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Psychometric Properties of the French and English Short Form of the Protective Behavioral Strategies for Marijuana Scale in Canadian University Students

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TITLE PAGE

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Original Research

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ABSTRACT

Background: The Protective Behavioral Strategies for Marijuana (PBSM) scale serves to identify and measure strategies employed by young adults before, during or after using cannabis. After adapting and translating the instrument into French following a systematic procedure, a methodological study was conducted to evaluate the psychometric properties of this French version (FV) and of the PBSM-17 original English version (EV) in a sample of bilingual Canadian university students.

Methods: A total of 211 cannabis users (mean age=22.1 years) completed a sociodemographic questionnaire, a question on frequency of cannabis use (4 categories: 1-3 times a month, once a week, more than once a week, everyday), and both versions (FV and EV) of the PBSM-17.

Results: Both versions had similar internal reliability (α=0.91;α=0.88). The one-factor solution explained 42.26% of the variance for the EV and 36.46% for the FV. As hypothesized, greater use of protective behavioral strategies (PBS) was related to lower frequency of cannabis use. One-way ANOVA test results revealed a statistically significant difference in use of strategies by frequency of cannabis use for both the FV ($F(3, 207)=27.38$, $p<0.001$) and EV ($F(3, 207)=29.32$, $p<0.001$). Post hoc comparisons showed that everyday users employed fewer strategies on average than did lower-frequency users.

Conclusion: The English and French versions of the scale demonstrated satisfactory psychometric properties. The proposed FV of the PBSM-17 is a reliable instrument that could be used for research and clinical purposes. PBS can serve as indicator of lower-risk cannabis use and should be targeted in prevention interventions.

Keywords: Cannabis, Psychometric evaluation, Scale, Protective behavioral strategies, University students.

ARTICLE SUMMARY

Strengths and limitations of the study

- The legalization of cannabis use affords the opportunity to set up prevention initiatives to promote safer consumption behaviors
- The use of protective behavioral strategies (PBS) is a robust predictor of outcomes such as frequency of cannabis use and cannabis-related harms.
- This article reports on full psychometric properties of the English version of the Protective Behavioral Strategies for Marijuana short form (PBSM-17) and its French translation in a Canadian context.
- This validation of psychometric properties was conducted among a sample of university students, thus they might not necessarily be representative of the entire adult population.
- The PBSM-17 is a reliable instrument that could be used for research and clinical purposes in the context of the prevention and promotion of safe cannabis use.

MAIN TEXT

Psychometric Properties of the French and English Short Form of the Protective Behavioral Strategies for Marijuana Scale in Canadian University Students

INTRODUCTION

Prospective cohort studies suggest that substance use generally begins in adolescence and peaks in young adulthood [1]. In Canada, 18- to 24-year-olds constitute the age group with the highest proportion of cannabis users [2]. Canada was the first G7 country to legalize cannabis consumption for recreational purposes nationwide. According to Degenhardt and colleagues [1], substance availability, access and regulatory environment are factors that affect substance use in young people. Legalization, then, affords the opportunity to put forth initiatives aimed at reducing cannabis-related harms such as risk behaviors, social-interpersonal consequences and impaired control [3].

Bravo and colleagues stressed that using protective behavioral strategies (PBS) could help regulate cannabis use and even reduce the associated negative consequences [4]. PBS were initially tied to the context of young adult alcohol use [5]. They were conceptualized as behaviors used immediately prior to, during, and/or after a drinking episode to reduce alcohol misuse and/or alcohol-related harm. In a critical review of the literature, Pearson et al. concluded that PBS were indeed promising ways to reduce alcohol misuse and the negative consequences of drinking [6]. Transferring PBS to the context of cannabis use, Bravo et al. carried out a cohort study of 2,000 students from 11 universities in the United States. It showed PBS use to be a robust predictor of outcomes such as

frequency of cannabis use and cannabis-related harms (e.g., social-interpersonal consequences, impaired control, and risk behaviors) [7]. Examples of PBS include avoiding using marijuana while spending time with family, avoiding mixing marijuana with other drugs, and purchasing marijuana from a trusted source [8]. Considering that PBS use could mitigate the harms related to cannabis use, it is of great importance to develop a reliable tool for the purpose of measuring the extent to which these strategies are used by young adults.

In 2016, Pedersen and colleagues developed the Protective Behavioral Strategies for Marijuana (PBSM) scale to identify and measure the strategies employed by young adult cannabis users [8]. In their initial exploratory study with 210 college student marijuana users, they developed the PBSM scale from a pool of 50 items reduced to a single-factor 39-item measure through iterative principal component analysis. Initial psychometric properties revealed excellent internal consistency (α=0.95) and convergent validity with a measure of alcohol PBS [8]. In their subsequent work, Pedersen et al. sought to validate the PBSM scale further with a larger and more diverse sample (n=2,117, 40% men, 30% non-White) of college students from 11 different universities across the United States [9]. Two versions of the scale, the 36-item version (PBSM-36) and the 17-item short form (PBSM-17), were developed and tested. Advanced factor analytic techniques (i.e., confirmatory factor analysis) and advanced item response theory techniques confirmed the unidimensionality and good content coverage of both the PBSM-36 and the PBSM-17 [9]. The correlation between the two was high (r=0.98, p<0.001). Both versions demonstrated appreciable criterion-related validity and were strongly and negatively associated with past-month marijuana use and consequences. Also, they were free of bias in terms of gender, race and ethnicity [9].

There is no denying that the short form of the scale (PBSM-17) can be of great value as it requires less time to complete. This renders it highly appealing for use in both research and clinical settings where professionals have limited time and interaction with research participants and patients. The

PBSM-17 however was not available in French and had never been adapted to the Canadian context until recently. The aim of this methodological study was to evaluate the psychometric properties of the English and French short forms of the PBSM scale in a sample of bilingual university students in the province of Quebec, Canada.

METHODS

The study was conducted according to the methodology proposed by Sousa and Rojjanasrirat for translating, adapting and validating the psychometric properties of scales. How the PBSM-17 was translated into French and adapted to the Canadian context is covered elsewhere [10]. This article reports specifically on the fidelity (internal consistency and inter-item correlation), construct validity (factor analysis) and criterion-related validity of the English version of the PBSM-17 and its French translation in a sample of bilingual university students.

This study was approved by the CHUM Research Ethics Board (20.172) and by the *Comité d'éthique de la recherche en sciences et en santé (CERSES)* of the *Université de Montréal* (CERSES-20-114-D). All participants provided informed consent.

Selection and Description of Participants

The study was conducted with a sample of university students from the province of Quebec, Canada. A convenience sampling strategy was used to recruit participants through social media, specifically the Université de Montréal Students Facebook Groups. Interested students were invited to visit the study webpage using a mobile device connected to the Internet (smartphone, tablet or laptop) in order to complete the online survey. Students 18 years old or over, who used cannabis at least once in the past month and were bilingual (i.e., proficiency in written French and English) were included.

Online Data Collection

The study was conducted entirely online. LimeSurvey, an online survey system, was used to complete consent forms and questionnaires. After accepting the conditions and consenting, students were invited to complete a short sociodemographic questionnaire, one question on frequency of cannabis use, the French version of the PBSM-17, and the original English version of the PBSM-17. Eligibility criteria evaluation was integrated in the online questionnaire: participants who reported no cannabis use in the past year or less than once a month were not invited to complete the rest of the survey (i.e., completion of the PBSM-17 was conditional on current cannabis use). Participants who completed the survey were compensated for their time with a $10 Amazon.ca gift certificate.

Outcome Measures

Participants completed a brief sociodemographic questionnaire covering age, gender self-identification, ethnicity and student status (full-time/part-time, graduate/undergraduate).

They were asked to rate their frequency of cannabis use by answering the following question from the Canadian Community Health Survey [11]: "How often did you use cannabis in the past 12 months?". Frequency was measured on a six-point scale: 1) never, 2) less than once a month, 3) 1 to 3 times a month, 4) once a week, 5) more than once a week, and 6) every day.

Participants were asked how often they resorted to employing 17 PBS when they used cannabis. Frequency of PBS use was rated on a six-point Likert scale: 1) never, 2) rarely, 3) occasionally, 4) sometimes, 5) usually, and 6) always. As suggested by Pedersen et al., (2017) the overall score was calculated by tallying the numbers corresponding to the answers given and converting this raw total to a t-score. There were no subscales. The higher the score, the greater the use of PBS.

For this study, participants were asked to complete the original English and the translated French versions of the PBSM-17. For the former, the order of the items was shuffled, as recommended by Sousa and Rojjanasrirat (2011).

Sample Size

Following Sousa and Rojjanasrirat's guideline [12] of about 10 participants per item for general psychometric approaches (17 items * 10 participants = 170) and projecting that 15% of participants might have missing data, we targeted a rounded-up total sample size of 200 participants.

Statistics

Descriptive statistics were computed for each item (frequency distribution for categorical data and means with standard deviations for continuous variables). Fidelity was assessed by examining internal consistency (Cronbach's alpha) and inter-item correlation. As a general rule of thumb, a Cronbach's alpha higher than $\alpha = 0.70$ is considered adequate. Gliem and Gliem (2003) describe $\alpha = 0.80$ as a reasonable goal for internal consistency, and that higher alpha values can suggest higher internal consistency. These authors also describe an adequate corrected item-total correlation having a value of at least r=0.40 [13]. For descriptive purposes, the preliminary psychometric properties of the English and French versions of the scale were compared.

As in the original study [8], a factor analysis with a one-factor solution structure was performed to evaluate the construct validity. Criterion-related validity was evaluated by conducting a one-way ANOVA to determine whether PBSM scale mean scores differed by frequency of cannabis use.

All statistical analyses were run on SPSS version 26 (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.).

The creators of the PBSM scale were contacted for permission to translate and adapt the instrument. They were consulted during the translation process and reviewed the final manuscript. The tool is considered to be in the public domain and is available free of charge[1].

RESULTS

Sample Description

In September/October of 2020, 375 students provided consent, completed the sociodemographic questionnaire and answered the question on cannabis use frequency. Of these, 164 were excluded: 101 participants did not complete the two versions of the PBSM because they reported no cannabis use in the past year or using cannabis less than once a month (and were therefore not considered current cannabis users), 2 did not adhere with study procedures, and 61 had missing data. As a result, a total of 211 questionnaires were considered for analysis.

Mean age of participants was 22 years (range of 18 to 44). Most of them self-identified as women (61.1%) and as Caucasian (83.9%). Most were full-time students (88.2%) and undergrads (84.4%). Regarding frequency of cannabis use in the past 12 months, 46.9% indicated 1 to 3 times a month, 15.2% once a week, 22.3% more than once a week, and 15.6% every day.

Fidelity: Internal Consistency and Inter-item Correlation

Cronbach's alpha showed that the French version of the scale reached acceptable reliability, α=0.88. All of the items deserved retention; withdrawing any of them resulted in a lower alpha. Item-to-total corrected correlations ranged from r=0.38 to r=0.68 [Table 1]. Cronbach's alpha

[1] https://www.rand.org/health-care/surveys_tools.html

showed that the original English version of the short form reached acceptable internal reliability (α=0.91). Item-to-total corrected correlations ranged from r=0.45 to r=0.72 [Table 1].

Table 1. Inter-Item Correlation Matrix for the English version (above diagonal) and the French version (below diagonal) of the PBSM-17 (n=211)

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Item 14	Item 15	Item 16	Item 17
Item 1		0.409	0.470	0.380	0.463	0.495	0.490	0.431	0.513	0.459	0.311	0.248	0.308	0.390	0.487	0.501	0.526
Item 2	0.442		0.663	0.291	0.416	0.384	0.460	0.311	0.419	0.377	0.325	0.250	0.202	0.323	0.422	0.342	0.483
Item 3	0.456	0.619		0.376	0.384	0.436	0.411	0.273	0.408	0.398	0.271	0.200	0.176	0.341	0.358	0.371	0.626
Item 4	0.303	0.272	0.351		0.483	0.284	0.497	0.270	0.285	0.170	0.313	0.351	0.203	0.225	0.264	0.374	0.312
Item 5	0.450	0.392	0.354	0.389		0.316	0.659	0.514	0.452	0.439	0.480	0.331	0.355	0.329	0.477	0.544	0.399
Item 6	0.347	0.326	0.370	0.180	0.236		0.371	0.331	0.455	0.328	0.233	0.124	0.224	0.338	0.340	0.451	0.452
Item 7	0.442	0.363	0.425	0.363	0.659	0.285		0.474	0.399	0.361	0.622	0.402	0.298	0.300	0.502	0.490	0.490
Item 8	0.294	0.255	0.301	0.234	0.425	0.292	0.517		0.413	0.347	0.487	0.337	0.306	0.350	0.417	0.615	0.343
Item 9	0.387	0.325	0.343	0.250	0.410	0.379	0.398	0.399		0.446	0.312	0.168	0.278	0.394	0.422	0.473	0.403
Item 10	0.308	0.293	0.295	0.033	0.386	0.274	0.334	0.415	0.415		0.268	0.231	0.392	0.376	0.443	0.474	0.441
Item 11	0.290	0.375	0.361	0.284	0.397	0.141	0.544	0.408	0.315	0.239		0.473	0.276	0.272	0.440	0.431	0.395
Item 12	0.205	0.182	0.212	0.285	0.219	0.093	0.301	0.195	0.157	0.189	0.471		0.294	0.365	0.255	0.374	0.278
Item 13	0.241	0.198	0.178	0.091	0.277	0.171	0.291	0.251	0.299	0.343	0.303	0.227		0.309	0.308	0.484	0.204
Item 14	0.317	0.308	0.304	0.133	0.180	0.298	0.235	0.275	0.324	0.330	0.238	0.360	0.334		0.343	0.421	0.372
Item 15	0.308	0.309	0.286	0.111	0.253	0.238	0.287	0.272	0.384	0.271	0.320	0.151	0.231	0.307		0.566	0.416
Item 16	0.356	0.289	0.308	0.222	0.464	0.359	0.494	0.460	0.396	0.380	0.460	0.187	0.331	0.345	0.508		0.428
Item 17	0.424	0.426	0.566	0.242	0.316	0.312	0.424	0.267	0.332	0.282	0.445	0.241	0.214	0.311	0.374	0.379	

Construct Validity: Factor Analysis

A principal component analysis using a one-factor solution was performed to assess construct validity. In this sample, for the English version of the scale, the 17 items explained 42.26% of the variance, with factor loadings of 0.495 to 0.763. For the French version, it explained 36.46% of the variance, with factor loadings of 0.432 to 0.741 [Table 2].

Table 2. PBSM items and factor loadings by language version (n=211)

PBSM items	French version factor loadings	English version factor loadings
Item 1	0.652	0.725
Item 2	0.633	0.647
Item 3	0.670	0.655
Item 4	0.452	0.546
Item 5	0.684	0.740
Item 6	0.513	0.598
Item 7	0.741	0.757
Item 8	0.621	0.662
Item 9	0.643	0.664
Item 10	0.566	0.633
Item 11	0.652	0.628
Item 12	0.432	0.497
Item 13	0.471	0.495
Item 14	0.531	0.576
Item 15	0.549	0.687
Item 16	0.691	0.763
Item 17	0.652	0.695

Criterion-related Validity

To evaluate the criterion-related validity of the instruments, we examined the association between PBSM scale mean score and frequency of cannabis use. A negative relationship was hypothesized with higher mean scores on the PBSM (i.e., greater use of PBS) related to lower frequency of cannabis use. The one-way ANOVA test results revealed a statistically significant difference in use of marijuana PBS by frequency of cannabis use for the French version ($F(3, 207)=27.38$, $p<0.001$) and the English version ($F(3, 207) = 29.32$, $p<0.001$). Post hoc comparisons (using Bonferroni

correction) suggested that everyday cannabis users employed fewer marijuana PBS, on average, than did lower-frequency cannabis users. Additionally, people who used cannabis 1–3 times per month made significantly greater use of marijuana PBS than did those who used cannabis more than once a week [Figure 1].

Figure 1. Mean Score Plots

DISCUSSION

The objective of our methodological study was to evaluate the full psychometric properties of the English and French versions of the PBSM-17 in a sample of bilingual university students. The two versions had similar internal reliability (α=0.91 and α=0.88, respectively). To our knowledge, few studies have reported on the reliability of the short form of the scale. In Pedersen et al. (2017) too, the marginal reliability of the PBSM-17 was high (α=0.93). Similarly to what was observed with the original structure of the scale [8 9], the single-factor solution explained 42.26% of the variance for the English version and 36.46% for the French. Criterion-related validity, too, was established for both versions. PBS use differed by frequency of cannabis use, with, overall, greater use of PBS being associated with lower frequency of cannabis use.

Conducting rigorous psychometric assessments of instruments prior to their use in large-scale experimental studies is crucial. Multiple factors may impact the reliability obtained by an instrument such as the PBSM-17. These include scoring system, instrument's characteristics (e.g., item formulation, language), physical and emotional state of respondents at time of measure, and characteristics of context of administration [14]. This study addressed factors related to the instrument's characteristics, including item formulation and language, relevant to using the French version of the PBSM-17 with a sample of bilingual university students.

Both the English and the French versions of the PBSM-17 demonstrated satisfactory psychometric properties, in particular fidelity, construct validity and criterion-related validity. The PBSM-17 serves to assess strategies that can be applied prior to, during and after using cannabis. We validated the instruments in a population of university students, as did the creators of the PBSM. It is important to bear in mind that this student population is not necessarily representative of the adult population, which includes adults in the labor market. Also, the French version of the scale, like the English version, was developed and validated with current cannabis users as they were the ones who could resort to using the strategies under study.

It should be noted that the study took place in the context of the COVID-19 pandemic. Data collection was carried out at the start of the academic year in the fall of 2020, between the first and second waves of the pandemic in Canada.

When applied, PBS may limit frequency of marijuana use and the negative consequences associated with cannabis use. To our knowledge, PBS are not often used in research interventions. We found only two digital interventions that had PBS as an intervention target. The team led by Prince et al. [15] created a brief in-person intervention, including a smartphone application (MApp) to distribute tips related to PBS in order to reduce cannabis use. Another team, based in the United States, developed the Marijuana eCHECKUPTO GO, a web-based personalized feedback tool with normative information and PBS [16]. Their study results revealed a decrease in frequency of cannabis use among heavy-user college students who participated in the intervention. In the experimental group, females increased their use of PBS more than males did [16]. This suggests that PBS use should be considered as a target when developing interventions to encourage lower-risk cannabis use.

In the context of the prevention and promotion of safe cannabis use, the PBSM scale could be useful to both health professionals and community/social workers. It can be easily used in various

specialized but also non-specialized settings and contexts, such as primary care services, family practices, schools and community settings, and for various purposes, such as evaluation, screening, personalized feedback and intervention. It is important to offer tools to better help professionals who might feel ill equipped in the face of cannabis legalization and of the adoption of the harm reduction paradigm in response to lifting of the prohibition on the use of this substance.

Conclusion

The French-Canadian version of the 17-item short form of the Protective Behavioral Strategies for Marijuana Scale (PBSM-17) and its English version were found to be valid with Canadian university students. The legalization of cannabis use affords the opportunity to set up prevention initiatives to promote safer consumption behaviors such as those measured by the PBSM. A significant research effort is critically needed for new, evidence-based public health prevention interventions to target PBS, using innovative strategies to encourage cannabis users to apply them.

FIGURE LEGEND

Figure 1. Mean Score Plots

STATEMENTS

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Competing interest statement

The authors report no conflict of interest.

Contributorship statement

All co-authors had substantial contributions to the conception or design of the work, or the acquisition, analysis or interpretation of data. JC and PA drafted the manuscript. SC and SCM conducted the analysis. SC, GMP, SMC, GF, GC, GR, CG, JL, ERP, DJA revised the manuscript and added important intellectual content. JC and PA produced the final document. All co-authors reviewed and approved the final version of the manuscript.

Data sharing statement

Data are available upon reasonable request by emailing the corresponding author, JC.

Ethics statement

This study obtained ethics approval by the *Centre Hospitalier de l'Université de Montréal* Research Ethics Board (20.172) and by the *Comité d'éthique de la recherche en sciences et en santé (CERSES)* of the *Université de Montréal* (CERSES-20-114-D). All participants provided informed consent.

Patient and Public Involvement statement

The participants in this study were not patients, but rather members of the general population (university students). Some members of the research team - involved in the development of the protocol for this study – are undergraduate and graduate students. They contributed to inform the research question, outcome measures and analyses. The research assistant who contributed to participant recruitment was an undergraduate student. Results will be disseminated to study participants using a plain language summary available upon email request.

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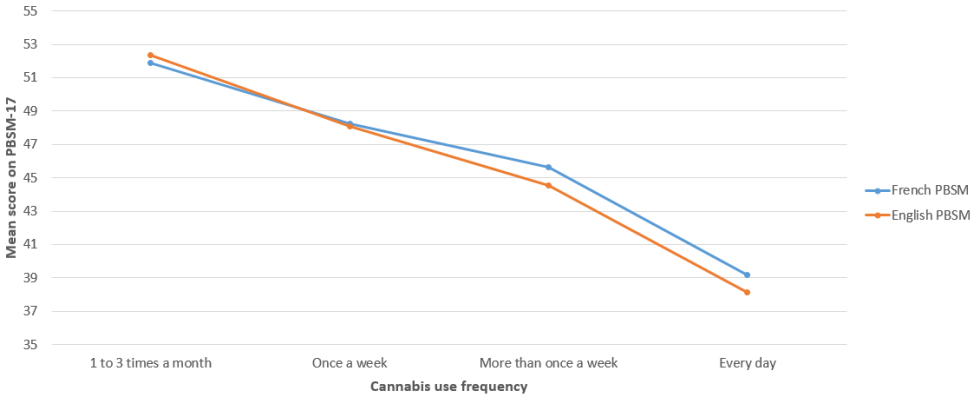

Figure 1. Mean Score Plots

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Original Research

Psychometric Properties of the French and English Short Form of the Protective Behavioral Strategies for Marijuana Scale in Canadian University Students

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ABSTRACT

Background: The Protective Behavioral Strategies for Marijuana scale (PBSM-17) scale serves to identify and measure strategies employed by young adults before, during or after cannabis use. After the adaptation and translation of the PBSM-17 into French, a methodological study was conducted to evaluate the psychometric properties of this French version (FV) and of the original English version (EV) in a sample of bilingual Canadian university students.

Methods: A total of 211 cannabis users (mean age=22.1 years) completed a sociodemographic questionnaire, a question on frequency of cannabis use (4 categories: 1-3 times a month, once a week, more than once a week, everyday), and both versions (FV and EV) of the PBSM-17.

Results: Both versions had similar internal reliability (α=0.91; α=0.88). The one-factor solution explained 42.26% of the variance for the EV and 36.46% for the FV. As hypothesized, greater use of protective behavioral strategies was related to lower frequency of cannabis use. One-way ANOVA test results revealed a statistically significant difference in use of strategies by frequency of cannabis use for both the FV ($F(3, 207)=27.38$, $p<0.001$) and EV ($F(3, 207)=29.32$, $p<0.001$). Post hoc comparisons showed that everyday users employed fewer strategies on average than lower-frequency users.

Conclusion: The English and French versions of the PBSM-17 demonstrated satisfactory psychometric properties. The proposed FV of the PBSM-17 is a reliable instrument that could be used for research and clinical purposes. Protective behavioral strategies can serve as indicator of lower-risk cannabis use and could be targeted in prevention interventions.

Keywords: Cannabis, Psychometric evaluation, Scale, Protective behavioral strategies, University students.

ARTICLE SUMMARY

Strengths and limitations of the study

- The legalization of cannabis use affords the opportunity to set up prevention initiatives to promote safer consumption behaviors.
- The use of protective behavioral strategies (PBS) is a robust predictor of outcomes such as frequency of cannabis use and cannabis-related harms.
- This article reports on full psychometric properties of the English version of the Protective Behavioral Strategies for Marijuana short form (PBSM-17) and its French translation in a Canadian context.
- This validation of psychometric properties was conducted among a sample of university students, thus they might not necessarily be representative of the entire adult population.
- The PBSM-17 is a reliable instrument that could be used for research and clinical purposes in the context of the prevention and promotion of safe cannabis use.

MAIN TEXT

Psychometric Properties of the French and English Short Form of the Protective Behavioral Strategies for Marijuana Scale in Canadian University Students

INTRODUCTION

Prospective cohort studies suggest that substance use generally begins in adolescence and peaks in young adulthood [1]. In Canada, 18- to 24-year-olds constitute the age group with the highest proportion of cannabis users [2]. Canada was the first G7 country to legalize cannabis consumption for recreational purposes nationwide. According to Degenhardt and colleagues [1], substance availability and access as well as regulatory environment are factors that affect substance use in young people. Legalization, then, affords the opportunity to put forth initiatives aimed at reducing cannabis-related harms such as risk behaviors, social-interpersonal consequences and impaired control [3].

Bravo and colleagues stressed that using protective behavioral strategies (PBS) could help regulate cannabis use and even reduce the associated negative consequences [4]. PBS were initially tied to the context of young adult alcohol use and conceptualized as behaviors used immediately prior to, during, and/or after a drinking episode to reduce alcohol misuse and/or alcohol-related harm.[5] In a systematic review, Pearson et al.[6] concluded that PBS were promising ways to reduce alcohol misuse and the negative consequences of drinking. Transferring PBS to the context of cannabis use, Bravo et al. carried out a cohort study of 2,000 students from 11 universities in the United States. Findings showed PBS use to be a robust predictor of outcomes such as frequency of

cannabis use and cannabis-related harms (e.g., social-interpersonal consequences, impaired control, and risk behaviors) [7]. Examples of PBS include avoiding using marijuana while spending time with family, avoiding mixing marijuana with other drugs, and purchasing marijuana from a trusted source [8]. Considering that PBS use could mitigate the harms related to cannabis use, it is of great importance to develop a reliable tool for the purpose of measuring the extent to which these strategies are used by young adults.

In 2016, Pedersen and colleagues developed the Protective Behavioral Strategies for Marijuana scale (PBSM) to identify and measure the strategies employed by young adult cannabis users [8]. They developed the PBSM scale in an initial exploratory study with 210 college student marijuana users by reducing a pool of 50 items down to a single-factor 39-item measure through iterative principal component analysis. According to psychometric evaluations, the unique structure of this scale explained 34% of the variance in protective behaviors related to cannabis use. Initial psychometric properties revealed excellent internal consistency (α=0.95) and convergent validity with a measure of alcohol PBS [8]. In their subsequent work, Pedersen et al. sought to validate the PBSM further with a larger and more diverse sample (n=2,117, 40% men, 30% non-White) of college students from 11 different universities across the United States [9]. Two versions of the scale, the 36-item version (PBSM-36) and the 17-item short form (PBSM-17), were developed and tested. Advanced factor analytic techniques (i.e., confirmatory factor analysis) and advanced item response theory techniques confirmed the unidimensionality and good content coverage of both the PBSM-36 and the PBSM-17 [9]. The correlation between the two versions of the scale was high (r=0.98, p<0.001). Both versions demonstrated appreciable criterion-related validity and were strongly and negatively associated with past-month marijuana use and consequences. They were found to be free of bias in terms of gender, race and ethnicity [9].

The short form of the scale (PBSM-17) can be of great value as it requires less time to complete. This renders it highly appealing for use in both research and clinical settings where professionals have limited time and interactions with research participants and patients.

However, the PBSM-17 was not available in French and had never been adapted to the Canadian context until recently. The aim of this methodological study was to evaluate the psychometric properties of the English and French short forms of the PBSM scale in a sample of bilingual university students in the province of Quebec, Canada.

METHODS

The study was conducted according to the methodology proposed by Sousa and Rojjanasrirat for translating, adapting and validating the psychometric properties of scales [10]. The procedure of French translation and adaptation of the PBSM-17 to the Canadian context is covered elsewhere [11]. Briefly, the process involved members of the research team who were bilingual native French speakers, four translators, researchers with expertise in the development and validation of scales, and researchers with expertise in the area of cannabis use among young adults. It comprised five steps: 1) the original English instrument was translated to French by two translators separately (forward translation); 2) the two translations were compared and differences were resolved by consensus (synthesis 1); 3) this version was translated back to English by two translators blindly and separately (backward translation); 4) the two back translations were compared against one another and against the original English version (synthesis 2); and 5) the pre-final French version was pilot-tested [11].

This article reports specifically on the fidelity (internal consistency and inter-item correlation), construct validity (factor analysis) and criterion-related validity of the English version of the PBSM-17 and its French translation in a sample of bilingual university students.

Following a rigorous adaptation and validation process, we expected to obtain alpha coefficients for the French version of the PBSM-17 similar to those obtained by the English versions. Regarding the criterion-related validity, a negative relationship was hypothesized: We expected a higher PBSM-17 mean score (indicating a greater use of protective behavioral strategies) to be associated with a lower frequency of cannabis use. This study was approved by the CHUM Research Ethics Board (20.172) and by the *Comité d'éthique de la recherche en sciences et en santé (CERSES)* of the *Université de Montréal* (CERSES-20-114-D). All participants provided informed consent.

Selection and Description of Participants

The study was conducted with a sample of university students from the province of Quebec, Canada. A convenience sampling strategy was used to recruit participants through social media, specifically the Université de Montréal Students Facebook Groups. Interested students were invited to visit the study webpage using a mobile device connected to the Internet (smartphone, tablet or laptop) in order to complete the online survey. Students 18 years old or over, who used cannabis at least once in the past month and were bilingual (i.e., proficiency in written French and English) were included.

Online Data Collection

The study was conducted entirely online. LimeSurvey, an online survey system, was used to complete consent forms and questionnaires. After accepting the conditions and consenting, students were invited to complete a short sociodemographic questionnaire, one question on frequency of cannabis use, the French version of the PBSM-17, and the original English version of the PBSM-17. Eligibility criteria evaluation was integrated in the online questionnaire: participants who reported no cannabis use in the past year or less than once a month were not invited to complete

the rest of the survey (i.e., completion of the PBSM-17 was conditional on current cannabis use). Participants who completed the survey were compensated for their time with a $10 Amazon.ca gift certificate.

Outcome Measures

Participants completed a brief sociodemographic questionnaire covering age, gender self-identification, ethnicity and student status (full-time/part-time, graduate/undergraduate).

They were asked to rate their frequency of cannabis use by answering the following question from the Canadian Community Health Survey [12]: "How often did you use cannabis in the past 12 months?". Frequency was measured on a six-point scale: 1) never, 2) less than once a month, 3) 1 to 3 times a month, 4) once a week, 5) more than once a week, and 6) every day.

Participants were asked how often they resorted to employing 17 PBS when they used cannabis. Frequency of PBS use was rated on a six-point Likert scale: 1) never, 2) rarely, 3) occasionally, 4) sometimes, 5) usually, and 6) always. As suggested by Pedersen et al., (2017) [9] the overall score was calculated by tallying the numbers corresponding to the answers given and converting this raw total to a t-score. There were no subscales. The higher the score, the greater the use of PBS.

For this study, participants were asked to complete the original English and the translated French versions of the PBSM-17. For the former, the order of the items was shuffled, as recommended by Sousa and Rojjanasrirat (2011) [10].

Sample Size

Following Sousa and Rojjanasrirat's guideline [10] of about 10 participants per item for general psychometric approaches (17 items * 10 participants = 170) and projecting that 15% of participants might have missing data, we targeted a rounded-up total sample size of 200 participants.

Statistics

Descriptive statistics were computed for each item (frequency distribution for categorical data and means with standard deviations for continuous variables). Fidelity was assessed by examining internal consistency (Cronbach's alpha) and inter-item correlation. As a general rule of thumb, a Cronbach's alpha higher than α=0.70 is considered adequate. Gliem and Gliem (2003) describe α=0.80 as a reasonable goal for internal consistency, and that higher alpha values can suggest higher internal consistency. These authors also describe an adequate corrected item-total correlation having a value of at least r=0.40 [13]. For descriptive purposes, the preliminary psychometric properties of the English and French versions of the scale were compared.

As in the original study [8], a factor analysis with a one-factor solution structure was performed to evaluate the construct validity. Criterion-related validity was evaluated by conducting a one-way ANOVA to determine whether PBSM scale mean scores differed by frequency of cannabis use.

All statistical analyses were run on SPSS version 26 (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.).

The creators of the PBSM scale were contacted for permission to translate and adapt the instrument. They were consulted during the translation process and reviewed the final manuscript. The tool is in the public domain and available free of charge[1].

Patient and Public Involvement statement

The participants in this study were not patients, but rather members of the general population (university students). Some members of the research team, involved in the development of the

[1] https://www.rand.org/health-care/surveys_tools.html

protocol for this study,are undergraduate and graduate students. They contributed to inform the research question, outcome measures and analyses. The research assistant who contributed to participant recruitment was an undergraduate student. Results will be disseminated to study participants using a plain language summary available upon email request.

RESULTS

Sample Description

In September/October of 2020, 375 students provided consent, completed the sociodemographic questionnaire and answered the question on cannabis use frequency. Of these, 164 were excluded: 101 participants did not complete the two versions of the PBSM because they reported no cannabis use in the past year or using cannabis less than once a month (and were therefore not considered current cannabis users), 2 did not adhere with study procedures, and 61 had missing data. As a result, a total of 211 questionnaires were considered for analysis.

Mean age of participants was 22 years (range of 18 to 44). Most of them self-identified as women (61.1%) and as Caucasian (83.9%). Most were full-time students (88.2%) and at the undergraduate level (84.4%). Regarding frequency of cannabis use in the past 12 months, 46.9% indicated 1 to 3 times a month, 15.2% once a week, 22.3% more than once a week, and 15.6% every day.

As proposed by Pedersen et al. (2017) [9], a total raw score was calculated for each participant by summing the scores obtained on the response scales of all 17 items. This total raw score was then converted to a T-score with a possible range of 15 to 73. In our sample, participants presented a mean T-score of 47.95 (SD: 8.53) on the French version and a mean T-score of 47.73 (SD: 9.45) on the original English version of the PBSM-17 scale.

Fidelity: Internal Consistency and Inter-item Correlation

Cronbach's alpha showed that the French version of the scale reached acceptable reliability, α=0.88. All of the items deserved retention; withdrawing any of them resulted in a lower alpha. Item-to-total corrected correlations ranged from r=0.38 to r=0.68 [Table 1]. Cronbach's alpha showed that the original English version of the short form reached acceptable internal reliability (α=0.91). Item-to-total corrected correlations ranged from r=0.45 to r=0.72 [Table 1].

Table 1. Inter-Item Correlation Matrix for the English version (above diagonal) and the French version (below diagonal) of the PBSM-17 (n=211)

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Item 14	Item 15	Item 16	Item 17
Item 1		0.409	0.470	0.380	0.463	0.495	0.490	0.431	0.513	0.459	0.311	0.248	0.308	0.390	0.487	0.501	0.526
Item 2	0.442		0.663	0.291	0.416	0.384	0.460	0.311	0.419	0.377	0.325	0.250	0.202	0.323	0.422	0.342	0.483
Item 3	0.456	0.619		0.376	0.384	0.436	0.411	0.273	0.408	0.398	0.271	0.200	0.176	0.341	0.358	0.371	0.626
Item 4	0.303	0.272	0.351		0.483	0.284	0.497	0.270	0.285	0.170	0.313	0.351	0.203	0.225	0.264	0.374	0.312
Item 5	0.450	0.392	0.354	0.389		0.316	0.659	0.514	0.452	0.439	0.480	0.331	0.355	0.329	0.477	0.544	0.399
Item 6	0.347	0.326	0.370	0.180	0.236		0.371	0.331	0.455	0.328	0.233	0.124	0.224	0.338	0.340	0.451	0.452
Item 7	0.442	0.363	0.425	0.363	0.659	0.285		0.474	0.399	0.361	0.622	0.402	0.298	0.300	0.502	0.490	0.490
Item 8	0.294	0.255	0.301	0.234	0.425	0.292	0.517		0.413	0.347	0.487	0.337	0.306	0.350	0.417	0.615	0.343
Item 9	0.387	0.325	0.343	0.250	0.410	0.379	0.398	0.399		0.446	0.312	0.168	0.278	0.394	0.422	0.473	0.403
Item 10	0.308	0.293	0.295	0.033	0.386	0.274	0.334	0.415	0.415		0.268	0.231	0.392	0.376	0.443	0.474	0.441
Item 11	0.290	0.375	0.361	0.284	0.397	0.141	0.544	0.408	0.315	0.239		0.473	0.276	0.272	0.440	0.431	0.395
Item 12	0.205	0.182	0.212	0.285	0.219	0.093	0.301	0.195	0.157	0.189	0.471		0.294	0.365	0.255	0.374	0.278
Item 13	0.241	0.198	0.178	0.091	0.277	0.171	0.291	0.251	0.299	0.343	0.303	0.227		0.309	0.308	0.484	0.204
Item 14	0.317	0.308	0.304	0.133	0.180	0.298	0.235	0.275	0.324	0.330	0.238	0.360	0.334		0.343	0.421	0.372
Item 15	0.308	0.309	0.286	0.111	0.253	0.238	0.287	0.272	0.384	0.271	0.320	0.151	0.231	0.307		0.566	0.416
Item 16	0.356	0.289	0.308	0.222	0.464	0.359	0.494	0.460	0.396	0.380	0.460	0.187	0.331	0.345	0.508		0.428
Item 17	0.424	0.426	0.566	0.242	0.316	0.312	0.424	0.267	0.332	0.282	0.445	0.241	0.214	0.311	0.374	0.379	

Construct Validity: Factor Analysis

A principal component analysis using a one-factor solution was performed to assess construct validity. In this sample, for the English version of the scale, the 17 items explained 42.26% of the variance, with factor loadings of 0.495 to 0.763. For the French version, it explained 36.46% of the variance, with factor loadings of 0.432 to 0.741 [Table 2]. The Kayser-Mayer-Olkin (KMO) test and Bartlett's test of sphericity showed that the data were suited for factor analysis (KMO = 0.886, Bartlett 1270.65, df = 130, $p < 0.001$ for the French version and KMO = 0.915, Bartlett 1590.15, df = 136, $p < 0.001$ for the English version).

Table 2. PBSM items and factor loadings by language version (n=211)

PBSM items	French version factor loadings	English version factor loadings
Item 1	0.652	0.725
Item 2	0.633	0.647
Item 3	0.670	0.655
Item 4	0.452	0.546
Item 5	0.684	0.740
Item 6	0.513	0.598
Item 7	0.741	0.757
Item 8	0.621	0.662
Item 9	0.643	0.664
Item 10	0.566	0.633
Item 11	0.652	0.628
Item 12	0.432	0.497
Item 13	0.471	0.495
Item 14	0.531	0.576
Item 15	0.549	0.687
Item 16	0.691	0.763
Item 17	0.652	0.695

Criterion-related Validity

To evaluate the criterion-related validity of the instruments, we examined the association between PBSM scale mean score and frequency of cannabis use. A negative relationship was hypothesized with higher mean scores on the PBSM (i.e., greater use of PBS) related to lower frequency of cannabis use. The one-way ANOVA test results revealed a statistically significant difference in use of marijuana PBS by frequency of cannabis use for the French version ($F(3, 207)=27.38$, $p<0.001$) and the English version ($F(3, 207) = 29.32$, $p<0.001$). Post hoc comparisons (using Bonferroni correction) suggested that everyday cannabis users employed fewer marijuana PBS, on average, than did lower-frequency cannabis users. Additionally, people who used cannabis 1–3 times per month made significantly greater use of marijuana PBS than did those who used cannabis more than once a week [Figure 1].

Figure 1. Mean Score Plots

DISCUSSION

The objective of our methodological study was to evaluate the full psychometric properties of the English and French versions of the PBSM-17 in a sample of bilingual university students. The two versions had similar internal reliability ($\alpha=0.91$ and $\alpha=0.88$, respectively). To our knowledge, few studies have reported on the reliability of the short form of the scale. In Pedersen et al. (2017) too, the marginal reliability of the PBSM-17 was high ($\alpha=0.93$) [9]. Similarly to what was observed with the original structure of the scale [8 9] the single-factor solution explained 42.26% of the variance for the English version and 36.46% for the French. Criterion-related validity, too, was established for both versions. PBS use differed by frequency of cannabis use, with overall greater use of PBS being associated with lower frequency of cannabis use.

Conducting rigorous psychometric assessments of instruments prior to their use in large-scale experimental studies is crucial. Multiple factors may impact the reliability obtained by an instrument such as the PBSM-17. These include scoring system, instrument's characteristics (e.g., item formulation, language), physical and emotional state of respondents at time of measure, and characteristics of context of administration [14]. This study addressed factors related to the instrument's characteristics, including item formulation and language, relevant to using the French version of the PBSM-17 with a sample of bilingual university students.

Both the English and the French versions of the PBSM-17 demonstrated satisfactory psychometric properties, in particular fidelity, construct validity and criterion-related validity. The PBSM-17 serves to assess strategies that can be applied prior to, during and after using cannabis. We validated the instruments in a population of university students, as did the creators of the PBSM. It is important to bear in mind that this student population is not necessarily representative of the adult population, which includes adults in the labor market. Also, the French version of the scale, like the English version, was developed and validated with current cannabis users as they were the ones who could resort to using the strategies under study.

It should be noted that the study took place in the context of the COVID-19 pandemic. Data collection was carried out at the start of the academic year in the fall of 2020, between the first and second waves of the pandemic in Canada.

When applied, PBS may limit frequency of marijuana use and the negative consequences associated with cannabis use. To our knowledge, PBS are not often used in research interventions. We found only two digital interventions that had PBS as an intervention target. The team led by Prince et al. [15] created a brief in-person intervention, including a smartphone application (MApp) to distribute tips related to PBS in order to reduce cannabis use. Another team, based in the United States, developed the Marijuana eCHECKUPTO GO, a web-based personalized feedback tool with

normative information and PBS [16]. Their study results revealed a decrease in frequency of cannabis use among heavy-user college students who participated in the intervention. In the experimental group, females increased their use of PBS more than males did [16]. This suggests that PBS use should be considered as a target when developing interventions to encourage lower-risk cannabis use.

In the context of the prevention and promotion of safe cannabis use, the PBSM scale could be useful to both health professionals and community/social workers. It can be easily used in various specialized but also non-specialized settings and contexts, such as primary care services, family practices, schools and community settings, and for various purposes, such as evaluation, screening, personalized feedback and intervention. It is important to offer tools to better help professionals who might feel ill equipped in the face of cannabis legalization and of the adoption of the harm reduction paradigm in response to lifting of the prohibition on the use of this substance.

Limitations

This article reports on the full psychometric properties of the English version of the Protective Behavioral Strategies for Marijuana short form (PBSM-17) and its French translation in a Canadian context. Though we applied a systematic procedure and high standards to adapt, translate and evaluate the PBSM-17, our study is not without limitations. First, the PBSM was validated among a sample of university students with particular sociodemographic characteristics, which is to say a population not necessarily representative of the entire adult population. Second, we could have evaluated criterion validity using other indicators instead of just frequency of cannabis use, such as number of days of cannabis use, quantity of cannabis use, cannabis use consequences, and substance abuse diagnosis. The fact that frequency of cannabis use was measured dichotomously rather than continuously can also be considered as a limitation. Third, there was a reduction in

accounted variance for the French version of the scale compared to the English version. Though the difference is small, it suggests that the one-factor structure is less well represented in French. This possibility should be investigated in future research given that this was the first attempt to evaluate the factor structure of the French version of the PBSM-17.

Conclusion

The French-Canadian version of the 17-item short form of the Protective Behavioral Strategies for Marijuana Scale (PBSM-17) and its English version were found to be valid with Canadian university students. The legalization of cannabis use affords the opportunity to set up prevention initiatives to promote safer consumption behaviors such as those measured by the PBSM. A significant research effort is critically needed for new, evidence-based public health prevention interventions to target PBS, using innovative strategies to encourage cannabis users to apply them.

FIGURE LEGEND

Figure 1. Mean Score Plots

STATEMENTS

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The authors report no conflict of interest.

Contributorship statement

All co-authors had substantial contributions to the conception or design of the work, or the acquisition, analysis or interpretation of data. JC and PA drafted the manuscript. SC and SCM conducted the analysis. SC, GMP, SMC, GF, GC, GR, CG, JL, ERP, DJA revised the manuscript and added important intellectual content. JC and PA produced the final document. All co-authors reviewed and approved the final version of the manuscript.

Data sharing statement

Data are available upon reasonable request by emailing the corresponding author, JC.

Ethics statement

This study obtained ethics approval by the *Centre Hospitalier de l'Université de Montréal* Research Ethics Board (20.172) and by the *Comité d'éthique de la recherche en sciences et en santé (CERSES)* of the *Université de Montréal* (CERSES-20-114-D). All participants provided informed consent.

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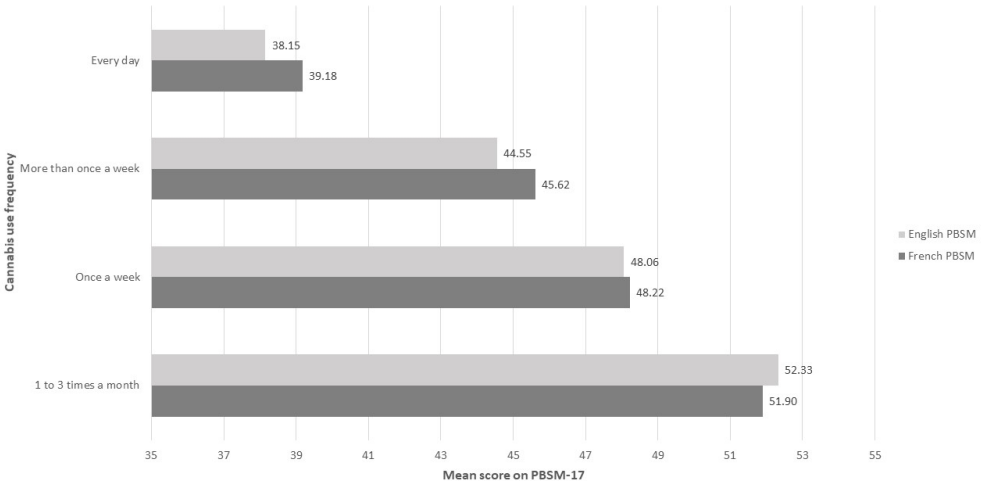

Figure 1. Mean Score Plots

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Original Research

Psychometric Properties of the French and English Short Form of the Protective Behavioral Strategies for Marijuana Scale in Canadian University Students

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ABSTRACT

Background: The Protective Behavioral Strategies for Marijuana (PBSM-17) scale serves to identify and measure strategies employed by young adults before, during or after cannabis use. After the adaptation and translation of the PBSM-17 into French, a methodological study was conducted to evaluate the psychometric properties of this French version (FV) and of the original English version (EV) in a sample of bilingual Canadian university students.

Methods: A total of 211 cannabis users (mean age=22.1 years) completed a sociodemographic questionnaire, a question on frequency of cannabis use (4 categories: 1-3 times a month, once a week, more than once a week, everyday), and both versions (FV and EV) of the PBSM-17.

Results: Both versions had similar internal reliability (α=0.91; α=0.88). The one-factor solution explained 36.46% of the variance for the FV and 42.26% for the EV. As hypothesized, greater use of protective behavioral strategies was related to lower frequency of cannabis use. One-way ANOVA test results revealed a statistically significant difference in use of strategies by frequency of cannabis use for both the FV ($F(3, 207)=27.38$, $p<0.001$) and EV ($F(3, 207)=29.32$, $p<0.001$). Post hoc comparisons showed that everyday users employed fewer strategies on average than lower-frequency users.

Conclusion: The French and English versions of the PBSM-17 demonstrated satisfactory psychometric properties. The proposed FV of the PBSM-17 is a reliable instrument that could be used for research and clinical purposes. Protective behavioral strategies can serve as indicator of lower-risk cannabis use and could be targeted in prevention interventions.

Keywords: Cannabis, Psychometric evaluation, Scale, Protective behavioral strategies, University students.

ARTICLE SUMMARY

Strengths and limitations of the study

- The legalization of cannabis use affords the opportunity to set up prevention initiatives to promote safer consumption behaviors.
- The use of protective behavioral strategies (PBS) is a robust predictor of outcomes such as frequency of cannabis use and cannabis-related harms.
- This article reports on full psychometric properties of the English version of the Protective Behavioral Strategies for Marijuana short form (PBSM-17) and its French translation in a Canadian context.
- This validation of psychometric properties was conducted among a sample of university students, thus they might not necessarily be representative of the entire adult population.
- The PBSM-17 is a reliable instrument that could be used for research and clinical purposes in the context of the prevention and promotion of safe cannabis use.

MAIN TEXT

Psychometric Properties of the French and English Short Form of the Protective Behavioral Strategies for Marijuana Scale in Canadian University Students

INTRODUCTION

Prospective cohort studies suggest that substance use generally begins in adolescence and peaks in young adulthood [1]. In Canada, 18- to 24-year-olds constitute the age group with the highest proportion of cannabis users [2]. Canada was the first G7 country to legalize cannabis consumption for recreational purposes nationwide. According to Degenhardt and colleagues [1], substance availability and access as well as regulatory environment are factors that affect substance use in young people. Legalization, then, affords the opportunity to put forth initiatives aimed at reducing cannabis-related harms such as risk behaviors, social-interpersonal consequences and impaired control [3].

Bravo and colleagues stressed that using protective behavioral strategies (PBS) could help regulate cannabis use and even reduce the associated negative consequences [4]. PBS were initially tied to the context of young adult alcohol use and conceptualized as behaviors used immediately prior to, during, and/or after a drinking episode to reduce alcohol misuse and/or alcohol-related harm.[5] In a systematic review, Pearson et al.[6] concluded that PBS were promising ways to reduce alcohol misuse and the negative consequences of drinking. Transferring PBS to the context of cannabis use, Bravo et al. carried out a cohort study of 2,000 students from 11 universities in the United States. Findings showed PBS use to be a robust predictor of outcomes such as frequency of

cannabis use and cannabis-related harms (e.g., social-interpersonal consequences, impaired control, and risk behaviors) [7]. Examples of PBS include avoiding using marijuana while spending time with family, avoiding mixing marijuana with other drugs, and purchasing marijuana from a trusted source [8]. Considering that PBS use could mitigate the harms related to cannabis use, it is of great importance to develop a reliable tool for the purpose of measuring the extent to which these strategies are used by young adults.

In 2016, Pedersen and colleagues developed the Protective Behavioral Strategies for Marijuana scale (PBSM) to identify and measure the strategies employed by young adult cannabis users [8]. They developed the PBSM scale in an initial exploratory study with 210 college student marijuana users by reducing a pool of 50 items down to a single-factor 39-item measure through iterative principal component analysis. According to psychometric evaluations, the unique structure of this scale explained 34% of the variance in protective behaviors related to cannabis use. Initial psychometric properties revealed excellent internal consistency (α=0.95) and convergent validity with a measure of alcohol PBS [8]. In their subsequent work, Pedersen et al. sought to validate the PBSM further with a larger and more diverse sample (n=2,117, 40% men, 30% non-White) of college students from 11 different universities across the United States.[9] Two versions of the scale, the 36-item version (PBSM-36) and the 17-item short form (PBSM-17), were developed and tested. Advanced factor analytic techniques (i.e., confirmatory factor analysis) and advanced item response theory techniques confirmed the unidimensionality and good content coverage of both the PBSM-36 and the PBSM-17 [9]. The correlation between the two versions of the scale was high (r=0.98, p<0.001). Both versions demonstrated appreciable criterion-related validity and were strongly and negatively associated with past-month marijuana use and consequences. They were found to be free of bias in terms of gender, race and ethnicity [9].

The short form of the scale (PBSM-17) can be of great value as it requires less time to complete. This renders it highly appealing for use in both research and clinical settings where professionals have limited time and interactions with research participants and patients.

However, the PBSM-17 was not available in French and had never been adapted to the Canadian context until recently. The aim of this methodological study was to evaluate the psychometric properties of the English and French short forms of the PBSM scale in a sample of bilingual university students in the province of Quebec, Canada.

METHODS

The study was conducted according to the methodology proposed by Sousa and Rojjanasrirat for translating, adapting and validating the psychometric properties of scales [10]. The procedure of French translation and adaptation of the PBSM-17 to the Canadian context is covered elsewhere [11]. Briefly, the process involved members of the research team who were bilingual native French speakers, four translators, researchers with expertise in the development and validation of scales, and researchers with expertise in the area of cannabis use among young adults. It comprised five steps: 1) the original English instrument was translated to French by two translators separately (forward translation); 2) the two translations were compared and differences were resolved by consensus (synthesis 1); 3) this version was translated back to English by two translators blindly and separately (backward translation); 4) the two back translations were compared against one another and against the original English version (synthesis 2); and 5) the pre-final French version was pilot-tested [11].

This article reports specifically on the fidelity (internal consistency and inter-item correlation), construct validity (factor analysis) and criterion-related validity of the English version of the PBSM-17 and its French translation in a sample of bilingual university students.

Following a rigorous adaptation and validation process, we expected to obtain alpha coefficients for the French version of the PBSM-17 similar to those obtained by the English versions. Regarding the criterion-related validity, a negative relationship was hypothesized: We expected a higher PBSM-17 mean score (indicating a greater use of protective behavioral strategies) to be associated with a lower frequency of cannabis use. This study was approved by the *Centre Hospitalier de l'Université de Montréal (CHUM)* Research Ethics Board (20.172) and by the *Comité d'éthique de la recherche en sciences et en santé (CERSES)* of the *Université de Montréal* (CERSES-20-114-D). All participants provided informed consent.

Selection and Description of Participants

The study was conducted with a sample of university students from the province of Quebec, Canada. A convenience sampling strategy was used to recruit participants through social media, specifically the Université de Montréal Students Facebook Groups. Interested students were invited to visit the study webpage using a mobile device connected to the Internet (smartphone, tablet or laptop) in order to complete the online survey. Students 18 years old or over, who used cannabis at least once in the past month and were bilingual (i.e., proficiency in written French and English) were included.

Online Data Collection

The study was conducted entirely online. LimeSurvey, an online survey system, was used to complete consent forms and questionnaires. After accepting the conditions and consenting, students were invited to complete a short sociodemographic questionnaire, one question on frequency of cannabis use, the French version of the PBSM-17, and the original English version of the PBSM-17. Eligibility criteria evaluation was integrated in the online questionnaire: participants

who reported no cannabis use in the past year or less than once a month were not invited to complete the rest of the survey (i.e., completion of the PBSM-17 was conditional on current cannabis use). Participants who completed the survey were compensated for their time with a $10 Amazon.ca gift certificate.

Outcome Measures

Participants completed a brief sociodemographic questionnaire covering age, gender self-identification, ethnicity and student status (full-time/part-time, graduate/undergraduate).

They were asked to rate their frequency of cannabis use by answering the following question from the Canadian Community Health Survey [12]: "How often did you use cannabis in the past 12 months?". Frequency was measured on a six-point scale: 1) never, 2) less than once a month, 3) 1 to 3 times a month, 4) once a week, 5) more than once a week, and 6) every day.

Participants were asked how often they resorted to employing 17 PBS when they used cannabis. Frequency of PBS use was rated on a six-point Likert scale: 1) never, 2) rarely, 3) occasionally, 4) sometimes, 5) usually, and 6) always. As suggested by Pedersen et al., (2017) [9] the overall score was calculated by tallying the numbers corresponding to the answers given and converting this raw total to a t-score. There were no subscales. The higher the score, the greater the use of PBS.

For this study, participants were asked to complete the original English and the translated French versions of the PBSM-17. For the former, the order of the items was shuffled, as recommended by Sousa and Rojjanasrirat (2011) [10].

Sample Size

Following Sousa and Rojjanasrirat's guideline [10] of about 10 participants per item for general psychometric approaches (17 items * 10 participants = 170) and projecting that 15% of participants might have missing data, we targeted a rounded-up total sample size of 200 participants.

Statistics

Descriptive statistics were computed for each item (frequency distribution for categorical data and means with standard deviations for continuous variables). Fidelity was assessed by examining internal consistency (Cronbach's alpha) and inter-item correlation. As a general rule of thumb, a Cronbach's alpha higher than α=0.70 is considered adequate. Gliem and Gliem (2003) describe α=0.80 as a reasonable goal for internal consistency, and that higher alpha values can suggest higher internal consistency. These authors also describe an adequate corrected item-total correlation having a value of at least r=0.40 [13]. For descriptive purposes, the preliminary psychometric properties of the English and French versions of the scale were compared.

As in the original study [8], a factor analysis with a one-factor solution structure was performed to evaluate the construct validity. Criterion-related validity was evaluated by conducting a one-way ANOVA to determine whether PBSM scale mean scores differed by frequency of cannabis use.

All statistical analyses were run on SPSS version 26 (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.).

The creators of the PBSM scale were contacted for permission to translate and adapt the instrument. They were consulted during the translation process and reviewed the final manuscript. The tool is in the public domain and available free of charge[1].

[1] https://www.rand.org/health-care/surveys_tools.html

Patient and Public Involvement statement

The participants in this study were not patients, but rather members of the general population (university students). Some members of the research team, involved in the development of the protocol for this study, are undergraduate and graduate students. They contributed to inform the research question, outcome measures and analyses. The research assistant who contributed to participant recruitment was an undergraduate student. Results will be disseminated to study participants using a plain language summary available upon email request.

RESULTS

Sample Description

In September/October of 2020, 375 students provided consent, completed the sociodemographic questionnaire and answered the question on cannabis use frequency. Of these, 164 were excluded: 101 participants did not complete the two versions of the PBSM because they reported no cannabis use in the past year or using cannabis less than once a month (and were therefore not considered current cannabis users), 2 did not adhere with study procedures, and 61 had missing data. As a result, a total of 211 questionnaires were considered for analysis.

Mean age of participants was 22 years (range of 18 to 44). Most of them self-identified as women (61.1%) and as Caucasian (83.9%). Most were full-time students (88.2%) and at the undergraduate level (84.4%). Regarding frequency of cannabis use in the past 12 months, 46.9% indicated 1 to 3 times a month, 15.2% once a week, 22.3% more than once a week, and 15.6% every day.

As proposed by Pedersen et al. (2017) [8], a total raw score was calculated for each participant by summing the scores obtained on the response scales of all 17 items. This total raw score was then converted to a T-score with a possible range of 15 to 73. In our sample, participants presented a

mean T-score of 47.95 (SD: 8.53) on the French version and a mean T-score of 47.73 (SD: 9.45) on the original English version of the PBSM-17 scale.

Fidelity: Internal Consistency and Inter-item Correlation

Cronbach's alpha showed that the French version of the scale reached acceptable reliability, α=0.88. All of the items deserved retention; withdrawing any of them resulted in a lower alpha. Item-to-total corrected correlations ranged from r=0.38 to r=0.68 [Table 1]. Cronbach's alpha showed that the original English version of the short form reached acceptable internal reliability (α=0.91). Item-to-total corrected correlations ranged from r=0.45 to r=0.72 [Table 1].

Table 1. Inter-Item Correlation Matrix for the English version (above diagonal) and the French version (below diagonal) of the PBSM-17 (n=211)

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Item 14	Item 15	Item 16	Item 17
Item 1		0.409	0.470	0.380	0.463	0.495	0.490	0.431	0.513	0.459	0.311	0.248	0.308	0.390	0.487	0.501	0.526
Item 2	0.442		0.663	0.291	0.416	0.384	0.460	0.311	0.419	0.377	0.325	0.250	0.202	0.323	0.422	0.342	0.483
Item 3	0.456	0.619		0.376	0.384	0.436	0.411	0.273	0.408	0.398	0.271	0.200	0.176	0.341	0.358	0.371	0.626
Item 4	0.303	0.272	0.351		0.483	0.284	0.497	0.270	0.285	0.170	0.313	0.351	0.203	0.225	0.264	0.374	0.312
Item 5	0.450	0.392	0.354	0.389		0.316	0.659	0.514	0.452	0.439	0.480	0.331	0.355	0.329	0.477	0.544	0.399
Item 6	0.347	0.326	0.370	0.180	0.236		0.371	0.331	0.455	0.328	0.233	0.124	0.224	0.338	0.340	0.451	0.452
Item 7	0.442	0.363	0.425	0.363	0.659	0.285		0.474	0.399	0.361	0.622	0.402	0.298	0.300	0.502	0.490	0.490
Item 8	0.294	0.255	0.301	0.234	0.425	0.292	0.517		0.413	0.347	0.487	0.337	0.306	0.350	0.417	0.615	0.343
Item 9	0.387	0.325	0.343	0.250	0.410	0.379	0.398	0.399		0.446	0.312	0.168	0.278	0.394	0.422	0.473	0.403
Item 10	0.308	0.293	0.295	0.033	0.386	0.274	0.334	0.415	0.415		0.268	0.231	0.392	0.376	0.443	0.474	0.441
Item 11	0.290	0.375	0.361	0.284	0.397	0.141	0.544	0.408	0.315	0.239		0.473	0.276	0.272	0.440	0.431	0.395
Item 12	0.205	0.182	0.212	0.285	0.219	0.093	0.301	0.195	0.157	0.189	0.471		0.294	0.365	0.255	0.374	0.278
Item 13	0.241	0.198	0.178	0.091	0.277	0.171	0.291	0.251	0.299	0.343	0.303	0.227		0.309	0.308	0.484	0.204
Item 14	0.317	0.308	0.304	0.133	0.180	0.298	0.235	0.275	0.324	0.330	0.238	0.360	0.334		0.343	0.421	0.372
Item 15	0.308	0.309	0.286	0.111	0.253	0.238	0.287	0.272	0.384	0.271	0.320	0.151	0.231	0.307		0.566	0.416

Item 16	0.356	0.289	0.308	0.222	0.464	0.359	0.494	0.460	0.396	0.380	0.460	0.187	0.331	0.345	0.508		0.428
Item 17	0.424	0.426	0.566	0.242	0.316	0.312	0.424	0.267	0.332	0.282	0.445	0.241	0.214	0.311	0.374	0.379	

Construct Validity: Factor Analysis

A principal component analysis using a one-factor solution was performed to assess construct validity. In this sample, for the French version, it explained 36.46% of the variance, with factor loadings of 0.432 to 0.741. For the English version of the scale, the 17 items explained 42.26% of the variance, with factor loadings of 0.495 to 0.763 [Table 2]. The Kayser-Mayer-Olkin (KMO) test and Bartlett's test of sphericity showed that the data were suited for factor analysis (KMO = 0.886, Bartlett 1270.65, df = 130, $p < 0.001$ for the French version and KMO = 0.915, Bartlett 1590.15, df = 136, $p < 0.001$ for the English version).

Table 2. PBSM items and factor loadings by language version (n=211)

PBSM items	French version factor loadings	English version factor loadings
Item 1	0.652	0.725
Item 2	0.633	0.647
Item 3	0.670	0.655
Item 4	0.452	0.546
Item 5	0.684	0.740
Item 6	0.513	0.598
Item 7	0.741	0.757
Item 8	0.621	0.662
Item 9	0.643	0.664
Item 10	0.566	0.633
Item 11	0.652	0.628
Item 12	0.432	0.497
Item 13	0.471	0.495

Item 14	0.531	0.576
Item 15	0.549	0.687
Item 16	0.691	0.763
Item 17	0.652	0.695

Criterion-related Validity

To evaluate the criterion-related validity of the instruments, we examined the association between PBSM scale mean score and frequency of cannabis use. A negative relationship was hypothesized with higher mean scores on the PBSM (i.e., greater use of PBS) related to lower frequency of cannabis use. The one-way ANOVA test results revealed a statistically significant difference in use of marijuana PBS by frequency of cannabis use for the French version ($F(3, 207)=27.38$, $p<0.001$) and the English version ($F(3, 207) = 29.32$, $p<0.001$). Post hoc comparisons (using Bonferroni correction) suggested that everyday cannabis users employed fewer marijuana PBS, on average, than did lower-frequency cannabis users. Additionally, people who used cannabis 1–3 times per month made significantly greater use of marijuana PBS than did those who used cannabis more than once a week [Figure 1].

Figure 1. Mean Score Plots

DISCUSSION

The objective of our methodological study was to evaluate the full psychometric properties of the English and French versions of the PBSM-17 in a sample of bilingual university students. The two versions had similar internal reliability ($\alpha=0.91$ and $\alpha=0.88$, respectively). To our knowledge, few studies have reported on the reliability of the short form of the scale. In Pedersen et al. (2017) too, the reliability of the PBSM-17 was high ($\alpha=0.93$) [9]. Similarly to what was observed with the

original structure of the scale [8 9] the single-factor solution explained 42.26% of the variance for the English version and 36.46% for the French. Criterion-related validity, too, was established for both versions. PBS use differed by frequency of cannabis use, with overall greater use of PBS being associated with lower frequency of cannabis use.

Conducting rigorous psychometric assessments of instruments prior to their use in large-scale experimental studies is crucial. Multiple factors may impact the reliability obtained by an instrument such as the PBSM-17. These include scoring system, instrument's characteristics (e.g., item formulation, language), physical and emotional state of respondents at time of measure, and characteristics of context of administration [14]. This study addressed factors related to the instrument's characteristics, including item formulation and language, relevant to using the French version of the PBSM-17 with a sample of bilingual university students.

Both the English and the French versions of the PBSM-17 demonstrated satisfactory psychometric properties, in particular fidelity, construct validity and criterion-related validity. The PBSM-17 serves to assess strategies that can be applied prior to, during and after using cannabis. We validated the instruments in a population of university students, as did the creators of the PBSM. It is important to bear in mind that this student population is not necessarily representative of the adult population, which includes adults in the labor market. Also, the French version of the scale, like the English version, was developed and validated with current cannabis users as they were the ones who could resort to using the strategies under study.

It should be noted that the study took place in the context of the COVID-19 pandemic. Data collection was carried out at the start of the academic year in the fall of 2020, between the first and second waves of the pandemic in Canada.

When applied, PBS may limit frequency of marijuana use and the negative consequences associated with cannabis use. To our knowledge, PBS are not often used in research interventions.

We found only two digital interventions that had PBS as an intervention target. The team led by Prince et al. [15] created a brief in-person intervention, including a smartphone application (MApp) to distribute tips related to PBS in order to reduce cannabis use. Another team, based in the United States, developed the Marijuana eCHECKUPTO GO, a web-based personalized feedback tool with normative information and PBS [16]. Their study results revealed a decrease in frequency of cannabis use among heavy-user college students who participated in the intervention. In the experimental group, females increased their use of PBS more than males did [16]. This suggests that PBS use should be considered as a target when developing interventions to encourage lower-risk cannabis use.

In the context of the prevention and promotion of safe cannabis use, the PBSM scale could be useful to both health professionals and community/social workers. It can be easily used in various specialized but also non-specialized settings and contexts, such as primary care services, family practices, schools and community settings, and for various purposes, such as evaluation, screening, personalized feedback and intervention. It is important to offer tools to better help professionals who might feel ill equipped in the face of cannabis legalization and of the adoption of the harm reduction paradigm in response to lifting of the prohibition on the use of this substance.

Limitations

This article reports on the full psychometric properties of the English version of the Protective Behavioral Strategies for Marijuana short form (PBSM-17) and its French translation in a Canadian context. Though we applied a systematic procedure and high standards to adapt, translate and evaluate the PBSM-17, our study is not without limitations. First, the PBSM was validated among a sample of university students with particular sociodemographic characteristics, which is to say a population not necessarily representative of the entire adult population. Unfortunately, analyses of

the differences between PBSM scales by gender and race have not been carried out. Second, we could have evaluated criterion validity using other indicators instead of just frequency of cannabis use, such as number of days of cannabis use, quantity of cannabis use, cannabis use consequences, and substance abuse diagnosis. The fact that frequency of cannabis use was measured dichotomously rather than continuously can also be considered as a limitation. Third, there was a reduction in accounted variance for the French version of the scale compared to the English version. Though the difference is small, it suggests that the one-factor structure may be less well represented in French although this was the first attempt to evaluate the factor structure of the French version of the PBSM-17. This possibility should be investigated in future research, for instance using CFA.

Conclusion

The French-Canadian version of the 17-item short form of the Protective Behavioral Strategies for Marijuana Scale (PBSM-17) and its English version were found to be valid with Canadian university students. The legalization of cannabis use affords the opportunity to set up prevention initiatives to promote safer consumption behaviors such as those measured by the PBSM. A significant research effort is critically needed for new, evidence-based public health prevention interventions to target PBS, using innovative strategies to encourage cannabis users to apply them.

FIGURE LEGEND

Figure 1. Mean Score Plots

STATEMENTS

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Competing interest statement

The authors report no conflict of interest.

Contributorship statement

All co-authors had substantial contributions to the conception or design of the work, or the acquisition, analysis or interpretation of data. JC and PA drafted the manuscript. SC and SCM conducted the analysis. SC, GMP, SMC, GF, GC, GR, CG, JL, ERP, DJA revised the manuscript and added important intellectual content. JC and PA produced the final document. All co-authors reviewed and approved the final version of the manuscript.

Data sharing statement

Data are available upon reasonable request by emailing the corresponding author, JC.

Ethics statement

This study obtained ethics approval by the *Centre Hospitalier de l'Université de Montréal (CHUM)* Research Ethics Board (20.172) and by the *Comité d'éthique de la recherche en sciences et en santé (CERSES)* of the *Université de Montréal* (CERSES-20-114-D). All participants provided informed consent.

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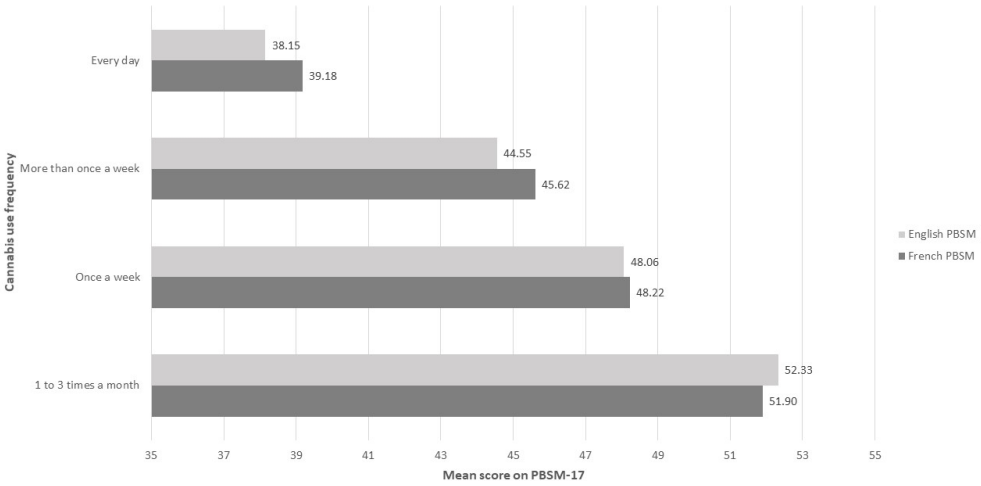

Figure 1. Mean Score Plots

338x190mm (96 x 96 DPI)