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Drinking Motives Predict Subjective Effects of Alcohol and Alcohol Wanting and Liking During Laboratory Alcohol Administration: A Mediated Pathway Analysis

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Abstract

Background—Motivational models of alcohol use suggest that individual differences in sensitivity to the acute subjective effects of alcohol play an important role in motivational pathways to alcohol use. However, few studies have examined the link between drinking motives and subjective responses to alcohol. This study investigated the associations of coping and enhancement drinking motives with subjective stimulant and sedative effects during a laboratory alcohol administration session. We also examined whether stimulation and sedation following alcohol administration mediated the relationships between drinking motives and post-alcohol ratings of alcohol wanting and liking.

Methods—Heavy episodic drinkers ($n=147$, ages 19–25) at two sites participated in an intravenous alcohol administration session in which blood alcohol concentration was raised to a target of 80mg% over 20 min. Participants completed measures of stimulation and sedation at baseline and 20 min, and also rated alcohol liking and wanting at 20 min. Drinking motives and alcohol use were assessed during a previous laboratory visit.

Results—A path analysis controlling for baseline stimulation and sedation showed that enhancement motives were positively associated with post-alcohol stimulation and negatively associated with post-alcohol sedation. In contrast, coping motives were positively associated with post-alcohol sedation. In turn, post-alcohol stimulation, but not sedation, was associated with alcohol wanting and liking. Further, indirect pathways from enhancement motives to post-alcohol wanting and liking mediated through post-alcohol stimulation were statistically significant.

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Coping motives, on the other hand, were directly associated with increased post-alcohol wanting and liking.

Conclusions—The results demonstrate that drinking motives are linked with individual differences in sensitivity to the effects of alcohol, which may serve as a mechanism underlying alcohol reinforcement and the motivation to consume more alcohol during a drinking episode.

Keywords

Subjective Response; Craving; Liking; Coping; Alcohol Challenge

Introduction

Motivational theories of alcohol use (Cox and Klinger, 1988, Cooper et al., 1995) have been widely cited in the literature on heavy drinking and alcohol-related problems. Central to motivational models is the concept that trait-like individual differences in drinking motives underlie distinct pathways to alcohol outcomes (for reviews, see Kuntsche et al., 2005, Kuntsche et al., 2006). Drinking motives have been classified into several subtypes, including internal, mood-regulation motives (i.e., drinking to enhance positive mood or to cope with negative mood), and external, social motives (i.e., drinking to facilitate social interactions or to conform with social expectations; Cooper, 1994). For emerging adults (i.e., individuals aged 18–25; see Arnett, 2005), drinking motives – particularly enhancement and coping motives – are among the strongest predictors of heavy drinking and alcohol problems when controlling for other related constructs (Kuntsche et al., 2005; Neighbors et al., 2007, Windle and Windle, 1996).

Motivational models of alcohol use contend that individual differences in drinking motives arise in part from differential sensitivity to the reinforcing pharmacological effects of alcohol (Cox and Klinger, 1988, Verheul et al., 1999, Wilkie and Stewart, 2005). For example, individuals who are more sensitive to the positive mood enhancing effects of alcohol may be more likely to drink for enhancement reasons, whereas individuals who are more sensitive to the tension reducing effects of alcohol may develop a stronger motivation to drink to cope with negative affect. As a result, drinking motives may be linked with individual differences in sensitivity to these acute reinforcing effects of alcohol at the event level; once a drinking episode has begun, the acute effects of alcohol may influence state motivation to drink more alcohol, mediating the link between drinking motives and alcohol consumption.

Yet, despite the emphasis placed by motivational theories on sensitivity to the acute effects of alcohol, the links between drinking motives and subjective effects following alcohol dosing have rarely been examined. In one exception, Wilkie and Stewart (2005) examined the associations among drinking motives and state changes in positive and negative mood following alcohol administration, but did not find support for the hypothesized relationships. Thus, more research is needed to improve our understanding of the role of drinking motives in state subjective processes that may motivate alcohol consumption during a drinking episode.

While conspicuously absent from the drinking motives literature, laboratory alcohol administration paradigms have been widely applied to examine individual differences in the subjective effects of alcohol. This research shows that both low sensitivity to alcohol's sedative effects and high sensitivity to alcohol's stimulant effects are associated with heavier drinking and increased risk for alcohol dependence (Schuckit, 1994, King et al., 2011a, King et al., 2014; for reviews, see Morean and Corbin, 2010, Quinn and Fromme, 2011). Further, the role of subjective effects of alcohol in drinking behavior has been described in terms of reward-related motivational processes (Bujarski and Ray, 2014, King et al., 2011b, Ray et al., 2010). For example, stimulant effects of alcohol (which include positive mood effects such as "elation") are thought to be rewarding and may motivate further drinking in order to enhance these rewarding effects. Thus, heightened sensitivity to the stimulant effects of alcohol may be part of an enhancement pathway to drinking. Further, the motivational role of stimulant effects of alcohol has been supported by research linking alcohol-induced stimulant effects with indices of alcohol reinforcement such as craving (Bujarski and Ray, 2014, Hendershot et al., 2015, Bujarski et al., 2015), as well as alcohol self-administration behavior (Wardell et al., 2015).

Moreover, some sedative effects of alcohol may be negatively reinforcing (i.e., tension reduction) and may increase motivation to consume alcohol. Yet, most studies to date have not adequately assessed reinforcing sedative effects of alcohol (Morean and Corbin, 2010) and have focused primarily on sedative effects that are thought to be largely unpleasant (i.e., general impairing effects on behavior and cognition; e.g., "sluggish," "slow thoughts"). Even among these studies, findings for the motivational significance of sedative effects have been mixed. For example, both positive and negative associations between unpleasant/impairing sedative effects and indices of reinforcement such as craving and self-administration have been observed (Wardell et al., 2015), while other studies have found no associations (e.g., Bujarski and Ray, 2014, Rose et al., 2010). These mixed findings point to potential individual differences in the degree to which these types of sedative effects are reinforcing versus punishing. Indeed, research shows that heavier drinkers have a tendency to perceive certain types of negative outcomes from drinking as more positive, including the impairing effects of alcohol on cognition, behavior, and memory (Fromme and D'Amico, 2000; Mallet et al., 2008). This suggests that some negative outcomes of drinking could serve a reinforcing effect for some drinkers (see also Read et al., 2013). With respect to subjective effects of alcohol, perhaps individuals who are high on coping motives may be sensitive to negative reinforcement from alcohol's general sedative properties, including impairing effects. For example, coping-motivated drinkers who drink to "forget their worries" may find relief from alcohol's impairing effects on cognition (e.g., "slow thoughts"). However, this hypothesis has not been examined.

In sum, although the large body of research on individual differences in subjective responses to alcohol has clear implications for motivational models of alcohol use, this literature is largely independent from the literature on self-reported drinking motives. Thus, there is a need for research that examines the link between drinking motives and subjective stimulant and sedative effects of alcohol, as well as indices of alcohol reinforcement such as the extent to which an individual likes the effects of alcohol (i.e., liking) and the extent to which an

individual craves or desires more alcohol (i.e., wanting), constructs which are central to neurobiological theories of addiction (see Robinson and Berridge, 1993).

The Present Study

This study examined the associations of drinking motives with subjective stimulant and sedative effects of alcohol. We focused on the internal drinking motives (enhancement and coping) as they arguably are most relevant in the context of predicting these subjective effects. We also investigated the mediating role of the subjective effects of alcohol in the links between drinking motives and post-alcohol reports of wanting and liking. To do so, we conducted an analysis of combined data from two samples of emerging adults who participated in a virtually identical intravenous alcohol administration session.

Motivational theory posits that individuals who drink for enhancement reasons may be more sensitive to the rewarding, positive mood effects of alcohol. Thus, we hypothesized that self-reported enhancement motives would be associated with greater stimulant effects of alcohol. In contrast, we hypothesized that coping drinking motives would be associated with greater general sedative effects of alcohol given that some sedative effects (including impairing effects on cognition and behavior) could be negatively reinforcing for coping-motivated drinkers. Finally, we also expected that the subjective effects of alcohol would mediate the associations of drinking motives with wanting more alcohol and liking the effects of alcohol, thereby linking drinking motives with indicators of state motivation to consume alcohol at the event level.

Materials and Methods

Participants

Participants were 147 young adult heavy episodic drinkers who participated in an intravenous alcohol administration session as part of one of two separate parent studies at different sites (one located in Albuquerque, New Mexico, $n=59$; and the other located in Toronto, Ontario, Canada, $n=88$). This alcohol session served primarily as a baseline to establish that participants could tolerate the intravenous procedures prior to subsequent study components not examined here (i.e., MRI sessions involving intravenous alcohol infusion). Because this was the first session in each of the two parent studies, participants were assumed to be naïve to intravenous alcohol administration. Table 1 shows participant characteristics for each of the samples. Because of the differences in the minimum legal drinking age in the two locations and efforts to recruit a younger sample, the Toronto sample had a significantly lower average age than the Albuquerque sample. Also, the Toronto and Albuquerque samples differed on frequency and quantity of alcohol consumption (see Table 1).¹

¹Age differences between the Toronto and Albuquerque samples fully accounted for the observed differences in self-report drinking indices. ANCOVAs controlling for age showed that the effect of site was no longer significant ($p>.38$), but the age covariate was a significant predictor of both frequency of drinking, $F(1, 143)=7.38$, $p=.007$, and drinks per drinking day, $F(1,143)=4.35$, $p=.039$.

Procedure

Recruitment and Eligibility—At both sites, recruitment consisted of web-based and community-based advertisements targeting social drinkers. Interested participants were contacted and an initial eligibility assessment was conducted via telephone. Other than age criteria (19–21 in the Toronto study; 21–25 in the Albuquerque study), the majority of eligibility criteria were the same for both sites, and included: no current psychiatric medications or diagnoses requiring treatment, no recent illicit drug use except cannabis, no current medication use or medical contraindications to alcohol, no history of treatment for alcohol problems or current attempts to reduce drinking, and no history of difficulty with intravenous protocols (e.g., fainting, nausea). The Toronto study required at least one past-month heavy-drinking episode, while the Albuquerque study required at least two past-month heavy-drinking episodes. Additional eligibility criteria for the Toronto study included a Brief Michigan Alcohol Screening Test (Pokorny et al., 1972) score less than 10 and a Fagerström Test for Nicotine Dependence (Heatherton et al., 1991) score less than 6. Participants in the Toronto study were also screened for family history of alcohol dependence, which in part determined eligibility (see Hendershot et al., 2016). Participants in both studies were excluded if they reported contraindications to fMRI protocols associated with the studies (e.g., metal implants, history of brain injury, left-handedness).

Participants who were deemed eligible following the telephone screen were booked for an in-person assessment session, which included a more thorough assessment of the same eligibility criteria (including standardized screenings for physical and mental health conditions). Participants completed a urine toxicology screen to confirm self-reported abstinence from recreational drugs (with the exception of cannabis). This session also involved a more thorough assessment of alcohol use and completion of self-report measures via computer (including the Drinking Motives Questionnaire; see Measures). Participants who were still eligible after the assessment session (according to the criteria above) were then scheduled to participate in the alcohol session.

Alcohol Session—Sessions took place in a private room under medical supervision. Participants were asked not to consume food, caffeine, or nicotine for four hours prior to their appointment, and to abstain from alcohol or psychoactive drugs for at least 24 hours prior to the session. Upon arrival, a breathalyzer was administered to confirm zero breath alcohol concentration (BrAC), and then participants consumed a standard low calorie meal. Female participants also completed a pregnancy screening. Participants were then escorted to a private room and seated in a comfortable chair, where the study nurse placed an indwelling catheter. Immediately prior to the start of the infusion, participants completed baseline subjective questionnaires (see Measures) and some cognitive tasks that were not the focus of the present analysis and are reported elsewhere (Hendershot et al., 2015).

Alcohol administration consisted of an intravenous infusion of 6% (v/v) ethanol in normal saline. The infusion rate was determined by a physiologically-based pharmacokinetic (PBPk) model (O'Connor et al., 1998, Ramchandani et al., 1999). The model stipulated a linear ascent in BAC from 0 to 80mg% in exactly 20 minutes, after which BAC was held pseudo-constant (clamped) at 80mg% for another 80 minutes. Subjective questionnaires

were administered at baseline (S1) and at several time points when BAC was clamped at 80mg%. This paradigm allows for the estimation of subjective alcohol effects while holding peak BAC, rate of BAC increase, and time to peak BAC virtually identical across participants, which is not possible with oral alcohol administration.

For the present analyses, we focused on subjective effects and ratings of alcohol wanting and liking that coincided with the initial attainment of 80mg% BAC (approximately 20 min after the start of the infusion). This allowed us to examine the link between drinking motives and individual differences in subjective effects of alcohol at the peak of the ascending limb, while minimizing the influence of acute tolerance or sensitization processes (e.g., Morzorati et al., 2002). Moreover, the initial effects of alcohol are thought to play a significant role in motivation to continue consuming alcohol during a drinking episode (Fillmore, 2001, Fillmore and Rush, 2001) and thus are conceptually relevant to drinking motives.

At the end of the alcohol session, the nurse removed the catheter. Participants were given a snack and were monitored until BAC fell below 30mg%, at which point they were provided with compensation and discharged.

Measures

Drinking Motives—Enhancement and coping motives were measured with the Drinking Motives Questionnaire-Revised (Cooper, 1994). The enhancement motives scale assessed the frequency with which individuals drink to obtain or enhance positive mood effects (5 items; $\alpha = .85$; e.g., “Because it gives you a pleasant feeling”). The coping motives scale assessed the frequency of drinking to reduce negative mood and to help put worries out of one’s mind (5 items; $\alpha = .81$; e.g., “To forget about your problems”). Participants rated each item on a 5 point scale ranging from 1=*Never/almost never* to 5=*Almost always/always*. Responses to items were averaged to derive scale scores.

Alcohol use—We assessed alcohol use with the timeline follow back (TLFB; Sobell and Sobell, 1992), a structured calendar assessment of drinking behavior. The TLFB was used to estimate past 90-day drinking frequency, average number of drinks per drinking day, and heavy episodic drinking frequency.

Subjective Effects of Alcohol—The Biphasic Effects of Alcohol Scale (BAES; Martin et al., 1993) contains 7 items assessing subjective stimulation (e.g., “energized,” “high”) and 7 items assessing subjective sedation (e.g., “drowsy,” “tired”). Participants responded to items on a visual analogue scale (anchors 0–10 at the Albuquerque site; 0–100 at the Toronto site) to indicate the extent to which they were currently experiencing each effect at baseline and after 20 min of the alcohol infusion. We used a variant of the BAES in which participants were not instructed to explicitly link their subjective feelings to the effects of alcohol (Rueger et al., 2009). Responses to items were summed for each subscale and transformed into a summary score on a 0–100 scale to permit direct comparison across the two sites. Cronbach’s alphas were .84 at baseline and .89 at the 20 min assessment for stimulation, and .79 at baseline and .83 at 20 min for sedation.

Wanting and Liking—Items assessing wanting and liking were adapted from items that have been widely used in prior research (see Morean et al., 2013b). The wanting item read, “How much do you want more of the infusion?” The liking item read, “How much do you like the effects you are feeling now?” At both sites, participants responded to each item on a 0–100 scale. Because these items specifically reference the effects of alcohol, only post-alcohol ratings (i.e., at 20 min) were included in analyses.

Data Analysis

All model variables approximated normal distributions (all skewness estimates < 0.86 , all kurtosis estimates < 1.67). Three extreme univariate outliers were observed on the drinking frequency variable and were recoded to one value greater than the most extreme, non-outlying value (Tabachnick and Fidell, 2007). One participant was missing data on alcohol use variables. Further, two participants were missing baseline stimulation and sedation ratings and three participants were missing some or all of the post-alcohol ratings. We used full information maximum likelihood estimation in order to retain cases with partial missing data in the path analysis. Pairwise deletion was used to handle missing data for the t -tests and correlations reported in the descriptive analyses.

To investigate the mediating role of subjective responses to alcohol in the associations between drinking motives and alcohol liking and wanting, we conducted a path analysis using Mplus version 7.2 (Muthén and Muthén, 2012). Enhancement and coping motives were specified as predictors of subjective stimulation and sedation post-alcohol (i.e., at 20 min when BAC first reached 80mg%), while also controlling for baseline ratings of stimulation and sedation. Post-alcohol stimulation and sedation, in turn, were specified as predictors of post-alcohol (20 min) wanting and liking ratings. Given that some studies have found that both stimulant and sedative responses to alcohol are associated with craving (Bujarski et al., 2015; Wardell et al., 2015), and that we observed a significant negative correlation between post-alcohol stimulation and sedation ratings (see Supplemental Table 1), we examined stimulation and sedation together in the same model to control for shared variance and isolate unique pathways to wanting and liking. Bootstrapping was used to calculate bias-corrected confidence intervals for the indirect associations of drinking motives with post-alcohol wanting and liking mediated through post-alcohol stimulation and sedation. We also included direct paths from drinking motives to post-alcohol wanting and liking. All covariances among drinking motives and baseline stimulation and sedation were freely estimated. Model fit was considered good if the Root Mean Square Error of Approximation (RMSEA) $< .06$, the Comparative Fit Index (CFI) $> .95$, and the Standardized Root Mean Square Residual (SRMR) $< .05$ (Hu and Bentler, 1999).

Given that we observed some differences between the two data collection sites on participant demographics and drinking variables (see Table 1), we planned to test the path model for invariance across the two sites in order to determine whether the associations can be generalized to both samples. To do so, we conducted a multiple-groups analysis with data collection site as the grouping variable, and used a nested model chi-square test to compare the fit of a model in which all paths were constrained to be equal across the two sites to a

model in which all parameters were allowed to freely vary across sites. We also tested our model for invariance across sex using the same approach.

Results

Descriptive Statistics

The average BrAC observed at approximately 20 min into the infusion was 79.40mg% ($SD=5.03$). Table 1 shows the means and standard deviations for all variables in the model stratified by sex and data collection site. Ratings of both stimulation, $t(141)=9.85$, $p<.001$, and sedation, $t(141)=7.54$, $p<.001$, increased from baseline to post-alcohol assessments. As shown in Supplemental Table 1, drinking frequency was significantly correlated with both coping and enhancement motives, whereas drinks per drinking day and number of heavy drinking episodes were significantly correlated with enhancement motives but not coping motives. No significant correlations between self-reported drinking indices and subjective ratings during the alcohol session were observed.

Path Model

The results of the path model are shown in Figure 1. The model fit the data very well, $\chi^2(6)=4.68$, $p=.586$, $RMSEA<.001$, $CFI=1.00$, $SRMR=.03$. As expected, enhancement motives were significantly associated with greater post-alcohol stimulation, and coping motives were associated with significantly greater post-alcohol sedation. We also observed a significant unique association between greater enhancement motives and lower post-alcohol sedation, which was not hypothesized a priori. Further, as expected, post-alcohol stimulation was positively associated with both wanting and liking ratings. However, post-alcohol sedation was not uniquely related to post-alcohol wanting and liking. In addition, we observed direct positive associations between coping motives and wanting and liking ratings, but the direct paths from enhancement motives to wanting and liking ratings were not statistically significant.

Estimates and confidence intervals for the indirect associations from enhancement and coping motives to post-alcohol wanting and liking mediated through post-alcohol stimulation and sedation are presented in Table 2. As hypothesized, we observed significant indirect paths from enhancement motives to wanting and liking mediated through stimulation. However, none of the other indirect associations were statistically significant. Thus, although coping motives predicted greater sedative response to alcohol, we did not find evidence that sensitivity to sedative effects of alcohol mediated the links between coping motives and wanting and liking ratings.²

²We conducted a supplementary analysis controlling for past 90 day drinking frequency, which was the only drinking variable that was significantly correlated with both enhancement and coping motives. In this model, we regressed all post-alcohol variables on the drinking frequency variable, and freely estimated the covariances among drinking frequency, drinking motives, and baseline stimulation and sedation ratings. None of the paths from drinking frequency to the post-alcohol variables were statistically significant (all $ps>.54$). Further, the inclusion of drinking frequency did not affect the statistical significance of any of the other paths in the model. We also conducted a similar analysis controlling for age given that age differences between the samples were associated with different drinking patterns. Again, age was not a significant predictor of the post-alcohol variables (all $ps>.09$) and did not affect the other paths in the model. Thus, given that the addition of drinking frequency and age did not alter the substantive conclusions of the analysis, we report the more parsimonious model that does not include these covariates.

Invariance Testing

In multiple-group analyses, we examined the fit of the model with all paths constrained to be equal across data collection sites relative to the model with all paths freely estimated across sites. The results of the nested model test revealed that there was no significant difference in the fit of these two models, $\chi^2(14)=15.29, p=.358$, suggesting that the paths can be generalized to both samples. We next examined the fit of the model with all paths constrained to be equal for men and women relative to the model with all paths freely estimated across sex. The nested model test confirmed that the paths were also invariant across sex, $\chi^2(14)=10.49, p=.726$.

Discussion

Motivational theory suggests that differential sensitivity to alcohol's reinforcing effects on mood underlie individual differences in drinking motives, such that individuals who are more sensitive to the positive mood enhancing effects of alcohol may develop stronger enhancement motives, and individuals who are more sensitive to the negatively reinforcing effects of alcohol may develop stronger coping motives (Verheul et al., 1999, Wilkie and Stewart, 2005). At the same time, laboratory alcohol administration studies have shown that individual differences in sensitivity to alcohol's stimulant and sedative effects are associated with risk for heavy drinking and alcohol problems (King et al., 2011a) and predict state motivation to consume alcohol (Bujarski et al., 2015, Bujarski and Ray, 2014, Wardell et al., 2015). Given that subjective stimulant and sedative responses to alcohol include mood effects, they may represent important mechanisms in motivational pathways to alcohol use.

The present study found that individual differences in enhancement and coping motives predicted subjective stimulant and sedative responses to alcohol. As hypothesized, we found that individuals high on enhancement motives showed heightened responses to alcohol's rewarding, stimulant effects. We also observed a negative association between enhancement motives and sedative response to alcohol, which was not hypothesized a priori. Still, this finding makes sense from the perspective of motivational theory given that the BAES sedation items are thought to be largely unpleasant (Morean and Corbin, 2010) and could detract from the "fun" and "excitement" sought by enhancement drinkers. Thus, the combination of both high stimulant effects and low sedative effects may provide the greatest degree of positive mood enhancement.

In contrast, we found that coping motives were associated with greater sedative response to alcohol. While most of the sedative effects measured by the BAES are presumably unpleasant for most individuals (e.g., cognitive and behavioral impairment items such as "slow thoughts," "inactive", and "sedated"), we speculate that these types of effects could in fact be negatively reinforcing for coping-motivated individuals who may drink to avoid negative thoughts and to numb their feelings of distress. This notion is consistent with research showing that a range of negative alcohol outcomes may be perceived as more positive for heavier drinkers (Fromme and D'Amico, 2000; Mallet et al., 2008), suggesting that some of these effects could be reinforcing to some individuals. However, future studies that directly assess positive and negative evaluations of the subjective effects assessed in the present study will be necessary to confirm this hypothesis.

To our knowledge, only one prior study has examined the associations between drinking motives and the acute effects of alcohol following laboratory alcohol administration. In this study, Wilkie and Stewart (2005) reported no significant associations of enhancement and coping motives with positive mood and stress response dampening effects of alcohol. While the present findings are not consistent with this earlier study, the studies differ in a few key ways. First, the present study used intravenous alcohol administration, while the Wilkie and Stewart study used oral dosing procedures. Second, the present study included a much larger sample ($n=147$ vs. $n=48$) and thus had greater statistical power. Third, in the present study we focused on broad subjective stimulant and sedative responses to alcohol, while the Wilkie and Stewart study measured specific mood effects of alcohol. While it could be argued that specific mood effects are more relevant to enhancement and coping drinking, stimulant and sedative effects of alcohol have been widely supported as important determinants of drinking behavior and have clear motivational significance (see reviews by Quinn and Fromme, 2011, Morean and Corbin, 2010). Thus, the present study extends research on the links between drinking motives and the acute effects of alcohol by integrating the large literature on sensitivity to stimulant and sedative effects.

Furthermore, motivational theory contends that drinking motives are proximal determinants of drinking behavior that should influence decisions to drink in the moment (Cox and Klinger, 1988, Kuntsche et al., 2005). Therefore, drinking motives should relate to state subjective processes that impact decisions to continue drinking once a drinking episode has begun. The present study provided some support for this hypothesis. In particular, enhancement motives were indirectly associated with increased post-alcohol wanting and liking, and these associations were fully mediated by increased post-alcohol stimulation. This study is the first to our knowledge to demonstrate that heightened stimulant response to alcohol may be a specific mechanism underlying the link between enhancement motives and reinforcement from drinking (i.e., liking the effects and wanting more). Given that subjective responses to alcohol and craving assessed during alcohol administration have been shown to predict alcohol self-administration behavior at the event level (de Wit, 2000; Wardell et al., 2015), these findings suggest that enhancement motives may play a role in state motivation to consume alcohol during a drinking episode.

In contrast, although we did observe the hypothesized associations between coping motives and indices of alcohol reward (liking and wanting), the acute sedative effects of alcohol did not mediate these associations. However, coping-motivated drinking involves not only sensitivity to the reinforcing sedative mood effects of alcohol, but typically also involves negative mood states as antecedents for drinking (Birch et al., 2008, Mohr et al., 2005, Armeli et al., 2008). The mood context of the present laboratory study was relatively neutral, and so the sedative effects of alcohol may not have been a relevant mechanism in this context. Furthermore, although some of the sedative effects of alcohol measured with the BAES could be negatively reinforcing for coping-motivated drinkers, the BAES does not contain items directly assessing tension reduction, which may be a more relevant mediator of the link between coping motives and alcohol wanting and liking. Thus, future work on the role of drinking motives in acute responses to alcohol would benefit from including new measures that separate impairing sedative effects from tension reduction effects (e.g., Subjective Effects of Alcohol Scale; Morean et al., 2013a).

In addition to some measurement limitations, this study was also limited by the lack of a placebo condition. Because these sessions served largely to ensure that participants could tolerate intravenous alcohol administration before proceeding to subsequent neuroimaging sessions in the larger parent studies (see Method), the inclusion of a placebo condition was not imperative within this context. Consequently, the subjective effects examined here may reflect a combination of pharmacological effects, expectancy effects, and potentially other factors (e.g., passage of time). Still, it is worth noting that the use of an intravenous paradigm is likely to reduce the contribution of expectancy effects, as this is a novel experience for participants, which does not contain the same cues associated with oral alcohol consumption (e.g., sight, taste, smell). Moreover, prior placebo-controlled intravenous alcohol studies have not found substantial changes in subjective response profiles during placebo infusions (e.g., Kerfoot et al., 2013; Morzorati et al., 2002). However, in the current study we cannot disentangle pharmacological and expectancy processes, and so future placebo controlled studies will be necessary. Moreover, future studies should include measures of explicit expectancies that closely map on to the subjective alcohol response dimensions assessed in the lab (e.g., Morean et al., 2015) in order to permit an examination of the role that specific expectancies might play in the motivational pathways examined here.

Another limitation is that the intravenous alcohol administration procedures used in this study were not intended to replicate a real-life drinking scenario. While an advantage of the intravenous method is the ability to precisely control and standardize BAC across participants, future studies that are conducted in more naturalistic environments will be necessary to support the generalizability of these findings. In addition, we examined subjective effects only at a target BAC of 80 mg% and only when peak BAC was reached. While research suggests that individual differences in stimulation and sedation assessed at comparable levels of exposure are predictive of future risk for heavy drinking and alcohol dependence (King et al., 2011a, 2014), subsequent studies that examine subjective effects under different BAC levels and on the descending limb of the BAC curve will be necessary to fully examine the role of subjective effects in motivational pathways to drinking.

Further, this study was cross-sectional, which does not permit an examination of the direction of the associations between drinking motives and sensitivity to alcohol's effects. Future longitudinal research will be necessary to examine the directionality of these associations. Also, the present study focused on drinking motives as predictors of subjective responses to alcohol in order to test specific hypotheses informed by motivational theory that have not yet been fully examined. However, there are other individual difference factors that are known to influence subjective responses to alcohol, including alcohol expectancies, personality traits, and family history of alcoholism (Morean et al., 2015; Quinn & Fromme, 2011; Scott and Corbin, 2014). Future studies using larger samples will permit more comprehensive analyses of individual differences in subjective responses to alcohol. Finally, although emerging adults who engage in heavy episodic drinking represent a clinically relevant population, our findings will need to be replicated with different populations in order to determine their generalizability.

In summary, this study provides evidence that enhancement and coping drinking motives predict individual differences in the subjective stimulant and sedative effects of alcohol, as well as differences in ratings of alcohol wanting and liking. Further, we observed specific indirect pathways from enhancement motives to greater post-alcohol wanting and liking mediated via post-alcohol stimulation, providing some support for the mechanistic role of stimulant responses in the link between enhancement motives and reinforcement from alcohol at the event level. These findings provide an initial step toward examining the role of subjective effects of alcohol in motivational models of drinking, and future studies should attempt to confirm these findings using placebo-controlled designs. The results of this study point to the potential clinical utility of targeting interventions addressing subjective effects of alcohol (which may include both pharmacological and expected effects) toward heavy drinking emerging adults who drink for coping and enhancement reasons.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Path model of the associations among coping and enhancement motives, subjective stimulant and sedative effects, and alcohol liking and wanting. Standardized estimates are shown. The model included all paths from drinking motives to postalcohol stimulation, sedation, liking, and wanting, as well as all paths from postalcohol stimulation and sedation to liking and wanting; however, only statistically significant paths are shown for clarity. Also, only significant covariance estimates are shown, although all covariances among drinking motives and baseline stimulation and sedation were freely estimated. * $p < 0.05$, ** $p < 0.01$.

Table 1

Participant Characteristics and Descriptive Statistics by Data Collection Site and Sex

	Toronto (n=88) ^a		Albuquerque (n=59) ^a		Men (n=71) ^a		Women (n=76) ^a	
	n	%	n	%	n	%	n	%
Women	46	52	30	51	-	-	-	-
Hispanic/Latino	7 [*]	8	21 [*]	36	17	24	11	15
White Race	59	67	43	73	49	69	53	70
	M	SD	M	SD	M	SD	M	SD
Age	19.81 [*]	0.81	23.02 [*]	1.46	21.13	2.02	21.07	1.86
Drinking Frequency	21.28 [*]	11.48	26.40 [*]	15.06	24.03	15.03	22.64	11.28
Drinks per drinking day	5.23 [*]	2.03	4.07 [*]	1.43	5.29 [*]	1.88	4.28 [*]	1.78
Heavy episodes	13.35	10.69	11.40	9.32	12.42	10.70	12.72	9.73
Coping Motives^b	2.19	0.75	2.20	0.97	2.17	0.90	2.21	0.79
Enhancement Motives^b	3.41	0.94	3.27	0.96	3.39	0.93	3.33	0.97
Baseline Stimulation^c	44.75	15.66	41.45	17.38	45.67	17.56	41.37	15.01
Baseline Sedation^c	29.10 [*]	15.57	18.09 [*]	14.51	23.78	16.31	25.70	15.85
Post-alcohol Stimulation^c	56.77	16.08	61.32	20.02	60.95	18.71	56.26	16.71
Post-alcohol Sedation^c	38.56	17.57	37.01	19.33	36.49	17.71	39.36	18.75
Post-alcohol Liking^c	70.01	19.54	73.76	15.61	73.01	17.74	70.02	18.52
Post-alcohol Wanting^c	53.59	24.87	56.36	24.29	58.17	26.17	51.33	22.66

Notes.

^{*} Denotes statistically significant difference across data collection site or sex ($p < .05$).^a Sample sizes differ slightly across the variables because some participants were missing data on some variables.^b Possible range of scores 1–5.^c Possible range of scores 0–100.

Table 2

Indirect Associations from Drinking Motives to Post-Alcohol Wanting and Liking mediated via Post-Alcohol Stimulation and Sedation

Indirect Pathway	Unstandardized Estimate	95% CI ^a	Standardized Estimate
Enhancement→Stimulation→Liking	1.60 ^b	[0.03, 3.62]	.08
Enhancement→Stimulation→Wanting	1.53 ^b	[0.03, 3.80]	.06
Enhancement→Sedation→Liking	−0.04	[−0.81, 0.72]	.00
Enhancement→Sedation→Wanting	0.50	[−0.41, 2.17]	.02
Coping→Stimulation→Liking	−1.05	[−3.12, 0.94]	−.05
Coping→Stimulation→Wanting	−1.01	[−3.12, 0.85]	−.03
Coping→Sedation→Liking	0.04	[−0.65, 0.95]	.00
Coping→Sedation→Wanting	−0.50	[−1.95, 0.47]	−.02

Notes.

^aBased on 10,000 bootstrapped samples.

^b95% confidence interval does not contain zero.