



Measurement invariance of the Marijuana Motives Measure among men and women using Stop Cannabis App

Lucien Rochat^{a,b}, Stéphane Rothen^{c,d}, Yves Edel^e, Louise Penzenstadler^c, Tania Lecomte^f, Stéphane Potvin^f, Elise Dan Glauser^g, Jean-François Etter^h, Yasser Khazaal^{f,i,j,*}

^a Specialized Facility in Behavioral Addiction ReConnecte, Department of Mental Health and Psychiatry, University Hospitals of Geneva, Geneva, Switzerland

^b Faculty of Psychology, UniDistance, Brig, Switzerland

^c Addiction Division, Department of Mental Health and Psychiatry, University Hospitals of Geneva, Geneva, Switzerland

^d Research Center for Statistics, Geneva School of Management and Economics, University of Geneva, Geneva, Switzerland

^e ELSA, GHU Pitié-Salpêtrière, Sorbonne-Université Paris, Paris, France

^f Research Center of the Institut Universitaire en Santé Mentale de Montréal, Montreal and Université de Montréal, Montreal, Canada

^g Institute of Psychology, Lausanne University, Lausanne, Switzerland

^h Institute of Global Health, Geneva University, Geneva, Switzerland

ⁱ Addiction Medicine, Department of Psychiatry, Lausanne University Hospital and Lausanne University, Lausanne, Switzerland

^j Faculty of Biology and Medicine, Lausanne University, Lausanne, Switzerland

ARTICLE INFO

Keywords:

Cannabis
Sex-related differences
Motives
Coping
Conformity
Problematic cannabis use
App

ABSTRACT

Background: Motives to use cannabis play a central role in the development and maintenance of problematic cannabis use and previous studies stressed sex-related differences on motives to use cannabis. However, motives cannot be validly compared in men and women without first establishing the measurement invariance across sex. Therefore, the aim of the study is to (1) examine for the first time the measurement and structural invariance of the Marijuana Motives Measure (MMM) across sex, and (2) to investigate the motives for cannabis use that best explain problematic use.

Methods: 2951 (41.7% women) users of the “Stop cannabis” smartphone app of which 99.8% reported having used cannabis in the last three months completed an online MMM and ASSIST to assess the severity of their problematic cannabis use.

Results: Multigroup confirmatory factor analyses supported measurement invariance across sex, whereas structural invariance was not confirmed. Indeed, group comparisons indicated that women reported greater coping motives than men whereas men showed greater social motives than women. A multiple linear regression analysis showed that only coping and conformity motives were significantly associated with greater problematic cannabis use, whereas neither sex nor the sex by motives interactions were significantly related to problematic cannabis use.

Conclusions: The MMM appears to function comparably across men and women. Therefore, sex-related comparisons on the questionnaire can be considered valid. Coping and conformity motives may play a central role part in the development of marijuana use problems which may hold implications for intervention development and public policy.

1. Introduction

Cannabis is the most popular psychoactive substance under international regulations, with >192 million people worldwide who reported

having used cannabis at least once in 2016 (United Nations Office on Drugs and Crime, 2018). Although the prevalence of cannabis use disorders remains twice as high as in men than women (3.5% vs 1.7%), there is growing evidence that the prevalence gap between men and

* Corresponding author at: Research center of the Institut Universitaire en Santé Mentale de Montréal, Montreal and Université de Montréal, Montreal, Canada.
E-mail addresses: Lucien.Rochat@hcuge.ch (L. Rochat), Stephane.Rothen@hcuge.ch (S. Rothen), yves.edel@aphp.fr (Y. Edel), louise.e.penzenstadler@hcuge.ch (L. Penzenstadler), tania.lecomte@umontreal.ca (T. Lecomte), stephane.potvin@umontreal.ca (S. Potvin), elise.danglauser@unil.ch (E. Dan Glauser), Jean-Francois.Etter@unige.ch (J.-F. Etter), yasser.khazaal@unil.ch (Y. Khazaal).

<https://doi.org/10.1016/j.addbeh.2023.107866>

Received 4 April 2023; Received in revised form 8 September 2023; Accepted 18 September 2023

Available online 19 September 2023

0306-4603/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

women is actually decreasing (Center for Behavioral Health Statistics and Quality, 2017; Chapman et al., 2017; Substance Abuse and Mental Health Services Administration, 2007). Men and women show similar levels of cannabis intoxication following cannabis administration, yet some data suggest that women report a greater propensity to enjoy marijuana and to use it again (Cooper & Haney, 2009, 2014), experience more severe withdrawal symptoms and greater tolerance (Sanchis-Segura & Becker, 2016), develop cannabis-use disorder more quickly from first use (“telescoping” effect; Khan et al., 2013), and report persistent cannabis-related consequences, such as higher rates of anxiety and mood disorders, suicide risk as well as long term psychological distress than men (Danielsson et al., 2016). Corroborating these findings, among treatment-seeking patients, women begin treatment with more severe withdrawal symptoms and co-occurring psychiatric disorders as well as poorer overall quality of life than men (Sherman et al., 2017). However, the literature on the psychological processes associated with problematic cannabis use in women is still sparse as most clinical and non-clinical studies have included only men or had an imbalanced sex ratio, preventing specific examination of sex-related differences. Investigating psychological factors associated with problematic cannabis use across sex is thus critical to better inform health promotion and targeted prevention policies.

Among the psychological factors involved in cannabis problematic use, motives for marijuana use have received much attention. As laws allowing access to marijuana develop worldwide, there is a need to examine how various motives are associated with problematic marijuana use (e.g., reduced productivity, conflicts, legal issues), considering that motives for marijuana use might help explain the transition from recreational to problematic use and then cannabis use disorder among consumers (Bresin & Mekawi, 2019).

Building on the literature on drinking motives (Simons et al., 1998), a five-factor model for marijuana use motives was developed. These five factors are typically assessed with the Marijuana Motives Use Measure (MMM; Simons et al., 1998): (1) to cope with distress (coping), (2) to enhance positive emotions (enhancement), (3) to improve social gatherings (social), (3) to fit in with a group (conformity); and (4) to expand awareness and understanding of oneself and the world (expansion). A recent meta-analysis (Bresin & Mekawi, 2019) stressed that cannabis use problems were positively related to coping and conformity after adjusting for other motives (Bresin & Mekawi, 2019). Coping was actually found to be the strongest and most reliable predictor of both frequency and problematic use of cannabis (Bresin & Mekawi, 2019). Previous literature also stressed sex-related differences on motives to use cannabis with men endorsing more conformity motives than women (Buckner et al., 2012) and women using cannabis more frequently for relieving stress associated with adverse life events or trauma (Lynskey et al., 2002). In addition, coping motives more strongly predicted cannabis use in women than men (Simons et al., 1998) and more strongly mediated the association between distress intolerance and cannabis use-related problems in women than men (Bujarski et al., 2012). These data corroborate previous results stressing that coping motives were related to problematic substance use especially for women (Norberg, Norton, Olivier, & Zvolensky, 2010).

Although a number of studies have shed light on the importance of motives for use among individuals using cannabis with the MMM as well as sex-related differences, motives cannot be validly compared in men and women without first establishing the measurement invariance (MI) across sex. MI refers to whether or not a measure assesses the same trait in the same way in different groups (Widaman et al., 1993) and can be examined using multigroup confirmatory factor analyses (MG-CFA). As such, MI is used here to assess whether a psychometric test (MMM) reveals differences among individuals belonging to different group (i.e., men versus women) on the latent trait being measured because of the measurement itself (Millsap, 2011). Thus, before comparing levels of motives to use cannabis among men and women, one must ensure that the latent variable being assessed is measured similarly among men and

women. To the best of our knowledge, this is the first study to appraise the importance of MI in attempts to evaluate sex-related differences in motives to use cannabis. Once measurement invariance empirically established, the structural invariance can be determined, which addresses whether the characteristics (e.g., means) of the factors representing the traits being studied are equal across sex.

This study first seeks to examine both the measurement and the structural invariance of the MMM in a large sample of men and women using the Stop-Cannabis App. This App was specifically designed help participants stop or reduce their cannabis use or prevent relapse (Monney et al., 2015). Second, this study aimed to investigate which motives for cannabis use best account for problematic cannabis use according to sex. As such, we examined how motives and sex interact and relate to problematic cannabis use. According to previous studies stressing that (1) coping was the strongest and most reliable motive associated with problematic cannabis use (Bresin & Mekawi, 2019) and seems to have a stronger effect on problematic cannabis use in women than in men (Bujarski et al., 2012; Simons et al., 1998), and (2) women more frequently used cannabis to relief stress associated with adverse life events or trauma (Lynskey et al., 2002), we hypothesized that coping motives would be the strongest predictor of problematic cannabis use among the Stop-Cannabis App users, and that this association would be stronger for women than for men.

2. Material and methods

2.1. Participants

Between September 20, 2010 and January 13, 2020, 4077 people from French-speaking countries (i.e., France, Switzerland, Canada, Belgium and Luxembourg) downloaded the Stop-Cannabis App which is intended to help people to stop or reduce their cannabis use or prevent relapse (Monney et al., 2015). Participants clicked on a link in the App and answered a binary sex categorization question (men/women) and gave their age before answering an online questionnaire posted on “Stop-cannabis.ch”. There were no specific inclusion criteria except being older than 18 years old. As the Stop-Cannabis App aims to help people stop or decrease cannabis use or prevent relapse, endorsing current cannabis use was thus not mandatory. From a 32-character alpha-numeric string code associated with each user of the app, 95 duplicates were identified and removed. Then, after removing 450 minor users (i.e. < 18 years old), 3532 subjects remained. Of them, 2951 (83.6%) fully completed the MMM, which consists of the analyzed sample. The mean age of these 2951 participants was 28 years (SD = 9). There were 1719 men (58.3%) and 1232 (41.7%) women. As the age distribution was skewed to the left, this variable was transformed into tertiles for use in further analyses resulting in the following categories: 18–22 years old (N = 999), 23–30 (N = 1029) and > 30 (N = 923). Based on the *Alcohol, Smoking, and Substance Involvement Screening Test* (ASSIST; Heslop et al., 2013), 7 participants (0.2%) were classified in the low risk group for cannabis use (score 0–3), 1335 (45.2%) in the moderate risk group (score 4–26), and 1567 (53.1%) in the high risk group (score ≥ 27). Only 42 participants did not complete the ASSIST (1.4%).

2.2. Procedure

Participants were invited to accept or decline storage of their responses for research purposes. When using the app, participants were asked to complete the ASSIST (Heslop et al., 2013) for screening and assessing the severity of their cannabis use. The app also includes the Marijuana use Motives Measure (MMM; Simons et al., 1998). Participants then received a computer-tailored personal feedback report about their motives for cannabis consumption. Assessments and data were reported anonymously. In this context, the collection was not submitted to an ethics committee. The Swiss Human Research Act does not apply to this survey (Chapter 1, Section 1, Article 2, Scope: 2c) inasmuch as it

involves anonymously collected health-related personal data (<https://www.fedlex.admin.ch/eli/cc/2013/617/en>).

2.3. Questionnaires

2.3.1. Marijuana motives use measurement (MMM; Simons et al., 1998 ; French version: Chabrol et al., 2005)

The MMM is a 25-item self-report questionnaire that assesses five motives for cannabis use: coping (e.g., “To forget about my problems”), enhancement (e.g., “Because it gives me a pleasant feeling”), social (e.g., “Because it improves parties and celebrations”), conformity (e.g., “To be liked”), and expansion (e.g., “To be more open to experiences”). Items are rated on a 5-point scale ranging from 1 (almost never/ never) to 5 (almost always/ always). Higher scores indicate a greater endorsement of motives for cannabis use. All factors of the French version of the MMM showed fair internal consistency ranging from 0.76 to 0.84 (Chabrol et al., 2005).

2.3.2. ASSIST (French version, Khan et al., 2011)

The ASSIST is a screening measure for problematic substance use developed by the World Health Organization. For the purpose of the current study, only the marijuana subscale was administered. After a screening question (item 1) assessing lifetime cannabis use, the following six questions examining the severity of problematic cannabis use in the past three months are presented: frequency, craving, health/social/legal/financial problems, failure to handle daily responsibilities, relative expressing concern about cannabis use, failure to control, reduce or stop cannabis use. Items 2 and 3 are rated on a 5-point Likert scale ranging from 0 (never in the past 3 months) to 6 (daily or almost daily), whereas items 4 and 5 are rated on a 5-point Likert scale ranging from 0 to 7 and 8, respectively. Items 6 and 7 use a three category rating 0 = (no never), 6 (yes in the past 3 months) and 3 = (yes but not in the past 3 months). The total score is the total of items 2 to 9 and ranges from 0 to 39, with a higher score indicating more severe problematic cannabis use. In the French version of the ASSIST, all specific substance scores including cannabis showed fair internal consistency ranging from 0.74 to 0.93, as well as criterion and discriminative validity (Khan et al., 2011). In the current study, we used a continuous score rather than a dichotomous score since empirical data showed that cannabis use is better conceptualized on a continuum rather than as categories (e.g., Denson & Earleywine, 2006).

2.4. Statistics

Exploratory Factor Analysis (EFA) and Confirmatory Factor analyses (CFA) were first conducted to examine the factor structure of the MMM (see Annex 1). Then, assessment of measurement invariance was performed following the recommended guidelines from the literature whereby a new model constraint was added at each step (Brown, 2015). Configural invariance was first examined to assess whether the factor structure is equivalent across the groups being tested (i.e., whether cannabis use motives have an equivalent model form in men and women). This solution served as the baseline model for subsequent tests of measurement invariance. Second, metric (or weak invariance) was assessed by determining constraints on factor loadings forcing them to be identical across groups (i.e., it evaluates whether the scale items contribute to the motives latent factors in a similar manner for men and women). Third, scalar (or strong invariance) was achieved by constraining item intercepts to be equal across groups (i.e., it indicates whether groups have the same baseline item average). Of note, there is currently no consensus on which fit indices and criteria to use when examining measurement invariance. Consequently, we relied on multiple sources and recommendations. The first invariance, i.e. configural invariance, was examined using Comparative Fit Index (CFI) and Root Mean Square of Error Approximation (RMSEA). The next invariances were estimated using the difference between the CFI (Δ CFI) and the

RMSEA (Δ RMSEA) of the specified models. More restrictive models were considered invariant from less restrictive models if Δ CFI < 0.01 (Cheung & Rensvold, 2002) and Δ RMSEA < 0.015 (Chen, 2007). Values above the recommended thresholds indicate measurement non-invariance at the step where the model shows a significant degradation in fit. Then, scores on the five motives were compared across sex using Wilcoxon rank-order tests. Group comparisons of means were conducted only if configural, metric, and scalar invariance have been previously supported. The comparison between groups allowed determining whether the questionnaire is structurally invariant. The effect size value varies from 0 to close to 1. Commonly published interpretation values are as follows (Tomczak & Tomczak, 2014): 0.10 - < 0.3 (small effect), 0.30 - < 0.5 (moderate effect) and \geq 0.5 (large effect). Correlation analyses were then performed to examine the association between the five motives and problematic cannabis use for men and women separately using Spearman rank-order correlations. Finally, to examine the relationship between motives, sex and problematic cannabis use as assessed by the ASSIST, a multiple linear regression analysis was computed. The dependent variable was the ASSIST score, while the independent variables were the five motivation scales, sex, and age categories. Interaction between sex and motives for cannabis use were also examined. Since residuals were not normally distributed due to outliers, robust methods have been used (Heritier et al., 2009). Predictors in the regression analysis were considered statistically significant at $p < .05$, corrected for multiple tests by using Benjamini and Hochberg's (1995) false discovery rate (FDR) procedure.

Analyses were performed with R version 4.1.2 (R Core Team, 2021). EFA was performed with the psych package (Revelle, 2022), whereas CFA and Multigroup confirmatory analyses (MGCFAs) were performed with the lavaan package (Rosseel, 2012).

3. Results

Detailed results from the EFA and CFA conducted on three randomly determined subsamples are presented in the Annex 1. The main result showed that the 5-factor structure of the MMM was supported after removing four items which did not sufficiently load on their respective expected factors. Consequently, subsequent analyses were performed on a 21-item version of the MMM.

Results of the MGCFAs (Table 1) provides evidence of configural invariance indicating that the factor structure of the 21-item MMM is similar for men and women. The model fit indices for the metric invariance model did not substantially differ from the configural model indicating that the magnitude of the factor loadings was the same for men and women. Furthermore, the scalar invariance model did not substantially change from the metric model indicating the mean responses across items on each factor did not vary by sex.

Group comparisons according to sex (Table 2) showed that all motives significantly differ between men and women. More specifically, women scored significantly higher on coping, whereas males scored higher on enhancement, social, conformity and expansion motives. Effect sizes were the largest for social and coping motives, although they remained in the small effect size range. The other effect sizes were close to 0 and were thus considered negligible.

The correlation analysis (Table 3) indicated that coping and conformity were significantly and positively associated with the ASSIST total score for both men and women, indicating that the greater the

Table 1
Indices of the measurement invariance tests for the Marijuana Motives Measure across sex.

Models	CFI	RMSEA	Δ CFI	Δ RMSEA
Configural (factor structure)	0.931	0.055	–	–
Metric (loadings)	0.929	0.054	0.002	0.001
Scalar (intercepts)	0.924	0.055	0.005	0.001

Table 2
Sex-related comparisons on the five motives as assessed by the MMM using Wilcoxon rank order test (*w*).

Variables	Men (N = 1719)	Women (N = 1232)	<i>w</i>	<i>p</i> -value	Effect size	Composite reliability (90% CIs) Men/Women
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)				
Coping	11.59 (4.34)	12.99 (4.14)	862,613	< 2.2e-16	0.16	0.82 [0.81;0.83]/ 0.80 [0.78;0.82]
Enhancement	12.07 (2.66)	11.76 (2.82)	1,122,084	0.005148	0.05	0.74 [0.72;0.76]/ 0.72 [0.69;0.75]
Social	12.77 (5.03)	10.82 (4.88)	1,310,235	< 2.2e-16	0.20	0.80 [0.78;0.81]/ 0.82 [0.80;0.84]
Conformity	4.86 (2.01)	4.65 (1.69)	1,117,856	0.0009343	0.06	0.78 [0.76;0.80]/ 0.77 [0.75;0.79]
Expansion	10.58 (4.99)	9.95 (4.91)	1,149,810	6.328e-05	0.07	0.86 [0.85;0.87]/ 0.87 [0.86;0.88]

Table 3
Spearman rank-order correlation between the five MMM scales and problematic cannabis use as assessed by the ASSIST score in men and women.

	Men (N = 1719)	Women (N = 1232)
MMM_Coping	0.37**	0.37**
MMM_Enhancement	0.02	0.04
MMM_Social	0.02	0.02
MMM_Conformity	0.13**	0.13**
MMM_Expansion	0.04	0.09*

Note. * *p* < .01; ***p* < .001. MMM = Marijuana Motives Measure.

coping and conformity scores, the greater the problematic cannabis use. In addition, expansion was significantly and positively related to the ASSIST total score in women only, indicating that the greater the expansion, the greater the problematic cannabis use.

Table 4
Robust multilinear regression analysis on the ASSIST total score.

	Estimate	Std. err	<i>t</i> -value	<i>p</i> -value (critical value for significance according to FDR)
(intercept)	18.4	1.11	16.5	<.001
Age cat 1 vs 2	-0.11	0.34	-0.34	0.7 (0.0167)
Age cat 1 vs 3	-0.98	0.35	-2.82	0.005 (0.0045)
Sex (female = 0)	-0.79	1.66	-0.48	0.6 (0.0125)
MMM social	-0.09	0.04	-2.18	0.029 (0.0056)
MMM Coping	0.7	0.04	15.78	<.001* (0.0038)
MMM Enhancement	0.01	0.08	0.19	0.9 (0.0500)
MMM Conformity	0.38	0.09	4.14	<.001* (0.0042)
MMM Expansion	-0.05	0.04	-1.25	0.2 (0.0071)
MMM Social × sex	0.04	0.06	0.56	0.6 (0.0100)
MMM Coping × sex	0.02	0.07	0.25	0.8 (0.0250)
MMM Enhancement × sex	-0.08	0.11	-0.75	0.5 (0.0083)
MMM Conformity × sex	-0.27	0.16	-1.7	0.089 (0.0063)
MMM Expansion × sex	0.15	0.06	2.42	0.016 (0.0050)

Note. * significant after correction for multiple tests by using Benjamini and Hochberg's (1995) false discovery rate (FDR) procedure. Critical value for significance according to FDR are presented in parentheses in the *p*-value column. MMM = Marijuana Motives Measure; Age were dummy coded with category (cat) 1 as the reference category; Age cat 1 = 18–22 years old; Age cat 2 = 23–30 years old; Age cat 3 = > 30 years old. Due to missing value on the ASSIST, N = 2909.

The results of the robust multiple regression linear analysis (Table 4) showed that only coping and conformity motives were significantly and positively associated with the ASSIST total score, indicating that the greater the coping and conformity motives, the greater the problematic cannabis use. Neither the social, expansion and enhancement motives reached statistical significance, nor age, sex or any interaction effects between sex and motives after correction for multiple tests by FDR.

4. Discussion

The objectives of this study were to examine the measurement and structural invariance of the MMM in men and women who use the Stop-Cannabis App and determine how the five motives to use cannabis might differentially account for problematic cannabis use according to sex. The results indicate measurement invariance across groups, making comparisons across sex on the MMM valid. Differential results according to sex indicated that women reported significantly greater coping motives whereas men showed greater social motives, although with only small effect sizes. Finally, coping and conformity motives were the only motives to be significantly and positively associated with greater problematic cannabis use after adjusting for the other motives and age, whereas neither sex nor interaction sex × motives were statistically significant.

First, greater coping motives in women than in men is in line with the greater prevalence of mood disorders (Kessler, 2006) and rumination thinking style (Johnson & Whisman, 2013) reported in women than in men. It also corroborates previous literature showing that women more frequently used cannabis to relief stress associated with adverse life events or trauma (Lynskey et al., 2002). The results are also in line with the « telescoping effect » found in women, a more severe symptomatology (including co-morbidity) as well as greater negative consequences associated with cannabis use in women. Indeed, expectations that marijuana use helps cope with distress may perpetuate cannabis use, while in turn reinforcing these expectations over time (Lee et al., 2017). The greater frequency of social motives in men may be related to a greater sensitivity to novel and/or arousing stimuli reflecting an overactive motivational approach system, a greater sensitivity to reward or a higher sensation seeking (Argyriou et al., 2020; Wang et al., 2017; Warthen et al., 2020) that predispose individuals to proactively search for novelty and excitement in social situations. However, unlike coping motives, social motives were not significantly associated with problematic cannabis use suggesting that social motives are related to recreational and possibly non-addictive use of cannabis.

Second, in line with our hypotheses and corroborating a recent meta-analysis (Bresin & Mekawi, 2019), coping and conformity motives were significantly associated with problematic cannabis use, whereas social, expansion and enhancement motives were not. On the one hand, coping motives are likely to increase substance misuse in individuals experiencing negative affect, generating a vicious cycle of consumption maintained by negative reinforcement (Bujarski et al., 2012). It might also reflect poor underlying emotion regulation mechanism driving cannabis consumption (Stellern et al., 2023). On the other hand, higher conformity motives could be associated with lower intrinsic motivation to use cannabis and feelings of coercion (Bresin & Mekawi, 2019), in

turn increasing addictive cannabis use. It may also highlight lower levels of assertiveness or cannabis use related assertiveness, a factor possibly related to increased risk for addictive substance use (González-Yubero et al., 2021). In addition, in contrast to our expectations, there was no significant interaction between sex and coping motives. This may be explained by the sample characteristics which consisted mainly of people with moderate to severe problematic cannabis use and seeking help using the Stop-Cannabis App and for whom coping likely play a central role in their use of cannabis regardless of their sex. Further studies should hence examine the interaction between sex and motives in recreational and/or low risk users, and include measures of emotion regulation processes within longitudinal design.

Third, the results from the EFA and CFA supported the five-factor structure of the MMM found in previous studies and in various languages after removing four items which did not sufficiently load on their respective expected factors as was the case in Benschop et al. (2015). It seems that the original version of the MMM (with 25 items) may be more adequate to assess motives to use cannabis in homogenous samples of adolescents or college students with infrequent or mild problematic cannabis use than more heterogeneous samples in older adults with moderate to severe problematic use of cannabis (Benschop et al., 2015).

This study is not without limitations. First, we focused on sex-related differences only and therefore this study has only limited generalizability because the whole construct of gender is not covered. In addition, other identity-specific variables may still affect the invariance of the measure such as different norms, roles, and experiences from interacting in the world as someone with a gender identity and not the category of gender per se. Second, and because of its cross-sectional design, the temporal precedence of motives on cannabis problematic use cannot be determined. Third, no information was collected on type of consumption (e.g., alone or in a group), type of cannabis used, the mode of administration of cannabis, or age of first use, which might be differentially associated with motives-related factors. Fourth, the results of group comparisons showed only small effect sizes. This could be explained by the specific characteristics of the sample, which included almost only moderate to at risk users as defined by the ASSIST, and who searched for help to reduce or stop their cannabis use with a dedicated app. Fifth, we had no information about possible concomitant disorders (e.g., mood disorders) in our sample, which might be associated with a greater use of coping motives. Sixth, no data quality checks have been performed. However, we are confident that null results are not associated with low quality data inasmuch as the internal consistency of the subscales of the MMM as well as the relationships found between problematic cannabis use and specific motives corroborate previous published data (Bresin & Mekawi, 2019). Finally, comparing scores of MMM in our sample to other samples in previous published articles (e.g., Peraza et al., 2019) showed little differences on the enhancement motive, but lower motives on the other factors of MMM in our sample, which make sense given the recruitment source of our sample. It could thus be argued that people who downloaded the Stop-Cannabis App may have lower motivation to use cannabis than those who did not download the app and therefore that the MMM is invariant across sex for people with lower motivation only. The measurement invariance of the MMM across sex should therefore be further examined in participants with low versus high motivation to use cannabis.

5. Conclusions

The MMM appears to function comparably for men and women. Therefore, men versus women comparisons on this questionnaire can be considered valid. Furthermore, the psychometric properties of the MMM indicates that it constitutes a valid tool to examine motives to use cannabis online or within an app. Finally, sex-related differences on the MMM suggest that particular care should be taken to prevent the development of marijuana use problems in women, which may have implications for the development of intervention and public policy. In

particular, sex-specific prevention and intervention programs should be promoted, especially regarding coping motives among women. Targeting individuals among female adolescents who report high levels of coping motives may be relevant to identify those who may need early interventions and decrease the risk of a problematic cannabis use.

Availability of data and materials.

The complete dataset used in the present study is available on request from the corresponding author.

CRediT authorship contribution statement

Lucien Rochat: Conceptualization, Writing – original draft. **Stéphane Rothen:** Writing – original draft, Data curation, Formal analysis. **Yves Edel:** Writing – review & editing. **Louise Penzenstadler:** Writing – review & editing. **Tania Lecomte:** Writing – review & editing. **Stephane Potvin:** . **Elise Dan Glauser:** Writing – review & editing. **Jean-François Etter:** Writing – review & editing, Conceptualization, Methodology, Supervision. **Yasser Khazaal:** Writing – original draft, Conceptualization, Methodology, Supervision, Validation.

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.

Data availability

Data will be made available on request.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.addbeh.2023.107866>.

References

- Argyriou, E., Um, M., Wu, W., & Cyders, M. A. (2020). Measurement invariance of the UPPS-P Impulsive Behavior Scale across age and sex across the adult life span. *Assessment*, 27(3), 432–453. <https://doi.org/10.1177/1073191119832660>
- Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society. Series B*, 57(1), 289–300. <https://doi.org/10.1111/j.2517-6161.1995.tb02031.x>
- Benschop, A., Liebrechts, N., van der Pol, P., Schaap, R., Buisman, R., van Laar, M., ... Korf, D. J. (2015). Reliability and validity of the Marijuana Motives Measure among young adult frequent cannabis users and associations with cannabis dependence. *Addictive Behaviors*, 40, 91–95. <https://doi.org/10.1016/j.addbeh.2014.09.003>
- Bresin, K., & Mekawi, Y. (2019). Do marijuana use motives matter? Meta-analytic associations with marijuana use frequency and problems. *Addictive Behaviors*, 99, Article 106102. <https://doi.org/10.1016/j.addbeh.2019.106102>
- Brown, T. A. (2015). *Confirmatory factor analysis for applied research (Second Edition)*. Guilford Publications.
- Buckner, J. D., Zvolensky, M. J., & Schmidt, N. B. (2012). Cannabis-related impairment and social anxiety: The roles of gender and cannabis use motives. *Addictive Behaviors*, 37(11), 1294–1297. <https://doi.org/10.1016/j.addbeh.2012.06.013>
- Bujarski, S. J., Norberg, M. M., & Copeland, J. (2012). The association between distress tolerance and cannabis use-related problems: The mediating and moderating roles of coping motives and gender. *Addictive Behaviors*, 37(10), 1181–1184. <https://doi.org/10.1016/j.addbeh.2012.05.014>
- Center for Behavioral Health Statistics and Quality. (2017). *2016 National survey on drug use and health: Detailed tables. Substance abuse and mental health services administration*. Rockville, MD. Accessed December 02 2022 from: <https://www.samhsa.gov/data/sites/default/files/NSDUH-DeT-Tabs-2016/NSDUH-DeT-Tabs-2016.pdf>
- Chabrol, H., Ducongé, E., Casas, C., Roura, C., & Carey, K. B. (2005). Relations between cannabis use and dependence, motives for cannabis use and anxious, depressive and borderline symptomatology. *Addictive Behaviors*, 30(4), 829–840. <https://doi.org/10.1016/j.addbeh.2004.08.027>
- Chapman, C., Slade, T., Swift, W., Keyes, K., Tonks, Z., & Teesson, M. (2017). Evidence for sex convergence in prevalence of cannabis use: A systematic review and meta-regression. *Journal of Studies on Alcohol and Drugs*, 78(3), 344–352. 10.15288/jsad.2017.78.344.
- Chen, F. F. (2007). Sensitivity of goodness of fit indexes to Lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, 14(3), 464–504. <https://doi.org/10.1080/10705510701301834>

- Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, 9(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5
- Cooper, Z. D., & Haney, M. (2009). Actions of delta-9-tetrahydrocannabinol in cannabis: Relation to use, abuse, dependence. *International Review of Psychiatry*, 21(2), 104–112. <https://doi.org/10.1080/09540260902782752>
- Cooper, Z. D., & Haney, M. (2014). Investigation of sex-dependent effects of cannabis in daily cannabis smokers. *Drug and Alcohol Dependence*, 136, 85–91. <https://doi.org/10.1016/j.drugalcdep.2013.12.013>
- Danielsson, A.-K., Lundin, A., Allebeck, P., & Agardh, E. (2016). Cannabis use and psychological distress: An 8-year prospective population-based study among Swedish men and women. *Addictive Behaviors*, 59, 18–23. <https://doi.org/10.1016/j.addbeh.2016.03.005>
- Denson, T. F., & Earleywine, M. (2006). Pothead or pot smoker? A taxometric investigation of cannabis dependence. *Substance Abuse Treatment, Prevention, and Policy*, 1(1), 1–6. <https://doi.org/10.1186/1747-597X-1-22>
- González-Yubero, S., Lázaro-Visa, S., & Palomera, R. (2021). Personal variables of protection against cannabis use in adolescence: The roles of emotional intelligence, coping styles, and assertiveness as associated factors. *International Journal of Environmental Research and Public Health*, 18(11), Art. 11. <https://doi.org/10.3390/ijerph18115576>
- Heritier, S., Cantoni, E., Copt, S., & Victoria-Feser, M.-P. (2009). *Robust methods in biostatistics*. John Wiley & Sons.
- Heslop, K., Ross, C., Osmond, B., & Wynaden, D. (2013). The Alcohol Smoking and Substance Involvement Screening Test (ASSIST) in an acute mental health setting. *International Journal of Mental Health and Addiction*, 11(5), 583–600. <https://doi.org/10.1007/s11469-013-9428-3>
- Johnson, D. P., & Whisman, M. A. (2013). Gender differences in rumination: A meta-analysis. *Personality and Individual Differences*, 55(4), 367–374. <https://doi.org/10.1016/j.paid.2013.03.019>
- Kessler, R. C. (2006). The epidemiology of depression among women. In Keyes, C. & Goodman, S. (Eds.), *Women and depression: A handbook for the social, behavioral, and biomedical sciences* (pp. 22–37). Cambridge University Press.
- Khan, R., Chatton, A., Nallet, A., Broers, B., Thorens, G., Achab-Arigo, S., ... Zullino, D. (2011). Validation of the French version of the alcohol, smoking and substance involvement screening test (ASSIST). *European Addiction Research*, 17(4), 190–197. <https://doi.org/10.1159/000326073>
- Khan, S. S., Secades-Villa, R., Okuda, M., Wang, S., Pérez-Fuentes, G., Kerridge, B. T., & Blanco, C. (2013). Gender differences in cannabis use disorders: Results from the National Epidemiologic Survey of Alcohol and Related Conditions. *Drug and Alcohol Dependence*, 130(1), 101–108. <https://doi.org/10.1016/j.drugalcdep.2012.10.015>
- Lee, C. M., Cadigan, J. M., & Patrick, M. E. (2017). Differences in reporting of perceived acute effects of alcohol use, marijuana use, and simultaneous alcohol and marijuana use. *Drug and Alcohol Dependence*, 180, 391–394. <https://doi.org/10.1016/j.drugalcdep.2017.08.029>
- Lynskey, M. T., Heath, A. C., Nelson, E. C., Bucholz, K. K., Madden, P. A. F., Slutske, W. S., ... Martin, N. G. (2002). Genetic and environmental contributions to cannabis dependence in a national young adult twin sample. *Psychological Medicine*, 32(2), 195–207. <https://doi.org/10.1017/S0033291701005062>
- Millsap, R. E. (2011). *Statistical approaches to measurement invariance*. Routledge.
- Monney, G., Penzenstadler, L., Dupraz, O., Etter, J.-F., & Khazaal, Y. (2015). mHealth app for cannabis users: Satisfaction and perceived usefulness. *Frontiers in Psychiatry*, 6. <https://doi.org/10.3389/fpsy.2015.00120>
- Norberg, M. M., Norton, A. R., Olivier, J., & Zvolensky, M. J. (2010). Social anxiety, reasons for drinking, and college students. *Behavior Therapy*, 41(4), 555–566. <https://doi.org/10.1016/j.beth.2010.03.002>
- Peraza, N., Smit, T., Garey, L., Manning, K., Buckner, J. D., & Zvolensky, M. J. (2019). Distress tolerance and cessation-related cannabis processes: The role of cannabis use coping motives. *Addictive Behaviors*, 90, 164–170. <https://doi.org/10.1016/j.addbeh.2018.10.047>
- R Core Team. (2021). *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing. <http://www.R-project.org/>.
- Revelle, W. (2022). psych: procedures for psychological, psychometric, and personality research. 2020. *R package version, 2(7)*. <https://personality-project.org/r/psych-manual.pdf>.
- Rossee, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48, 1–36. <https://doi.org/10.18637/jss.v048.i02>
- Sanchis-Segura, C., & Becker, J. B. (2016). Why we should consider sex (and study sex differences) in addiction research. *Addiction Biology*, 21(5), 995–1006. <https://doi.org/10.1111/adb.12382>
- Sherman, B. J., McRae-Clark, A. L., Baker, N. L., Sonne, S. C., Killeen, T. K., Cloud, K., & Gray, K. M. (2017). Gender differences among treatment-seeking adults with cannabis use disorder: Clinical profiles of women and men enrolled in the achieving cannabis cessation—evaluating N-acetylcysteine treatment (ACCENT) study. *The American Journal on Addictions*, 26(2), 136–144. <https://doi.org/10.1111/ajad.12503>
- Simons, J., Correia, C. J., Carey, K. B., & Borsari, B. E. (1998). Validating a five-factor marijuana motives measure: Relations with use, problems, and alcohol motives. *Journal of Counseling Psychology*, 45(3), 265–273. <https://doi.org/10.1037/0022-0167.45.3.265>
- Steller, J., Xiao, K. B., Grennell, E., Sanches, M., Gowin, J. L., & Sloan, M. E. (2023). Emotion regulation in substance use disorders: A systematic review and meta-analysis. *Addiction*, 118(1), 30–47. <https://doi.org/10.1111/add.16001>
- Substance Abuse and Mental Health Services Administration. (2007). *Results from the 2006 national survey on drug use and health: National findings*. Office of Applied Studies, N.S.H. Accessed December 02 2022 from: <https://files.eric.ed.gov/fulltext/ED498206.pdf>.
- Tomczak, M., & Tomczak, E. (2014). The need to report effect size estimates revisited. An overview of some recommended measures of effect size. *Trends in Sport Sciences*, 1(21), 19–25.
- United Nations Office on Drugs and Crime. (2018). *United Nations Office on Drugs and Crime (2018). Analysis of drug markets. Opiates, cocaine, cannabis, synthetic drugs*. Vienna: United Nations. Accessed December 02 2022 from: https://www.unodc.org/pdf/opioids-crisis/WDR18_Booklet_3_DRUG_MARKETS.PDF.
- Wang, D., Liu, T., & Shi, J. (2017). Development of monetary and social reward processes. *Scientific Reports*, 7(1), Art. 1. 10.1038/s41598-017-11558-6.
- Warthen, K. G., Boyse-Pearcor, A., Jones, K. G., Sanford, B., Love, T. M., & Mickey, B. J. (2020). Sex differences in the human reward system: Convergent behavioral, autonomic and neural evidence. *Social Cognitive and Affective Neuroscience*, 15(7), 789–801. <https://doi.org/10.1093/scan/nsaa104>
- Widaman, K. F., Stacy, A. W., & Borthwick-Duffy, S. A. (1993). Construct validity of dimensions of adaptive behavior: A multitrait-multimethod evaluation. *American Journal of Mental Retardation: AJMR*, 98(2), 219–234.