than 0.002 (0.005). Finally, results from the strict factorial model revealed that neither criterion was met for invariance across gender ($\Delta\chi^2$ = 38.5, p < .001; ΔCFI = 0.015).

We performed the same set of analyses to determine if the 2-factor model of the PBSM was invariant across race/ethnicity. The 2-factor model indicated acceptable to marginal fit for White and ethnic minority (EM) samples across all indices (CFI_{white} = 0.883, CFI_{EM} = 0.897; TLI_{white}. = 0.858, TLI_{EM} = 0.864; $RMSEA_{white}$ = 0.078, $p < .05$; $RMSEA_{EM}$ = 0.086, $p < .001$; $SRMR_{white}$ = 0. 068, $SRMR_{EM}$ = 0.059). The configural model again indicated acceptable fit for most indices across race/ethnicity. Metric and scalar invariance were both demonstrated by both a non-significant $\Delta\chi^2$ test and CFI less than 0.002. Strict factorial invariance was supported by the non-significant $\Delta\chi^2$ test, but not ΔCFI (0.003).

5. Discussion

Our study demonstrated the factorability of the 17-item short form of the PBSM in undergraduate cannabis users. Initial confirmatory analyses demonstrated a poor fit for the one-factor 17-item scale, suggesting further examination of the measure’s underlying factor structure. Analyses revealed two factors with high internal reliability, Quantity and Context, that accounted for 53.7% of the total variance. Higher endorsement of each factor related to less cannabis use and fewer cannabis-related problems. Additionally, while both factors predicted less use, only Context predicted fewer problems. Invariance testing revealed poorer fit with more restrictive models, suggesting potential limitations with the two-factor model among diverse populations.

These findings are consistent with work examining longer forms of the PBSM. In addition to being inversely linked with use and problems, PBSM potentially buffers against risk factors for cannabis problems (Bravo et al., 2017). For example, sensation-seeking, a potential risk factor for problems, moderated the link such that high sensation-seekers showed a strong negative correlation between PBSM and negative consequences. PBSM also mediates the association between insomnia and negative use consequences, such that increased insomnia related to poor PBSM use, increasing the likelihood of cannabis-related problems (Wong et al., 2019). While both PBSM factors in our study covaried with select cannabis outcomes, the Context factor notably predicted fewer problems and less use. Our results indicated the while Quantity-specific PBS predicted less use, it was no longer a significant predictor with the addition of the Context factor. Context was the sole predictor for less use, and this pattern was similarly found for our model predicting fewer cannabis problems. While reducing quantity of cannabis use is an appealing intervention to reduce harms, these results indicate that context-specific strategies might be especially helpful for cannabis users. Prior work indicates that contextual factors, such as solitary use or to motivation to use cannabis to reduce anxiety around peers, can increase risk for CUD and cannabis-related impairment (Brodbeck et al., 2007; Creswell et al., 2015). Targeting these factors with context-specific could be a more effective strategy to mitigate cannabis harms. Further study might reveal unique links with other relevant constructs. For example, Context might target effects related to more potent cannabis products (e.g. self-reported intoxication) or the context of use (e.g. social context) which both influence use-related consequences. Moreover, this subscale might disrupt negative social consequences, possibly by relating to personality factors (e.g. sensation seeking) or interpersonal styles (e.g. attachment, dysfunctional attitudes) associated with riskier use. This could be consistent with our finding that Context alone predicted fewer problems. Similarly, the Quantity subscale might prove helpful in assessing frequency of use or patterns of heavy use that could lead to unintended intoxication and consequences. Results of the invariance testing do temper the generalizability of our findings. As the fit of the model dropped with more restrictive criteria, further work is certainly needed to examine and validate the 2-factor form across diverse populations. Nevertheless, the subscales of this form do appear to offer unique insights regarding cannabis outcomes. This work recommends a more nuanced examination of PBS dimensions.

Validation of the 17-item PBSM has future research and clinical implications. While the majority of interventions assess effectiveness through reductions in use or negative outcomes, PBS offers an alternative strategy (Copeland et al., 2001; Fischer et al., 2013; Gates et al., 2016). PBSM operates within a harm reduction framework for substance use treatment. Harm reduction preserves the dignity of substance-using individuals while offering pragmatic strategies for mitigating negative outcomes of use (Hunt et al., 2003). Interventions enhancing PBS can lead to increase safety behaviors, planned episodes of use, and less severe consequences. These include outcomes valuable in reducing harm not typically targeted or assessed. Interventions targeting PBS for cannabis use are limited, though results appear promising for problematic alcohol use (Barnett et al., 2007; Braitman & Henson, 2016; Kenney et al., 2014; Prince et al., 2013, 2019a; Riggs et al., 2018). Our results indicate that quantity-reducing methods might provide an overall benefit to cannabis users; importantly, enhancing social or contextual-related PBS might more effectively target particular problems. Specifically, two factors provide a framework for generating items with focused subscales that might buffer against certain types of problems. Users whose negative consequences are primarily associated with finances, fatigue, and respiratory irritation might benefit most from Quantity-focused interventions. In contrast, those whose negative consequences include failed obligations, interpersonal conflicts, or legal issues, might benefit most from interventions related to Context.

One PBSM targeted intervention increased strategies in women only, but failed to do so in men (Riggs et al., 2018). Relatedly, women in our sample indicated higher endorsement of total PBSM and both factors. While women tend to perceive use as risky, men are more likely to be diagnosed with CUD and report heavier cannabis use patterns (Cuttler et al., 2016; Khan et al., 2013; Pacek et al., 2015). While further work examining PBSM gender differences is needed, future interventions might benefit from enhancing PBSM among male users. Broadly, the short form of the PBSM has appealing utility in ongoing intervention efforts to mitigate cannabis-related harms.

The present study is not without limitations. Participants were recruited from an undergraduate research pool. Previous studies examining the psychometric properties of the PBSM also employed college students, but replication in clinical and community samples is essential. This recommendation is especially important given the measurement invariance findings. Given that are sample was unequal in breakdowns of gender and race, further invariance testing should be applied to validate the 2-factor form. Moreover, students resided in a state without recreational cannabis legalization, limiting generalizability. Certain PBSM strategies might appear less relevant or helpful in particular contexts, such as in states where cannabis is not legalized, or if participants are not encountering others while using cannabis. While potential ceiling effects of PBSM can occur, all items were endorsed to some extent by nearly 80% of our sample. Interestingly, quantitative were the less endorsed strategies. Additionally, the examination of factors with relevant cannabis outcomes was limited to use and problems. Differences between the factors might be better elucidated given a broader selection of outcome variables, such as social/contextual factors of use, personality dimensions, and other measures of consumption, such quantity or intoxication. Future studies should further examine additional relevant constructs related to both factors, including a more diverse range of outcome measures related to cannabis use. The Quantity factor had good internal reliability and Context factor demonstrated lower, but acceptable, reliability. Additional items might improve the scope of this factor in capturing Context-related strategies. Finally, overall invariance of the 2-factor model of the PBSM across race/ethnicity and gender was generally supported but not for all indices. Comparisons across gender, including our higher scores among women here and gender-related differences in attempts to increase protective behaviors (Riggs et al., 2018), will require cautious interpretation until the gender invariance has replicated elsewhere (See De Jong et al., 2007; Khorramdel et al., 2020). Researchers can rest assured that comparisons across groups using the single-factor total score will continue to provide valuable information for reducing cannabis use and related harms. Nevertheless, additional looks at the proposed 2-factor model in large, diverse samples also appears justified.

In sum, we believe our study offers increased psychometric support for the brief form of the PBSM. Future work should continue to replicate and confirm the psychometric properties of the PBSM. Our works offers an exploratory analysis yielded two factors of Quantity and Context strategies, suggesting nuanced applications of the scale in future work. Continued efforts to bolster harm reduction interventions can benefit from targeting and monitoring changes in PBSM to mitigate potentially harmful consequences resulting from cannabis use.

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Table 1

Item endorsements to the 17-item PBSM.

	Sample Mean (SD) (*N* = 454)	% who did not endorse strategy
1. Use only among trusted peers	3.92 (1.37)	4.0
2. Avoid use while with family	4.07 (1.47)	6.2
3. Avoid using before work or school	4.02 (1.42)	4.9
4. Avoid using to cope with emotions	2.90 (1.80)	13.8
5. Limit use to weekends	2.75 (1.87)	19.5
6. Only purchase marijuana from trusted source	4.05 (1.44)	5.3
7. Avoid using habitually	3.21 (1.90)	14.6
8. Use little at a time	3.00 (1.72)	12.9
9. Avoiding mixing marijuana with other drugs	3.86 (1.63)	6.9
10. Avoid using in public	3.56 (0.45)	6.0
11. Take breaks if using too frequently	3.49 (1.07)	8.9
12. Buy less to smoke less	2.59 (0.95)	22.9
13. Have set amount of hits	2.73 (1.09)	21.4
14. Avoid methods leading more intoxication	2.55 (0.94)	20.9
15. Only use one time during day/night	3.08 (1.79)	13.8
16. Limit amount to smoke in one sitting	3.08 (1.72)	11.2
17. Avoid using before physical activity	3.59 (1.64)	8.5

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Table 2

Confirmatory and Exploratory Factor Analysis of the 17-item Protective Behavioral Strategies for Marijuana Scale.

	Confirmatory (1 Factor)	Exploratory (2 Factor)	
Item		**Factor 1 (Quantity)**	**Factor 2 (Context)**
16. Limit amount to smoke in one sitting	**0.771**	**0.824**	
13. Have set amount of hits	**0.576**	**0.786**	
14. Avoid methods leading more intoxication	**0.677**	**0.774**	
12. Buy less to smoke less	**0.582**	**0.690**	
15. Only use one time during day/night	**0.718**	**0.514**	
8. Use little at a time	**0.612**	**0.409**	
3. Avoid using before work or school	**. 681**		**0.767**
2. Avoid use while with family	**0.602**		**0.748**
1. Use only among trusted peers	**0.434**		**0.609**
6. Only purchase marijuana from trusted source	**0.466**		**0.600**
10. Avoid using in public	**0.630**		**0.574**
9. Avoid mixing with other	**0.583**		**0.517**
4. Avoid using to cope with emotions	**0.558**		**0.403**
7. Avoid using habitually	**0.742**		
5. Limit use to weekends	**0.735**		
11. Take breaks if using too frequently	**. 750**		
17. Avoid using before physical activity	**. 630**		
% of Variance		**42.96**	**10.69**

Table 3

Bivariate associations between Factors, Use, and Problems.

	1	2	3
Total Sample			
(1) Quantity			
(2) Context	0.58**		
(3) Use	−0.29**	−0.40**	
(4) Global CAPQ	−0.27**	−0.38**	0.23**
CAPQ_partner	−0.14*	−0.14**	
CAPQ_family	−0.12**	−0.25**	
CAPQ_familyneglect	−0.10*	−0.26**	
CAPQ_friends	−0.11*	−0.17**	
Male			
(1) Quantity			
(2) Context	0.60**		
(3) Use	−0.45**	−0.52**	
(4) Global CAPQ	−0.30**	−0.28**	0.27**
Female			
(1) Quantity			
(2) Context	0.55**		
(3) Use	−0.21**	−0.35**	
(4) Global CAPQ	−0.25**	−0.42**	0.22**

Note: Bivariate correlations for individual CAPQ items (1–4) were only examined in relation to the two factors.

*$p < .05$,

**$p < .001$.

Table 4

Predicting Cannabis Use from Factor 1 and 2, and gender.

Variable	B	SEB	T	β [95%CI]	sr^2	Adj. R^2
Step 1						0.000
Male	−0.10	0.23	−0.44	−0.02[−0.55, 0.35]	−0.02	
Step 2						0.097**
Male	−0.31	0.22	−1.4	−0.07[−0.74, 0.12]	−0.07	
Quantity	−0.04	0.006	−6.6	−0.31**[−0.06, −0.03]	−0.31	
Step 3						0.088**
Male	−0.43	0.21	−2.1	−0.10*[−0.83, −0.02]	−0.10	
Quantity	−0.01	0.01	−1.8	−0.10[−0.03, −0.01]	−0.08	
Context	−0.06	0.01	−6.6	−0.37**[−0.08, −0.04]	−0.30	

Note: Gender was dummy coded (Male = 1, Female = −1)

* $p < .05$,

** $p < .001$.

Table 5

Predicting Cannabis Problems from Factor 1 and 2, use, and gender.

Variable	B	SEB	T	β [95%CI]	sr^2	Adj. R^2
Step 1						0.01 *
Male	0.49	0.22	2.01	0.10 *[0.01, 0.97]	0.1	
Step 2						0.06 **
Male	0.52	0.24	2.2	0.11 *[0.06, 0.99]	0.11	
Cannabis Use	0.26	0.05	5.0	0.24 **[0.15, 0.36]	0.24	
Step 3						0.04 **
Male	0.37	0.24	1.6	0.08[−0.10, 0.83]	0.07	
Cannabis Use	0.19	0.05	3.5	*0.17[0.08, 0.30]	0.17	
Quantity	−0.03	0.01	−4.1	**−0.21 [−0.04, −0.02]	−0.20	
Step 3						0.06 **
Male	0.24	0.23	1.1	0.05[−0.21, 0.70	0.05	
Cannabis Use	0.10	0.06	1.8	0.09[−0.01, 0.20]	0.08	
Quantity	−0.01	0.01	−0.73	−0.12[−0.02, 0.01]	−0.03	
Context	−0.06	0.01	−5.6	**−0.33[−0.08, −0.04]	−0.25	

Note: Gender was dummy coded (Male = 1, Female = − 1)

* $p < .05$,

** $p < .001$

Table 6

Test of Measurement Invariance for 2-factor form of the PBSM.

Model fit within groups for gender											
	χ^2	**df**	**CFI**	**TLI**	**RMSEA**	**SRMR**					
Men	130.42**	64	0.889	0.865	0.088* (0.066, 0.110)	0.068					
Women	181.77**	64	0.894	0.871	0.080** (0.066, 0.093)	0.060					
Model fit within groups for gender											
White	127.7**	64	0.883	0.858	0.078* (0.058, 0.098)	0.068					
Ethnic Minority	186.5**	64	0.897	0.864	0.086** (0.072, 0.100)	0.059					
Measurement Invariance Across Gender											
	χ^2	**df**	**CFI**	**TLI**	**RMSEA**	**SRMR**		**ΔCFI**	**ΔTLI**	**ΔRMSEA**	**$\Delta\chi^2$**
Configural	312.19**	128	0.892	0.868	0.082** (0.071, 0.084)	0.063					
Metric	330.07**	139	0.888	0.874	0.080** (0.069, 0.092)	0.07	Configural vs Metric	0.0040	−0.006	0.002	17.88
Scalar	348.99**	150	0.883	0.879	0.079** (0.068, 0.090)	0.073	Metric vs. Scalar	0.0046	−0.005	0.01	18.93
Strict Factorial	387.49**	163	0.868	0.874	0.081** (0.070, 0.091)	0.076	Scalar vs. Strict	0.0149	0.005	−0.002	38.5**
Measurement Invariance Across Race											
	χ^2	**df**	**CFI**	**TLI**	**RMSEA**	**SRMR**		**ΔCFI**	**ΔTLI**	**ΔRMSEA**	**$\Delta\chi^2$**
Configural	314.20**	128	0.892	0.869	0.083** (0.071, 0.095)	0.062					
Metric	319.74**	139	0.896	0.883	0.078** (0.067, 0.090)	0.064	Configural vs Metric	−0.0031	−0.014	0.005	5.51
Scalar	328.08**	150	0.897	0.893	0.075** (0.064, 0.086)	0.065	Metric vs. Scalar	−0.0015	−0.01	0.003	8.36
Strict Factorial	376.43**	163	0.894	0.898	0.073** (0.062, 0.084)	0.068	Scalar vs. Strict	0.0032	−0.005	0.002	18.68

* $p < .05$,

** $p < .001$