Cannabis Outcome Expectancies, Cannabis Use Motives, and Cannabis Use among a Small Sample of Frequent Using Adults

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ABSTRACT

Background: Little is known about the factors influencing use among frequent cannabis users, defined here as using at least three times per week. Outcome expectancies and motives for cannabis use have been independently examined in relation to cannabis use, but not among frequent users. Further, the associations among distinct expectancies and motives for cannabis use have yet to be explored. The current study examined whether expectancies influence cannabis use through cannabis use motives among frequent users. Additionally, we examined more nuanced relationships among three cannabis outcome expectancies (relaxation/tension reduction, social, perceptual/cognitive) and four motives (enhancement, social, coping, expansion). **Method:** Bayesian path analysis with informative priors was used to examine associations among expectancies, motives, and outcomes in a sample of 54 (63% male) young adult frequent users (i.e., at least three times per week; 65% used daily). Participants were recruited from the community and completed self-report questionnaires assessing cannabis use, expectancies, and motives. **Results:** Findings support hypotheses that cannabis use expectancies were associated with unique motives for frequent cannabis users. Perceptual/cognitive enhancement expectancies were the only expectancy to consistently relate to all four cannabis use motives. Social expectancies were related to enhancement, social, and expansion motives for use, and relaxation/tension reduction expectancies were associated with coping motives. **Conclusions:** Results extend previous work examining direct and indirect effects of expectancies and motives among frequent using young adults. Findings support the potential clinical utility of exploring the perceived functional benefits of cannabis use for individual frequent users as well as potential alternatives that might serve similar functions with fewer risks and consequences.

Key words: = cannabis use, cannabis expectancies, cannabis motives, Bayesian methods

Rates of cannabis use have remained relatively consistent over the past five years, with 33-39% of adults between the ages of 22 and 29 reporting past-year use in the United States in 2019 (Substance Abuse and Mental Health Services Administration [SAMHSA], 2021). Of these, approximately 5-7% report daily use (SAMHSA, 2021). Frequent cannabis use in large doses has been associated with more negative consequences, such as increased risk of cancer (e.g., Hall, 2015) and neurocognitive impairments (Figueiredo et al., 2020), yet most research on cannabis use is conducted with low- or moderate-using participants. Thus, there is a need to understand factors that contribute to frequent cannabis use to inform treatment development and intervention efforts. In the present study, frequent cannabis use is defined as using three or more days each week (Benschop et al., 2015).

Beliefs that drinking results in positive effects (i.e., alcohol expectancies), such as becoming more sociable, relaxed, or sexually appealing, are strong predictors of alcohol use (e.g., Read et al., 2003; Jones et al., 2001). However, self-reported

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reasons for using alcohol (i.e., alcohol use motives) are often more robust predictors of alcohol use than expectancies (see Kuntsche et al., 2005 for review). When examined concurrently, expectancies emerge as predictors of alcohol use motives, and mediation models have suggested the effects of expectancies on alcohol may be attributable to alcohol use motives (Cooper et al., 1995; Fischer et al., 2004; Kuntsche et al., 2007). In other words, motives appear to be most the proximal factors influencing alcohol use, and relations between alcohol use and distal factors, including alcohol expectancies, are mediated by motives (e.g., Hasking et al., 2011; Madden & Clap, 2021). This phenomenon has been explained through motivational theory, in which an individual's combined expectancies for drinking influence their decision about whether or not, and how much, to drink based on what they aim to achieve by drinking (i.e., the motive) (Kuntsche et al., 2010). Theoretical models of use expectancies and motives have been applied to cannabis use, resulting in the development of measurement instruments for cannabis-specific expectancies and motives (Aarons et al., 2001; Benschop et al., 2015; Schafer & Brown, 1991; Simons et al., 1998). However, few studies have simultaneously examined relations between cannabis use expectancies and motives for use, and it is unclear if the mediation effects typically observed in alcohol research are relevant to cannabis expectancies, motives, and use. Thus, the aim of the current investigation is to examine specific pathways through which cannabis effect expectancies are associated with use indirectly through specific motives among frequent users.

Cannabis Effect Expectancies and Cannabis Use Motives

Cannabis expectancies are perceived physical, cognitive, or behavioral effects anticipated to occur after using cannabis (Schafer & Brown, 1991; Kristjansson et al., 2012). Positive expectancies can include relaxation/tension reduction (e.g., to unwind), social facilitation (e.g., feel more romantic), and perceptual/cognitive enhancement (e.g., become more creative). Negative expectancies, alternatively, refer to the perceived negative consequences of cannabis use, and can include global negative effects (e.g., becoming careless) and sometimes cravings and physical effects (e.g., getting the "munchies"). While positive and negative outcome expectancies have been associated with frequency and quantity of use and dependence criteria, positive expectancies generally demonstrate larger effects on use and were therefore the focus of the present study (e.g., Altman et al., 2019; Brackenbury et al., 2016; Kristjansson et al., 2012; Lauritsen & Rosenberg, 2016).

Cannabis use motives describe self-reported reasons for using cannabis. Motives most commonly associated with cannabis use and problems include enhancement (e.g., because I like the feeling; to get high), social (e.g., be social; makes social gatherings more fun), coping (e.g., forget problems; cheer me up when I'm in a bad mood), and expansion (e.g., expand awareness; be more open to experiences) (Blevins et al., 2016; Bonar et al., 2017; Bonn-Miller & Zvolensky, 2009; Lee et al., 2009; Patrick et al., 2011). While a fifth motive, conformity, has also been proposed, this is previously failed to demonstrate associations with cannabis use (e.g., Bonn-Miller et al., 2007) and was not included in the current study. Coping motives, in particular, are associated with problematic use and cannabis-related negative consequences (Bravo et al., 2019; Kuntsche et al., 2005; Lee et al., 2009; Phillips et al., 2017). Coping motives have also been associated with lower distress tolerance (Semcho et al., 2016), higher anxiety sensitivity (Johnson et al., 2010), higher pain-related anxiety (Hogan et al., 2010), and higher depressive symptoms (Bravo et al., 2019).

In models of alcohol use, motives have typically been found to mediate associations between expectancies and drinking (e.g., Cooper et al., 1995; Fischer et al., 2004; Kuntsche et al., 2007). Although cannabis use expectancies and motives have both been independently associated with use, relatively little work has focused on integrating these constructs. In one study, Foster et al. (2016) found negative cannabis expectancies were more strongly associated with cannabis-related outcomes when accompanied by higher coping motives. However, this study did not examine positive expectancies and only examined one motive (i.e., coping). Buckner (2014) examined the unique predictive values of cannabis expectancies and motives on cannabis use and problems among college students, in addition to perceived cannabis use norms, but did not

examine associations among expectancies and motives. Amiet et al., (2020) found higher general endorsement of both cannabis motives and expectancies was associated with poorer psychosocial functioning, but this study did not examine interrelations between expectancies and motives. Thus, research has yet to consider cannabis motives as potential mediators of expectancy effects on cannabis-related outcomes. The present investigation seeks to fill these empirical and theoretical lacunae in a sample of frequent users.

Effects of Experience with Cannabis on Expectancies and Motives

Cannabis use expectancies have been prospectively associated with changes in cannabis use among adolescents over a two-year period (Skenderian et al., 2008). Similarly, motives for cannabis use have been found to fluctuate between the ages of 18 and 30 (Patrick et al., 2011). Exposure to cannabis may also influence perceptions of risk associated with use as college students who use cannabis report lower perceived risk than non-users whereas risk perception did not differ between cannabis heavy users and ever-users (Kilmer et al., 2007).

The existing literature on cannabis expectancies and motives have primarily focused on relatively light/infrequent users and college student samples. While this is understandable given the difficulty in recruiting individuals who use cannabis daily or almost daily, conclusions from light using samples may not generalize to those for whom effective intervention and treatment strategies are most needed (Benschop et al., 2015). For example, sensation-seeking may be a strong predictor of experimenting with cannabis, but it may have little to do with use among daily users. Similarly, treatment strategies developed based on findings from light using samples may have little impact among frequent users. Given the difficulty and expense associated with recruitment of frequent users, novel statistical methods which have fewer assumptions relative to traditional methods and are better suited for smaller samples (e.g., Bayesian approaches) may be useful in studying frequent cannabis users.

Using Bayesian Methods with Small Samples

Small sample sizes constrain researchers' ability to evaluate effects using traditional null hypothesis testing, known as the frequentist approach, in which parameters are considered fixed values with random error that reflect probabilistic determinants of a true effect. The frequentist approach considers the frequency of an occurrence over many trials, and is translated to the probability of observed attributes in a given sample relative to expected values from large number of samples drawn from a theoretical population with a given distribution. Increasing sample sizes reduces random sampling error, therefore increasing statistical power and resulting in higher t statistics and smaller p-values. Thus, sample size has considerable influence on the chance of finding statistically significant effects using traditional null hypothesis testing approaches.

Alternatively, the Bayesian approach incorporates knowledge of one's data and prior research to determine the probability of the theoretical model given the observed data (Dienes, 2011). Bayesian inference differs from the frequentist approach in that it incorporates prior information based on previous research findings, which vary in the degree of confidence attributed to them (Gelman et al., 2014). Prior distributions, often referred to as priors, are probability distributions that reflect the amount of uncertainty about a given parameter before data are examined. Priors can be either informative or non-informative. Informative priors are theoretically or empirically derived such that the researchers incorporate prior knowledge of the constructs and hypothesized relationships into the models. The extent to which the literature, both theoretical and empirical, used to specify priors is well-developed and robust reflects the strength of the priors selected to be incorporated into the model. Uninformative, or diffuse, priors are used when research and/or theory is limited and the researcher chooses to rely on observed associations within the data. These are uninformative because they place little emphasis on prior knowledge or findings, and have received cautionary recommendations as uninformative priors can have minimal impact on the results (Gelman, 1996) and using diffuse priors will often result in parameter estimates

that are similar to maximum likelihood estimates derived from the sample data (Clark, 2005). As sample size increases, the impact of priors on results diminishes (Gelman et al., 2004; Wang & Gelfand, 2002). Therefore, Bayesian methods are well suited for assessing the boundaries of the burgeoning body of theoretical and clinical research questions related to frequent cannabis use. Despite their strong applicability to this research area, Bayesian approaches have rarely been applied to cannabis research. Thus, an additional aim of the present study was to demonstrate how Bayesian methods can be used to evaluate complex theoretical models of cannabis use when sample sizes are small.

The overall purpose of this study was to determine the extent to which specific positive cannabis effect expectancies are associated with cannabis use motives using a Bayesian approach. In addition, the current research sought to determine whether cannabis use expectancies indirectly influence the likelihood of being a daily cannabis user and average number of joints used through cannabis use motives in a small sample of frequent cannabis users. We hypothesized that indirect pathways between cannabis expectancies and motives would align with alcohol use research (e.g., Hasking et al., 2011; Kuntsche et al., 2007), such that relaxation/tension-reduction expectancies would be mediated by enhancement, social, and coping motives, social facilitation expectancies would be mediated by enhancement and social motives, and perceptual/cognitive enhancement expectancies would be mediated enhancement and expansion motives.

METHODS

Participants and Procedures

Secondary data analyses were conducted using data from a broader mixed-methods study that included focus groups and a short survey (Prince et al., 2019). The present study used the survey data and the sample consisted of frequent cannabis users (n = 54; 63% male; 44.4% Caucasian; M_{age} =24.33 SD = 3.07), recruited from the community through local Facebook advertisements and received $50 as remuneration for participation. Participants had to be between the ages of 18-30, had to use cannabis as their drug of choice at least three times a week, and provide written consent. Participants were excluded if they had serious or ongoing legal problems, or had signs of severe mental illness. All procedures were approved by the university's IRB.

Measures

Cannabis use. A modified version of the Timeline Followback specific to cannabis use was used to assess cannabis use (TLFB; Collins et al., 2008). Participants were shown a past 30-day calendar, as well as pictures of what constituted a standard cannabis joint (1/2 gram), and indicated whether they used cannabis (yes/no) and how many joints they had used on each day. Average number of joints used per day was used to assess quantity of use. This method has been shown to be a valid method of assessing use (Hjorthoj et al., 2012).

Cannabis effect expectancies. The Marijuana Effect Expectancy Questionnaire (MEEQ; Aarons et al., 2001; Schafer & Brown, 1991) includes 48 items and six subscales. The three positive subscales were examined in the current study: relaxation/tension reduction, perceptual and cognitive enhancement, and social facilitation. Additional subscales include global negative effects (i.e., consequences), craving and physical effects, and cognitive/behavioral impairment. These subscales were not included as they are either negatively associated with use, as previously discussed, or were not hypothesized to relate to motivations for use (i.e., craving and physical effects) in the current study. Participants rated each item on a scale of 1 (*Strongly Disagree*) to 5 (*Strongly Agree*). The social facilitation scale included seven items and was revised from the nine-item social facilitation scale. Two of the nine items were uncorrelated with the rest of the items: "I am less motivated when I smoke marijuana" and "Marijuana does not make me feel more romantic or attracted to members of the opposite sex." These were the only items of the subscale that were reverse coded and one of the items was the only item that specifically referred to sex. Removal of these two items improved alpha from .595 to .771. No modifications were made either of the other two subscales. Example items included "It helps me to unwind" (relaxation/tension reduction), "I become more creative or imaginative on marijuana" (perceptual/cognitive enhancement), "Marijuana makes me talk more"

(social facilitation). See Table 1 for reliability estimates.

Cannabis use motives. The Marijuana Motives Questionnaire (MMQ; Simons et al., 1998) comprises 25 items assessing motives. Four of the five 5-item subscales were examined, including enhancement, social facilitation, coping, and expansion motives. Conformity motives have previously failed to demonstrate associations with cannabis use in previous studies (e.g., Bonn-Miller et al., 2007), and initial analyses confirmed that conformity motives were not related to use or correlated with the remaining subscales using the Bayesian framework. Therefore, conformity motives were not included in analyses. Participants indicate how often they used cannabis for each reason presented on a scale of 1 (*Almost Never/Never*) to 5 (*Almost Always/Always*). Example items included "Because it gives me a pleasant feeling" (enhancement), "Because it helps me enjoy a party" (social facilitation), "To forget my worries" (coping), and "Because it helps me be more creative and original" (expansion). Cronbach's alphas can be found in Table 1.

Analysis Plan

Bayesian analyses were used to tests hypotheses using M*plus* 7.4. Four Markov Chain Monte Carlo (MCMC) chains were used, running 50,000 iterations and thinning by 1 (i.e., retaining every other sample from MCMC simulations). Multiple imputation was used to replace missing values based on 20 generated datasets. Multiple fit indices were consulted to evaluate model fit, including Deviance Information Criteria (DIC; Spiegelhalter et al., 2002), Bayesian Information Criteria (BIC; Schwarz, 1978), *p*-value for Posterior Predictive Checking, and confidence limits for the differences between the observed and replicated chi-square values. Lower DICs and BICs were indicative of better fitting models. Non-significant p-values for Posterior Predictive Checking indicate that the differences between the observed and replicated posterior means and posterior standard deviations are not greater than chance.

Models with various informative and non-informative priors were estimated to test model sensitivity following recommendations by Gelman et al. (2004). Although definitions of degrees of informative priors vary among researchers, we adopted the use of definitions that reflect the strength of the literature used to inform prior distributions' specifications. Informative priors for associations of relaxation/tension reduction expectancies with enhancement and coping motives, as well as associations of expectancies and motives for use with cannabis use, were aggregate scores of standardized coefficients across studies (Gelman, 2002). Weakly informative priors derived from single study scores and results from studies on alcohol use were used to examine remaining parameters between expectancies and motives (Gelman, 2002). Relationships between expectancies and motives indicated in the alcohol use literature were used to inform priors for the relationship between cannabis use motives and expectancies (Cooper et al., 1995; Haskin et al., 2011; Read et al., 2003). Similarly, empirically-based priors were for specified relationships between motives and cannabis use (Bonn-Miller et al., 2007; Simons et al., 1998; 2005; Zvolensky et al., 2007). For relationships between expectancies and motives unique to cannabis use, perceptual/cognitive enhancement expectancies and expansion motives, priors were theoretically-based.

RESULTS

Descriptive information can be found in Table 1. Approximately 64.8% of the sample reported using cannabis on all 30 days in the past month, and remaining responses were evenly distributed across 14 to 29 days, although two individuals reporting using on zero days. The average number of joints reported per smoking day was 2.75, and ranged from 1 to 7. Thus, frequency was dichotomized to represent those who reporting using on all 30 days (1) and those who reported using fewer than 30 days (0). Correlations were evaluated using standard effect size criteria (i.e., .1 = small, .3 = medium, .5 = large; Cohen, 1992) rather than null hypothesis significance testing. Correlations among cannabis effect expectancies subscales and cannabis motives subscales suggested strong and positive associations between these cognitions. Additionally, expectancies and motives were positively associated with cannabis use. More specifically, correlations between motives and expectancies with cannabis use frequency were small in size for

Table 1. *Variable Statistics and Correlations*

				Correlations								
	α	Mean	SD	1	2	3	4	5	6	7	8	9
1. Relaxation/Tension Reduction	.79	4.02	0.75	-								
2. Per/Cog Enhancement	.75	3.74	0.74	.650	-							
3. Social Facilitation	.77	3.72	0.59	.600	.671	-						
4. Enhancement Motives	.89	4.03	1.04	.546	.650	.600	-					
5. Social Facilitation Motives	.88	3.59	1.08	.618	.749	.764	.794	-				
6. Coping Motives	.89	3.42	1.20	.616	.631	.609	.659	.746	-			
7. Expansion Motives	.92	3.64	1.25	.435	.717	.640	.581	.690	.609	-		
8. Average Joints Used	-	2.75	1.51	.096	.087	.049	.124	.055	.277	.129	-	
9. Frequency	-	0.65	0.48	.163	.159	.197	.176	.299	.157	.059	.285	-

Note. Frequency is dichotomous (i.e., 1 = all 30 days, 0 = < 30 days) and polychoric correlations are reported. α = Cronbach's alpha estimate. Per/Cog = Perceptual and Cognitive. SD = Standard Deviation.

all but expansions motives for which the correlation was positive but trivial in size. Regarding average number of joints, all correlations with expectancies were trivial, and only enhancement, coping, and expansion motives were associated with use quantity and these effects were small to moderate in size.

Model Building and Sensitivity Analyses

Informative priors found in Model 3 of Table 1 (effects retained in final analyses) and supplemental Table 1 (direct effects and all *a* paths) were initially specified to examine model fit. Models tested seven pathways between cannabis expectancies and motives: pathways between relaxation/tension-reduction expectancies and enhancement, social, and coping motives; pathways between social facilitation expectancies and enhancement and social motives; and pathways between perceptual/cognitive enhancement expectancies and enhancement and expansion motives. Each of the cannabis motives were hypothesized to be associated with cannabis use frequency and average number of joints used. To these models, the remaining five associations between expectancies and motives (i.e., relaxation/tension reduction expectancies with expansion motives; social facilitation expectancies with coping and expansion motives; perceptual/cognitive enhancement expectancies with social and coping motives) were also added. Direct effects of expectancies on cannabis use were then added to models of frequency and quantity of use, and all priors can be found in supplemental Table 1. The added parameters, and thus reduced degrees of freedom, of the direct effects included for frequency of use did not improve model fit for frequency of use (reduced model: posterior predictive *p*-value = .500, 95%CI[-14.54, 27.47]; direct effects model: posterior predictive *p*-value = .455, 95%CI[-26.83, 43.41]). Inclusion of direct effects for average joints used were also not determined to improve model fit (reduced model: posterior predictive *p*-value = .333, 95%CI[-17.75, 37.61], BIC = 1025.05, DIC = 921.20; direct effects model: posterior predictive *p*-value = .333, 95%CI[-9.41, 25.30], BIC = 1028.22, DIC = 917.82), Therefore, direct effects were not retained in the models.

The first set of priors used point estimates that were empirically- and theoretically-derived with modest and uniform variances of 0.10, which represented approximately 15% to 43% (average of 30%) of the estimates' magnitudes (Model 1). Variances were then adjusted to be very narrow (0.001) to represent highly precise estimates (Model 2), and relatively wide (0.40) to reflect a greater amount of variability and uncertainty (Model 3). Finally, model estimates were increased by two times in order to test whether the associations between expectancies and motives, as well as motives and use, were greater within the current sample of frequent users than those suggested in previous research (Model 4). Table 2 presents model fit results for selected models, and Table 3 presents the priors specified for each model. Across models, all pathways between expectancies and motives emerged. In Model 1, no effects of motives on frequency of use and average number of joints used were observed. However, all motives were associated with both frequency and average joints in Model 2. In both Models 3 and 4, only social motives were associated with use for frequency, and only coping motives emerged for average joints used.

Relationships between relaxation expectancies and enhancement motives ($b = 0.13$, 95%CI[-0.27, 0.58]), coping motives ($b = 0.41$, 95%CI[-0.03, 0.84]), and social motives ($b = 0.06$, 95%CI[-0.18, 0.39]), in addition to social expectancies and enhancement motives ($b = 0.36$, 95%CI[-0.07, 0.89]), were not indicated in models of frequency. Relationships between relaxation expectancies and enhancement motives ($b = 0.14$, 95%CI[-0.29, 0.65]), social motives ($b = 0.11$, 95%CI[-0.18, 0.49]), and expansion motives ($b = -0.30$, 95%CI[-0.75, 0.19]), as well as between social expectancies and coping motives ($b = 0.38$, 95%CI[-0.15, 0.87]) and enhancement expectancies and coping motives ($b = 0.43$, 95%CI[-0.03, 0.80]) failed to emerge in models of average use. These pathways were thus removed from the model.

Table 2. *Bayesian Path Analysis Model Fit Comparisons*

Outcome	Priors	BIC	DIC	Posterior Predictive Checking	95% CI [LL, UL]	
Frequency	Model 1	-	-	0.500	-14.54	27.47
	Model 2	-	-	0.083	-3.23	35.67
	Model 3	-	-	0.500	-16.08	28.51
	Model 4	-	-	0.500	-16.01	29.68
Average Joints Used	Model 1	1025.05	921.20	0.333	-17.75	37.61
	Model 2	1056.49	940.04	< .001	9.25	65.44
	Model 3	1017.81	919.74	0.417	-18.61	33.68
	Model 4	1019.71	920.29	0.333	-17.61	34.70

Note. Frequency of use is dichotomous (i.e., all 30 days vs. < 30 days). Selected models are highlighted. BIC and DIC model fit statistics are not available for Bayesian analyses using categorical outcomes. BIC = Bayesian Information Criteria. CI = Credibility Interval for the difference between the observed and replicated chi-square values. LL = Lower Limit. UL = Upper Limit.

Table 3. *Prior Distributions for Selected Models*

			Model 1		Model 2		Model 3		Model 4	
Expectancy		**Motive**	μ	σ^2	μ	σ^2	μ	σ^2	μ	σ^2
Relaxation	→	Enhancement	0.24	0.10	0.24	0.001	0.24	0.40	0.48	0.40
Social Facil	→	Enhancement	0.65	0.10	0.65	0.001	0.65	0.40	1.30	0.40
Relaxation	→	Coping	0.52	0.10	0.52	0.001	0.52	0.40	1.04	0.40
Social Facil	→	Social	0.42	0.10	0.42	0.001	0.42	0.40	0.84	0.40
Relaxation	→	Social	0.30	0.10	0.30	0.001	0.30	0.40	0.60	0.40
Enhancement	→	Coping	0.30	0.10	0.30	0.001	0.30	0.40	0.30	0.40
Enhancement	→	Social	0.50	0.10	0.50	0.001	0.50	0.40	1.00	0.40
Enhancement	→	Expansion	0.50	0.10	0.50	0.001	0.50	0.40	1.00	0.40
Social Facil	→	Expansion	0.50	0.10	0.50	0.001	0.50	0.40	1.00	0.40
Motive		**Outcome**								
Enhancement	→	MJ Use	0.38	0.10	0.38	0.001	0.38	0.40	0.76	0.40
Social	→	MJ Use	0.29	0.10	0.29	0.001	0.29	0.40	0.58	0.40
Coping	→	MJ Use	0.23	0.10	0.23	0.001	0.23	0.40	0.46	0.40
Expansion	→	MJ Use	0.29	0.10	0.29	0.001	0.29	0.40	0.58	0.40
Expectancy		**Outcome**								
Relaxation	→	MJ Use	0.38	0.10	0.38	0.001	0.38	0.40	0.76	0.40
Social Facil	→	MJ Use	0.29	0.10	0.29	0.001	0.29	0.40	0.58	0.40
Enhancement	→	MJ Use	0.23	0.10	0.23	0.001	0.23	0.40	0.46	0.40

Note. Social Facil = Social Facilitation. μ = Posterior mean. σ^2 = Variance.

Final Model Results

Model selection was based on model fit indices, which can be found in Table 2. Model 4 was selected for frequency of use given results of posterior predictive checking, which suggested this model demonstrated the smallest differences between the observed and replicated chi-square values with the narrowest credibility interval. However, model fit did not vary greatly across the models, with the exception of narrow variances (Model 2). Similarly, interpretations and results for expectancies and motives in Model 4 differed minimally from those indicated in Models 1 and 3, and relationships between motives and frequency of use were similar to those indicated in Model 3. Model 3 was selected for both frequency of use and average number of joints used based results indicating this model had the largest posterior predictive *p*-value, as well as the lowest DIC and BIC values. Path estimates and posterior standard deviations for the final model assessing frequency of use are reported in Table 4 and Figures 1 & 2. Estimates and posterior standard deviations for average number of joints used can be found in Table 5.

Across frequency and average number of joints used, results suggested increases in perceptual/cognitive enhancement cannabis effect expectancies were positively associated with greater social, enhancement, and expansion motives. Finally, social facilitation expectancies were positively associated with enhancement, social, and expansion motives. With regard to associations between cannabis motives and cannabis use, coping motives were associated with average number of joints used, and social motives were associated with frequency of use. No effects emerged for the remaining motives and either of the two cannabis use outcomes.

Table 4. *Path Model Results for Frequency of Use*

						95% CI	
Expectancy		**Motive**	*Est.*		*P*(SD)	LL	UL
Social Facil	→	Social	0.55	***	0.13	0.33	0.80
Enhancement	→	Social	0.63	***	0.13	0.32	0.87
Enhancement	→	Enhancement	0.82	***	0.13	0.54	1.05
Enhancement	→	Expansion	0.82	***	0.20	0.45	1.17
Relaxation	→	Expansion	-0.22		0.17	-0.57	0.12
Social Facil	→	Expansion	0.55	***	0.19	0.18	0.90
Social Facil	→	Coping	0.44	*	0.20	0.04	0.79
Enhancement	→	Coping	0.57	**	0.18	0.24	0.90
Motive		**Outcome**					
Enhancement	→	Frequency	0.09		0.21	-0.33	0.48
Social	→	Frequency	0.41	*	0.21	-0.05	0.81
Coping	→	Frequency	0.00		0.19	-0.39	0.31
Expansion	→	Frequency	-0.11		0.18	-0.49	0.23

Note. Priors noted in Model 3 of Table 3 are specified. Social Facil = Social Facilitation. CI = Credibility Interval. LL = Lower Limit. UL = Upper Limit. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5. *Model Results for Average Number of Joints Used.*

						95% CI	
Expectancy		**Motive**	*Est.*		*P*(SD)	LL	UL
Relaxation	→	Coping	0.75	***	0.16	0.43	1.07
Social Facil	→	Enhancement	0.41	***	0.16	0.15	0.73
Enhancement	→	Enhancement	0.50	***	0.16	0.19	0.76
Social Facil	→	Social	0.64	***	0.14	0.39	0.89
Enhancement	→	Social	0.50	***	0.12	0.27	0.72
Enhancement	→	Expansion	0.68	***	0.16	0.37	0.98
Social Facil	→	Expansion	0.48	**	0.16	0.14	0.73
Motive		**Outcome**					
Enhancement	→	Avg Joints	0.15		0.21	-0.26	0.54
Social	→	Avg Joints	-0.28		0.27	-0.80	0.23
Coping	→	Avg Joints	0.42	*	0.19	-0.03	0.76
Expansion	→	Avg Joints	0.09		0.18	-0.27	0.40

Note. Social Facil = Social Facilitation. CI = Credibility Interval. LL = Lower Limit. UL = Upper Limit. *$p < .05$. **$p < .01$. ***$p < .001$.

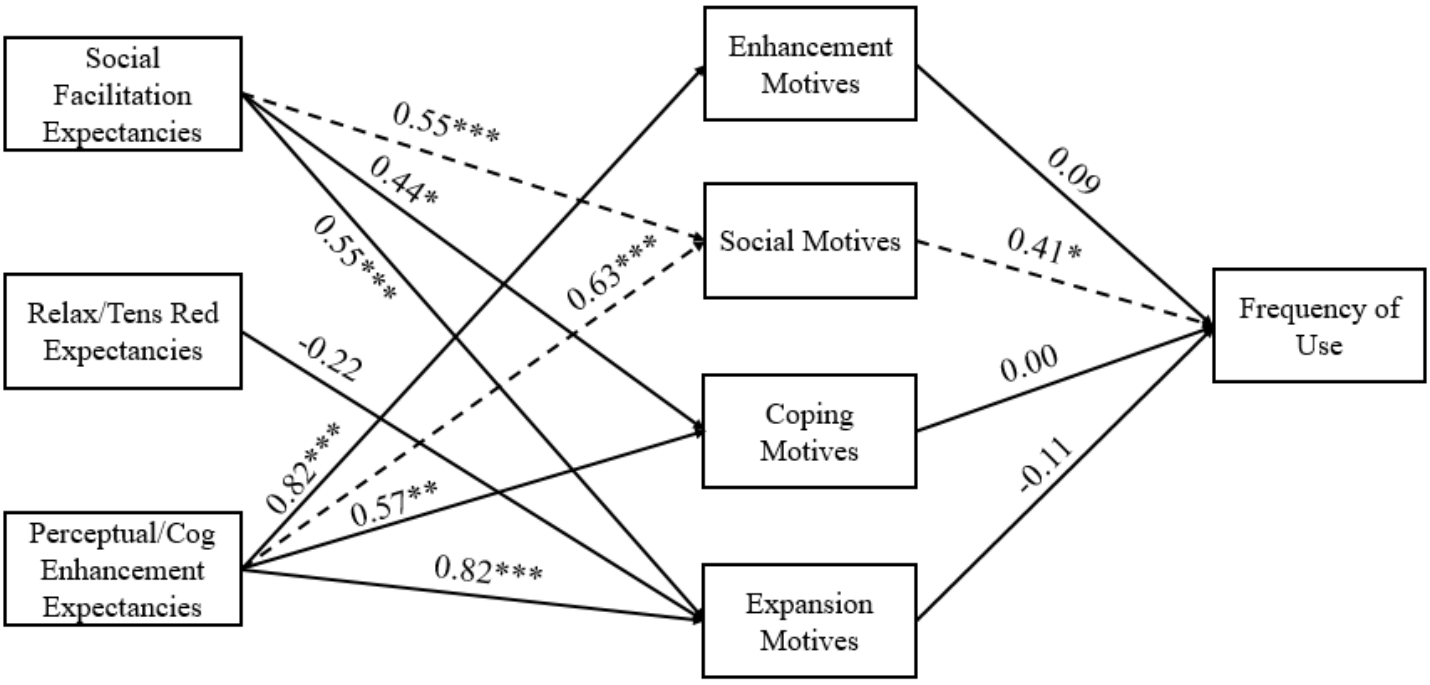

Figure 1. *Final Bayesian path analysis model for expectancies predicting frequency of use through three different forms of cannabis use motives. Dashed lines represent indirect pathways. Frequency is coded 0 (< than 30 days) and 1 (all 30 days). Social facilitation and perceptual/cognitive enhancement cannabis effect expectancies were indirectly related to average number of joints used on days when cannabis was used through social motives.*

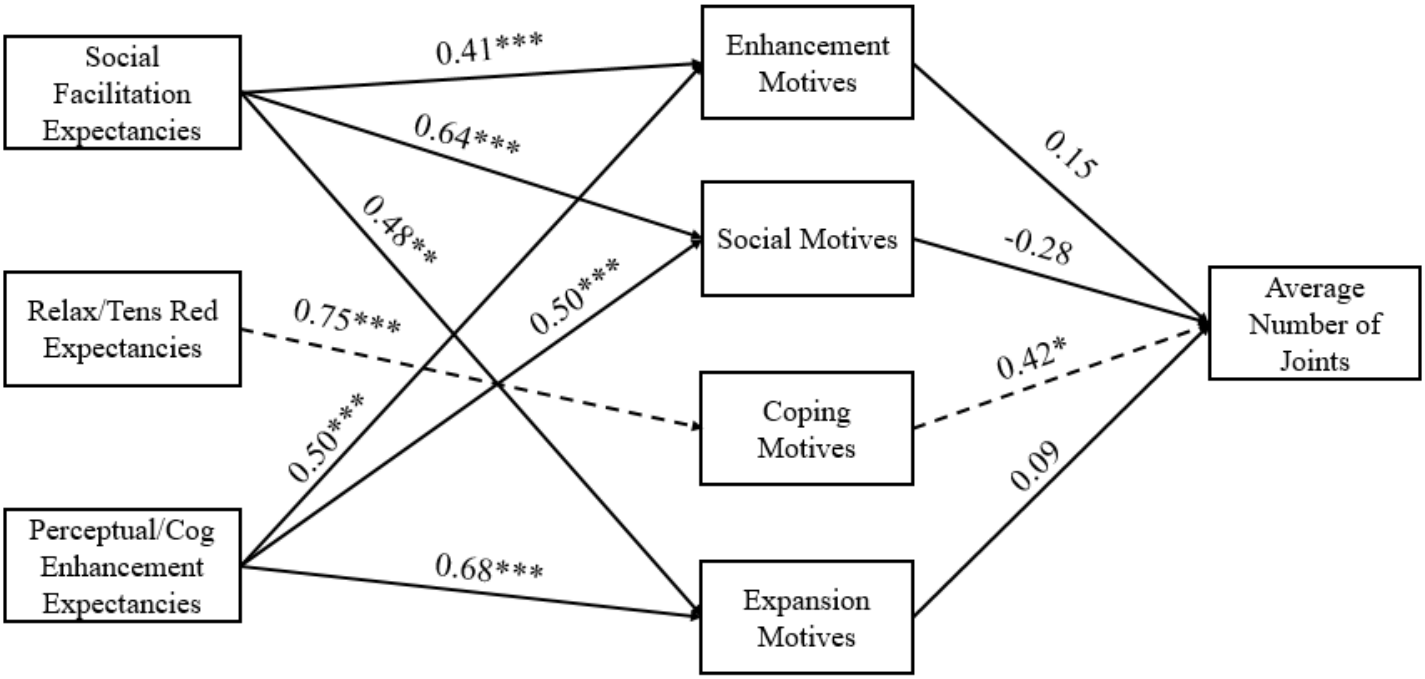

Figure 2. *Final Bayesian path analysis results for expectancies predicting average number of joints used through three different forms of cannabis use motives. Dashed lines represent indirect pathways. Perceptual/cognitive enhancement cannabis effect expectancies were indirectly related to average number of joints used on days when cannabis was used through coping motives.*

Table 6. *Indirect Effects of Cannabis Expectancies on Cannabis Use Through Motives for Use.*

							95% CI	
Expectancy	***a***	**Motive**	***b***	**Outcome**	*ab*		LL	UL
Social Facil	→	Expansion	→	Frequency	-0.05		-0.31	0.12
Social Facil	→	Coping	→	Frequency	0.00		-0.19	0.18
Social Facil	→	Social	→	Frequency	0.21	*	-0.03	0.49
Enhancement	→	Enhancement	→	Frequency	0.07		-0.27	0.39
Enhancement	→	Coping	→	Frequency	0.00		-0.24	0.19
Enhancement	→	Social	→	Frequency	0.24	*	-0.03	0.57
Enhancement	→	Expansion	→	Frequency	-0.09		-0.39	0.19
Relaxation	→	Expansion	→	Frequency	0.01		-0.08	0.17
Relaxation	→	Coping	→	Average Joints	0.29	*	-0.09	0.27
Social Facil	→	Enhancement	→	Average Joints	0.06		-0.12	0.27
Social Facil	→	Social	→	Average Joints	-0.19		-0.60	0.14
Enhancement	→	Enhancement	→	Average Joints	0.07		-0.12	0.27
Enhancement	→	Social	→	Average Joints	-0.13		-0.49	0.13
Enhancement	→	Expansion	→	Average Joints	0.06		-0.23	0.27
Social Facil	→	Expansion	→	Average Joints	0.04		-0.11	0.27

Note. Social Facil = Social Facilitation. CI = Credibility Interval. LL = Lower Limit. UL = Upper Limit. * $p < .05$.

Indirect Effects

Eight indirect effects were specified for each of the cannabis use expectancies on frequency of use and seven indirect effects were specified for average number of joints used through each of the cannabis use motives. The product of coefficients method was used to examine indirect effects; specifically, *a* paths between each expectancy and each motive were multiplied by the *b* paths assessing the effects of each respective motive on cannabis use. All indirect effects can be found in Table 6.

Two indirect effects emerged as significantly greater than zero for frequency of use: Social facilitation expectancies had a significant indirect effect on frequency through social motives. In addition, perceptual/cognitive enhancement expectancies were also indirectly related to frequency of use through social motives. One indirect effect was determined to be significantly different than zero for average number of joints used: relaxation/tension reduction expectancies were indirectly related to average joints used through coping motives.

DISCUSSION

The current study aimed to extend prior research demonstrating unique associations between expectancies and motives for alcohol consumption to cannabis use, an area of work with important theoretical and practical utility. We were also interested in examining the associations between the different types of motives and expectancies. Furthermore, we aimed to report on and demonstrate how Bayesian methods can be used to examine complex theoretical models with modest sample size. Results revealed similar positive relationships between expectancies and motives suggested in alcohol use literature (e.g., Hasking et al., 2011; Kuntsche et al., 2007). Notably, across all expectancies, perceptual/cognitive enhancement expectancies were the only expectancy determined to be consistently related to all four cannabis use motives. Social facilitation expectancies were related to enhancement, social, and expansion motives, and relaxation/tension reduction expectancies were determined to be associated with coping motives. Perceptual/cognitive enhancement expectancies were consistently associated with enhancement, social, and expansion motives. Furthermore, perceptual/cognitive expectancies and social expectancies were both indirectly related to frequency through social motives. Relaxation/tension reduction expectancies, conversely, were indirectly related to average number of joints used through coping motives. Of the four motives examined, only social motives were directly related to frequency of past 30-day use, whereas coping motives were associated with average amount of use.

Two unanticipated relationships emerged within the data: Social facilitation expectancies were associated with expansion motives and perceptual/cognitive enhancement expectancies were associated with social motives. Both perceptual/cognitive enhancement expectancies and expansion motives describe perceptions that cannabis increases one's ability to be creative, increase awareness, and increase openness to new ideas and experiences. That social expectancies and motives were associated with these cognitions indicates something distinctive about cannabis use that may be inherently social in nature to our frequent using participants. It is possible these individuals are highly embedded within social networks comprised of other frequent using adults, and consuming cannabis in such situations may facilitate social bonding.

Our results suggest motivational pathways may vary across outcomes. Social and cognitive perceptual expectancies were indirectly associated with daily use through social motives whereas tension reduction and cognitive/perception expectancies were indirectly associated with quantity through coping motives. The differential effects of social and coping motives on daily use frequency and quantity are somewhat analogous to motivational effects on drinking, where social motives have been associated more with consumption relative to coping motives, which have been more associated with problems (e.g., Kuntsche et al., 2007; Read, et al., 2003). Findings provide general support for motives as mediators of associations between expectancies and cannabis use, at least among frequent users. Subsequent research should examine whether motivational pathways may vary with use history and use patterns.

Clinical Implications

Our findings provide important clinical implications for prevention and intervention approaches. Interventions targeting perceptions

that cannabis enhances one's awareness and improves cognitive facilities may be ideal for interventions for frequent users (Figueiredo et al., 2020), as this was the only expectancy demonstrating associations with all four motives, as well as indirectly related to both frequency and quantity through cannabis social and coping motives, respectively. Further, intervening on social facilitation and relaxation/tension reduction cognitions may thwart the effects of these expectancies on subsequent use.

Interventions focused on challenging positive alcohol use expectancies have indicated significant decreases in alcohol use at follow-up (e.g., Darkes & Goldman, 1993; Larimer & Cronce, 2007), although meta-analyses have suggested these effects are rarely sustained beyond 30-day follow-ups (Scott-Sheldon et al., 2012). Thus, potentially altering positive expectancies for cannabis use may be one way to reduce use. More recently, researchers have demonstrated that interventions challenging coping motives for cannabis use can be used to significantly decrease use (Blevins & Stephens, 2016; Banes et al., 2014; Blevins et al., 2016). Similar methods may be applied to frequent users as our results indicated coping motives mediated the effects of expectancies (i.e., relaxation/tension reduction and perceptual/cognitive enhancement) on the amount of cannabis consumed. Programs altering the content of these strategies to target these specific expectancies and motives for cannabis use may be especially efficacious for frequent users.

Limitations and Future Directions

A number of limitations should be considered and provide important directions for future research. Given our focus on frequent cannabis using young adults, our findings may not extend to light or moderate users. Moreover, we had participants report cannabis use frequency relative to the number of standard joints used per day, which may not be the best approach for individuals who primarily used edibles, topicals, or other concentrated cannabis products. Replication of these models is needed to determine the extent to which similar relationships emerge and provide additional support for the theoretical model proposed. Replication within larger samples of frequent users would greatly bolster confidence in our findings as even Bayesian analyses cannot correct sampling error, as well as other concerns related to conservative sample sizes. Additionally, our findings are cross-sectional. Mediational analyses are best applied to samples with two or more time points during which mediators and outcomes are manipulated or assessed longitudinally (Preacher & Hayes, 2008). If these relationships are found in larger samples of cannabis users across multiple time points, greater confidence can be placed in our findings.

Lack of associations between reported use and most cannabis expectancies and motives (i.e., enhancement, coping, and expansion) in the present study diverge from those reported in previous studies involving frequent cannabis users (Simons et al., 2000), limiting the generalizability of the findings. However, one reason for the lack of association between motives and cannabis use may be the small sample size included in the current study as modest correlations were suggested across frequency and average joints, ranging from .11 to .36 with an average correlation of .21 when removing social facilitation motives (r = .05). Additional research is needed to replicate these effects in larger samples, samples with greater diversity, and samples of varying amounts of cannabis use prior to participation.

Although originally designed for use with adolescents, the MEEQ has been used in a large number of studies of adolescents and young adults. Most samples in which the MEEQ has been used have consisted of a relatively small proportion of daily or nearly daily users. This may account for the poor reliability of the social facilitation subscale and the need to drop two of the items. The fact that both of the items were reversed and that they were the only two that were reversed on this subscale could suggest that reversed items are more difficult to understand for frequent users. It also seems plausible that frequent users who may use multiple times every day or nearly every day may not associate use with sexual activity. In a review of self-reported effects of cannabis, Green, Kavanagh, and Young (2003) noted relatively frequent endorsement of enhanced sexual pleasure and sexual arousal but only when experiences were reported from a list of effects provided by researchers. In studies where responses were open ended, sexual effects were

not mentioned in any of the studies reported. Studies using open ended responses included heavier users than most of the studies where lists of possible effects were provided. Future research is needed to determine the extent to which the nature of expectancies differ markedly for very frequent users.

Conclusion

Collectively, results of the present study suggest expectancies have indirect effects on cannabis use through motives. To date, cannabis expectancies and motives have typically been evaluated separately. Our findings provide an initial foundation for more systematically examining how expectancies and motives operate in unison to predict cannabis use among frequent using adults. Additionally, our findings provide important implications for prevention and intervention research.

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