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Catching the Alcohol Buzz: An Examination of the Latent Factor Structure of Subjective Intoxication

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Background: The goal of this study was to examine the latent structure among measures of alcohol-induced subjective feelings of intoxication from a behavioral pharmacology perspective.

Methods: Data on subjective intoxication, measured concomitantly by the Subjective High Assessment Scale, Biphasic Alcohol Effect Scale, and the Short Version of the Profile of Mood States, were collected at 3 levels of breath alcohol concentration during an alcohol administration study in a sample of heavy drinkers ($n = 135$).

Results: Results of exploratory factor analyses supported a 3-factor model which captured the following dimensions of subjective intoxication: (1) stimulation and other pleasant effects, (2) sedative and unpleasant effects, and (3) alleviation of tension and negative mood. The tension-reduction factor was most consistently associated with more frequent drinking and alcohol problems in this sample.

Conclusions: These findings support the notion that the neuropharmacological and behavioral effects of alcohol are multifaceted and cannot be simply defined as either positive or negative. Rather, moderate levels of intoxication appear to have concomitant dimensions of positive reinforcement, negative reinforcement, and punishment. This study also suggests that factor scores may be useful in future alcohol administration studies to reduce the number of comparisons and perhaps increase statistical power to detect meaningful effects.

Key Words: Subjective Intoxication, Biphasic Alcohol Effect Scale, Profile of Mood States, Subjective High Assessment Scale, Factor Analysis, Alcohol.

INDIVIDUALS VARY WIDELY in their subjective experience of the pharmacological and neurobehavioral effects of alcohol upon consumption. While some individuals may be more or less sensitive to the positively reinforcing and stimulant effects of alcohol, others report higher sensitivity to its aversive and sedative effects. Research from alcohol administration studies has documented the substantial variability in individuals' subjective responses to alcohol and has shown that differences in these subjective experiences may play a significant role in the predisposition to alcohol use and misuse (e.g., Schuckit and Smith, 1996). Studies have also shown that subjective response to alcohol represents a heritable phenotype (Heath and Martin, 1991; Viken et al., 2003).

Given the variability in reactions to alcohol and its importance in understanding alcohol use disorders, clearly characterizing the nature of alcohol intoxication is of high priority. To this end, Schuckit (1980) produced the early seminal work on the assessment of self-reported subjective response to alcohol by measuring self-reported subjective intoxication during alcohol administration sessions. In this work, the primary measure of subjective responses to alcohol is the Subjective High Assessment Scale (SHAS), which consists of various positive and negative mood-related adjectives, in addition to a single item of "feeling high." Principal components analysis of the SHAS revealed a dominant initial factor accounting for 46% of the total variance that was interpreted as "maximum terrible feelings" (Schuckit, 1985), thereby suggesting that the SHAS is most sensitive to the unpleasant effects of alcohol. Perhaps the most compelling evidence that subjective responses to alcohol predict alcohol use and misuse comes from a longitudinal study of sons of alcohol dependent probands and controls, suggesting that individuals who demonstrated low response to alcohol in the laboratory, measured by the SHAS, were significantly more likely to develop alcoholism at 8- and 20-year follow-ups (Schuckit and Smith, 1996; Schuckit et al., 2004).

Preclinical data have suggested that alcohol's pharmacological effects are biphasic in nature (Pohorecky and Brick, 1977; Pohorecky and Newman, 1977) and this notion was later extended to human laboratory research (Earleywine, 1994a,b; Erblich et al., 2003; Martin et al., 1993). Specifically, it is thought that when blood alcohol levels are rising (i.e., the ascending limb of intoxication) alcohol produces robust

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stimulatory and other pleasurable subjective effects (Erblich et al., 2003; Martin et al., 1993). Conversely, when blood alcohol levels are declining (i.e., the descending limb of intoxication), alcohol's effects are largely sedative and unpleasant (Earleywine, 1994a,b; Erblich et al., 2003). This conceptualization argues for the construct of subjective responses to alcohol to be further parsed into stimulant and sedative effects. Indeed, the Biphasic Alcohol Effects Scale (BAES) (Martin et al., 1993) was developed to directly assess the stimulant and sedative aspects of intoxication in alcohol administration studies. When subjective responses to alcohol are parsed into stimulant and sedative effects, some studies have shown that greater alcohol-induced stimulation and reinforcement is associated with increased alcohol consumption (Lewis and June, 1990; Wise and Bozarth, 1987), whereas greater subjective experiences of the sedative and unpleasant effects of alcohol have been associated with decreased alcohol consumption (Leigh, 1987; O'Malley and Maisto, 1984).

In addition to the SHAS and the BAES, measures of mood or affective states are routinely used in alcohol administration studies to capture the "mood-altering" effects of alcohol. One of the most widely used measures of mood is the Profile of Mood States (POMS) (McNair et al., 1971), which uses an adjective checklist format. Although the concurrent use of these multiple measures provides more comprehensive assessment of individual differences in the subjective experience of alcohol consumption, and these measures are not entirely overlapping (Ray et al., in press), they also raise issues regarding the core construct(s) of subjective responses to alcohol and how to best define it (them). The use of multiple assessments of subjective intoxication may also complicate the integration of findings in the alcohol administration literature. A more parsimonious conceptual understanding of the set of variables, or measures, encompassing subjective intoxication to alcohol would help advance and further integrate the experimental and clinical pharmacology literature. A useful method to achieve this aim is to identify the latent dimensions that characterize the diverse variability in subjective responses to alcohol. Uncovering the latent dimensions that underlie subjective alcohol response is of considerable scientific interest because it may: (1) elucidate unique domains of individual differences in the phenomenology of alcohol response and (2) lead to new factor-based scoring algorithms, which could reduce the number of outcome variables in alcohol administration studies.

The goal of the present study was to examine the latent structure among measures of alcohol-induced subjective feelings of intoxication from a behavioral pharmacology perspective. Data on subjective intoxication, measured concomitantly by the SHAS, BAES, and the POMS, were collected at 3 levels of breath alcohol concentration (BrAC) during an alcohol administration study in a sample of heavy drinkers. Given the absence of previous research in this area, we elected to begin by using exploratory factor analysis (EFA) to examine the latent interrelationships among the different facets of the SHAS, BAES, and POMS. Because the different measures putatively reflect distinct features of alcohol intoxication, we predicted that the factor structure would be multidimensional. Based on the differentiator model proposed by Newlin and Thomson (1990), we expected that 2 distinct factors would emerge, one capturing the positive reinforcing and stimulant effects of alcohol and another capturing its sedative and unpleasant effects. Lastly, to characterize the clinical relevance of the latent factors identified, a secondary aim of this study was to examine the latent factors in relation to measures of alcohol use and alcohol-related problems.

METHOD

Participants

This study was approved by the Human Research Committee at the University of Colorado, and all participants provided written informed consent after receiving a full explanation of the study. Participants ($n = 135$) were recruited primarily from the college setting through campus flyers and advertisements targeting regular drinkers over the age of 21. All participants met the following eligibility criteria: (1) a score of 8 or higher on the Alcohol Use Disorders Identification Test (Allen et al., 1997), indicating a hazardous drinking pattern and (2) self-reported drinking frequency of 3 or more drinks (2 for women) at least twice per week. The primary objective of the experimental design was to examine genetic predictors of subjective responses to alcohol (Haughey et al., 2008). All female subjects tested negative for pregnancy prior to the alcohol administration and all subjects were required to have a BrAC of zero before each laboratory session. Participants' average age was 22.36 (SD = 2.82; range 21 to 31) and 50 females (36%) completed the study. The majority of the sample reported that their ethnic background was White (85%), followed by Native American (5%), Latino (4%), Asian (4%), and African American (2%).

Procedures

Upon arrival at the laboratory, participants provided written informed consent, were breathalyzed and completed several relevant measures of individual differences, such as quantity and frequency of alcohol use and alcohol-related problems (see Measures below). Each participant was tested individually and told they would be consuming an alcoholic beverage but no information about BrAC was disclosed to participants during the experiment. During alcohol administration participants were asked to consume 3 doses of high alcohol beer (McEwans Scotch Ale, 9.5% alcohol). Doses were calculated using a nomogram that takes into account height, weight, and gender (Watson, 1989). The desired peak BrAC was 0.06, and each dose consisted of 0.15 g/kg of alcohol (0.11 g/kg for females). Participants were assessed approximately 15 minutes after each dose of alcohol and measure administration took approximately 5 to 10 minutes at each target BrAC, which were: 0.02, 0.04, and 0.06 g/dl. No dependent variables, in addition to the ones reported herein, were collected in this study. Participants were compensated $50 for approximately 3 to 4 hours of involvement in this study.

Measures

Alcohol Use. Alcohol use was evaluated with a variation of the measure used by White and Labouvie (1989). The instructions defined one alcoholic drink as "one beer, one glass of wine, or one serving of hard liquor either by itself or in a mixed drink." Two items asked In the last year (1) "how often did you consume at least one alcoholic drink?" (answered on a 9-point scale ranging from "never" to "every day") and (2) "how many drinks did you usually have at one time?" The quantity of use question differed from the White and Labouvie (1989) in that we did not provide a 10-point scale for responses and rather asked participants to write down the typical number of alcoholic drinks they consume at one time.

Alcohol Problems. Alcohol problems were evaluated using The Rutgers Alcohol Problem Index (RAPI), which consists of 23 items, rated on a Likert scale ranging from 0 to 4, examining the impact of alcohol on social and health functioning over the past year. In this sample, the average score on the RAPI was 24.8 (SD = 15.5). The RAPI has high reliability (i.e., Cronbach's $\alpha = 0.92$ (White and Labouvie, 1989), which is consistent with the reliability estimate obtained in this study ($\alpha = 0.91$).

Subjective Feelings of Intoxication. Subjective feelings of intoxication were assessed at baseline and at each of the following 3 target BrACs (i.e., 0.02, 0.04, and 0.06 g/dl). Given that the study objective was to better understand subjective responses to alcohol, as opposed to dispositional variables present at baseline, difference scores were computed by subtracting the respective baseline scores from the postalcohol assessment. Difference scores were computed for each item of the SHAS, POMS, and BAES, and then integrated into an average score for each scale. The following scales were used:

Subjective High Assessment Scale. The SHAS was used to assess subjective feelings of alcohol intoxication. This measure has been adapted by Schuckit (1984) and has since been widely used in alcohol challenge studies. The SHAS consists of 13-items rated on a 10-point Likert scale ranging from "not at all" to "extremely." Sample items for this measure are: drunk, high, nauseated, dizzy, and drug effect (Schuckit, 1984). Reliability estimates of the SHAS composed of difference scores across rising BrAC were the following, $\alpha = 0.66$, 0.79, and 0.83, respectively. In addition, the item "high" of the SHAS was strongly correlated with total SHAS score at each level of BrAC, $r = 0.41$, 0.50, and 0.52, respectively.

Biphasic Alcohol Effects Scale. The BAES is a self-report measure consisting of unipolar and continuous items assessing subjective responses to alcohol. The BAES is composed of 2 subscales, each composed of 7 items: *Stimulation* (BAES-Stim: elated, energized, excited, stimulated, talkative, up, and vigorous) and *Sedation* (BAES-Sed; difficulty concentrating, down, heavy head, inactive, sedated, slow thoughts, and sluggish). The 14 items are listed in alphabetical order and participants are asked to rate on a 10-point scale the effects of alcohol they are experiencing *at the present moment* (Martin et al., 1993). Cronbach's alphas for the BAES-Stim composed of difference scores across rising BrAC were the following, $\alpha = 0.81$, 0.85, and 0.86, respectively. For the BAES-Sed, Cronbach's α were: 0.76, 0.73, and 0.73.

Profile of Mood States. The short-version of the POMS (McNair et al., 1971) is often used in this study to assess mood changes following alcohol administration (Hutchison et al., 2002; Ray and Hutchison, 2004, 2007). The following subscales of the POMS, each composed of 10 items, were used in this study: Vigor (POMS-Vig; e.g., lively, vigorous, energetic, active, powerful), Tension (POMS-Ten; e.g., tense, nervous, shaky, anxious, peaceful, calm; the last 2 items being reverse scored), positive mood (POMS-Hap; e.g., cheerful, friendly, lighthearted, joyful, and elated), and negative mood (POMS-Dep; e.g., sad, dejected, lonely, downhearted, discouraged, and inadequate). Each item is rated on a 5-point scale ranging from 0 = "not at all" to 4 = "extremely." Cronbach's alphas for the subscales of the POMS across levels of BrAC were as follows: POMS-Vig, $\alpha = 0.66$, 0.79, and 0.80; POMS-Ten, $\alpha = 0.67$, 0.75, and 0.77; POMS-Hap, $\alpha = 0.68$, 0.75, and 0.76; and POMS-Dep, $\alpha = 0.51$, 0.58, and 0.70.

Data Analysis

Exploratory factor analysis was selected as the analytic method given that the purpose of this study was to arrive at a parsimonious conceptual understanding of a set of variables used to capture subjective intoxication. In addition, no previous studies have factor analyzed the measures used in the current study, contraindicating confirmatory factor analysis (CFA) as an initial tool. EFA allows us a determination of the number and nature of common factors that account for the pattern of correlations among the observed variables (Fabrigar et al., 1999). Scores on measures of subjective intoxication (i.e., SHAS, BAES-Stim, BAES-Sed, POMS-Hap, POMS-Ten, POMS-Dep, and POMS-Vig) were subjected to EFA using squared multiple correlations as prior communality estimates. We elected to factor analyze scale scores, as opposed to single item scores, for 2 main reasons: (1) the study's sample size was inadequate for an item-level factor analysis and (2) we were primarily interested in understanding the factor structure of subjective intoxication in the context of commonly used measures of alcohol response. As such, using scale scores facilitates the interpretation of the findings and their application to the current literature. The principal factor analysis method was used to extract the factors and this was followed by a promax (oblique) rotation. An oblique rotation was selected because it allows correlations among factors thereby providing a more accurate representation of how constructs are likely to be related to one another and it produces estimates of the correlations among common factors (Fabrigar et al., 1999), which in turn are useful in interpreting the conceptual nature of the factors. A sample size of approximately 150 cases is sufficient for producing stable estimates for factor solutions that have several high loading marker variables (>0.80) and fewer marker variables (Guadagnoli and Velicer, 1988; Tabachnick and Fidell, 2001), which is the case in the present study.

Factor structure was determined by an Eigenvalue of >1 and by further examination of the scree plot for clear discontinuities between succeeding factors in the scree plot of Eigenvalues. A scree test suggested the number of meaningful test factors and only those meaningful factors were then retained for rotation. In interpreting the rotated factor pattern, an item was said to load on a given factor if the factor loading was 0.40 or greater for that factor, and was less than 0.40 for another (Hatcher, 2003). Regarding the different levels of BrAC (i.e., 0.02, 0.04, and 0.06), there were very high correlations among the indices of subjective intoxication across the 3 levels of intoxication. Therefore, to avoid identifying spurious latent variables because of these high correlations, 3 separate EFAs were conducted, one at each level of BrAC. No differences among the 3 factor structures were predicted, yet the convergence between the solutions was of interest as an indicator of the robustness of the latent structure observed.

Lastly, to address the secondary aim of this manuscript, Pearson's product–moment correlations (r) were used to examine the relations among the factors generated and measures of alcohol use (i.e., drinking quantity and frequency) and alcohol-related problems (i.e., RAPI scores). All analyses were performed using SAS Statistical Software v.9.1 (SAS Institute, Cary, NC).

RESULTS

Descriptive Statistics

Participants in this study drank an average of 5.2 (SD = 2.3) standard drinks per drinking episode (5.86 drinks for males and 4.00 drinks for females) and reported an average drinking frequency of approximately 3 times per week. Observed BrACs at each of the 3 assessment points were: 0.023 g/dl (SD = 0.010), 0.041 g/dl (SD = 0.013), and 0.056 g/dl (SD = 0.013), respectively. The following were the mean difference scores for each POMS subscale: POMS-Vig: 0.03, 0.01, and 0.08; POMS-Ten: −0.12, −0.12, and −0.12; POMS-Hap: 0.02, 0.04, and 0.11; and POMS-Dep: −0.08, −0.10, and −0.10. Mean difference scores on Stimulation across BrAC were: −0.15, −0.09, and 0.03. And mean difference scores for Sedation across rising BrAC levels were: −0.55, −0.30, and −0.10, respectively. Mean difference scores for the SHAS across BrAC were: 0.010, 0.24, and 0.57, respectively. Prior to conducting the main analyses reported below, data were screened for distribution normality and outliers. All variables were found to exhibit an adequately normal distribution such that no transformations were warranted.

Exploratory Factor Analysis

Exploratory factor analysis generated a 3-factor solution for the measures of subjective intoxication and the same solution was observed at all 3 time points in BrAC. The scree plot from the EFA revealed variance discontinuities that suggested 3 latent factors. Examination of Eigenvalues indicated that only 3 factors had Eigenvalues greater than 1.0. Specifically, at BrAC = 0.06 g/dl (i.e., target BrAC) the first factor had an Eigenvalue of 2.56 and accounted for 37% of the variance, the second factor had an Eigenvalue of 1.58 and accounted for 23% of the variance, the third factor had an Eigenvalue of 1.20 and accounted for 17% of the variance. The fourth factor had an Eigenvalue of only 0.60. These results suggested that a 3-factor solution was most appropriate for these data and accounted for 76% of the total variance.

Similar results were obtained at the other 2 time points in rising BrAC. Specifically, at BrAC = 0.02 g/dl, the first 3 factors had the following Eigenvalues: 2.46 (35%), 1.41 (20%), and 1.18 (17%), respectively. And at BrAC = 0.04 g/dl the first 3 factors had Eigenvalues of 2.63 (38% of the variance), 1.45 (21%), and 1.22 (17%). All scales substantially loaded on one of the 3 factors reaching the a priori factor loading of 0.40 (range = 0.75 to 0.90). At target BrAC (0.06 g/dl), positive mood (POMS-Hap) loaded on both factors 1 and 3, although with stronger loading on Factor 1. The following were the inter-factor correlations between Factor 1 and Factor 2 across the 3 time points in BrAC (i.e., 0.02, 0.04, and 0.06 g/dl): −0.19, −0.19, and −0.13. The correlations between Factor 1 and Factor 3 were: −0.18, −0.15, and −0.13. Lastly, the correlations between Factor 2 and Factor 3 were: 0.15, 0.14, and 0.16. None of the inter-factor correlations reached statistical significance, $p > 0.10$. The pattern matrix, providing the factor loading and reflecting the partial correlations between each variable and each rotated factor, is provided in Table 1.

As shown in Table 1, Factor 1 was composed of the following measures of subjective intoxication: BAES-Stim, POMS-Vig, and POMS-Hap. This factor captures the stimulant and positively reinforcing effects of alcohol such as feelings of stimulation, vigor, and positive mood following alcohol intake. Factor 2 was composed of the SHAS and BAES-Sed. This factor seems to capture the sedative and aversive effects of alcohol intoxication. Factor 3 was composed of the POMS-Ten and POMS-Dep. Given that these were difference scores, and that these change scores were negative for both variables, this factor captures decreases in tension and negative mood following alcohol consumption. In short, the stimulant effects of alcohol loaded onto Factor 1, the aversive-sedative effects of alcohol loaded on Factor 2, and the tension-reduction and alleviation of negative mood loaded onto Factor 3. As described above, these analyses relied on difference scores to more fully capture subjective intoxication due to the effects of alcohol. To further probe for the effects of BrAC participants ($n = 19$) whose BrAC was not higher than 0.04 g/dl at the target (peak) assessment point were dropped from the analyses and doing do did not change any of the results reported herein.

Correlations Between Factor Scores and Alcohol-Related Variables

Correlations between the 3 factors derived from the EFA at each level of BrAC, alcohol use, and alcohol-related problems are presented in Table 2. Correlation magnitude conventions are as follow: small $r = 0.10$, medium $r = 0.30$, large $r = 0.50$ (Cohen, 1988). Results suggested no significant association between Factor 1 and either alcohol use or alcohol-related problems over the past year. Factor 2 exhibited

Table 1. Indices of Alcohol Sensitivity and Corresponding Factor Loadings From the Pattern Matrices for the Iterated Principal Factor Analyses

	BAC = 0.02			BAC = 0.04			BAC = 0.06		
	Component			Component			Component		
Index	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
SHAS	−0.14	**0.85**	0.17	0.06	**0.81**	0.33	0.07	**0.86**	0.25
BAES-Stim	**0.81**	−0.03	−0.11	**0.83**	0.03	−0.12	**0.79**	0.04	−0.08
BAES-Sed	−0.03	**0.89**	−0.01	−0.20	**0.88**	−0.08	−0.19	**0.88**	0.01
POMS-Ten	−0.02	0.12	**0.82**	0.01	0.04	**0.88**	0.11	0.17	**0.88**
POMS-Vig	**0.88**	−0.16	0.10	**0.90**	−0.23	0.10	**0.88**	−0.26	0.13
POMS-Dep	−0.14	0.02	**0.77**	−0.25	0.15	**0.73**	−0.34	0.09	**0.75**
POMS-Hap	**0.81**	−0.05	−0.24	**0.78**	−0.03	−0.37	**0.75**	0.03	−0.**43**

Note: A criterion of 0.40 was used to determine whether an index loaded on a factor. SHAS, Subjective High Assessment Scale; POMS, Profile of Mood States; BAES, Biphasic Alcohol Effect Scale.

Table 2. Correlations Between the Factors Generated, Alcohol Use, and Alcohol-Related Problems

	Alcohol Use and Alcohol Problems		
Factor	Drinking quantity	Drinking frequency	RAPI score
Factor 1 (BAC = 0.02)	0.10	0.13	0.09
Factor 1 (BAC = 0.04)	0.13	0.10	0.10
Factor 1 (BAC = 0.06)	0.07	−0.03	0.04
Factor 2 (BAC = 0.02)	**−0.18**†	−0.13	−0.06
Factor 2 (BAC = 0.04)	−0.11	−0.09	−0.06
Factor 2 (BAC = 0.06)	**−0.23****	−0.15	0.05
Factor 3 (BAC = 0.02)	0.01	**−0.29****	**−0.21***
Factor 3 (BAC = 0.04)	−0.07	**−0.24***	**−0.20***
Factor 3 (BAC = 0.06)	−0.10	**−0.19***	−0.14

†$p < 0.10$, *$p < 0.05$, **$p < 0.01$. BAC is expressed in terms of g/dl. RAPI, Rutgers Alcohol Problem Index.

small-to-medium magnitude negative associations to average drinking quantity, which reached statistical significance at BrAC = 0.02 ($r = -18$, $p < 0.05$) and at BrAC = 0.06 ($r = -0.23$, $p < 0.01$). Specifically, individuals who scored higher on this factor reported drinking fewer drinks per drinking episode over the past year. Individuals who scored lower on Factor 3, indicating greater alcohol-induced alleviation of tension and negative mood, reported drinking more frequently and having more alcohol-related problems; these relationships reached statistical significance (see Table 2). Follow-up regression analyses were conducted in which all 3 factors were entered into the same model predicting each drinking outcome. Results of these multivariate regression models indicated that the results reported in Table 2 remained unchanged after controlling for the remaining factor scores.

Multicolinearity between the factor scores and the scale scores from which each factor was derived (rs ≥ 0.75) precluded analyses in which both factor scores and scale scores were entered into a single model of drinking outcomes. However, to provide a preliminary assessment of incremental validity of the obtained factor scores over scale scores, we compared the scale scores correlations to drinking outcomes to the correlations observed for factor scores. It was noted that the correlation between factor scores and drinking outcomes was consistently in the upper range of the observed correlations observed for the scale scores (not reported). Further assessment of the observed factor structure and their incremental validity in independent samples is clearly warranted.

DISCUSSION

The goal of the current study was to examine the latent structure underlying measures of alcohol-induced subjective feelings of intoxication in an experimental design in which alcohol was administered in vivo and subjective intoxication was assessed at baseline and at 3 target levels in rising BrAC. This was not an attempt at data reduction, but instead it focused on determining the number and nature of common factors comprising alcohol's subjective effects. Results of exploratory factor analyses revealed that a 3-factor solution best fit the data and that the same solution was obtained at each of the 3 levels of BrAC assessed during the alcohol administration. The first factor was composed of the BAES-Stim, POMS-Vig, and POMS-Hap, which captures the stimulant and positive mood-altering effects of alcohol. The second factor was composed of the SHAS and BAES-Sed, which captures the more unpleasant and sedative effects of alcohol. The third factor, in turn, was composed of the POMS-Tension and POMS-Depression, such that a lower score on this factor indicates greater tension-reduction and alleviation of negative mood as a result of alcohol intake.

The subjective effects of alcohol may be conceptualized in 2 broad domains, namely reinforcing (positively and negative) and punishing (aversive) effects. However, these effects may not be orthogonal to one another and instead may be experienced concomitantly to varying degrees within a single drinking episode. In fact, the Differentiator Model of subjective responses to alcohol proposed by Newlin and Thomson (1990), posits that individuals at risk for alcohol problems experience both increases in sensitivity to the reinforcing effects of alcohol and a decrease in sensitivity to its aversive effects over the course of a drinking episode. Importantly, the present study did not support the notion that only 2 factors, measuring reinforcing and punishing effects of alcohol, would be sufficient to capture the latent structure of subjective responses to alcohol, and instead, a 3-factor solution was supported. This solution distinguishes between the types of reinforcement and also includes punishment, with Factor 1 reflecting positive reinforcement, Factor 2 reflecting punishment, and Factor 3 reflecting negative reinforcement. Further, results of inter-factor correlations at the various levels of BrAC suggested that the 3 factors were relatively independent of one another with low magnitude and nonsignificant correlations.

Importantly, the present study sought to arrive at a more parsimonious conceptual understanding of the set of measures commonly used to assess subjective feeling of alcohol intoxication. The support for the 3-factor model was strong in the present study. Nevertheless, determining the underlying nature of the obtained factors may prove more challenging and will require further work. An interesting aspect of the observed factors was their differential relationship to alcohol use and alcohol-related problem. Analyses of the relationships between the factors derived and measures of alcohol use and problems suggested that the first factor, capturing the stimulant effects of alcohol, was unrelated to drinking quantity, frequency, and alcohol problems in this sample. Factor 2, which captured the sedative and unpleasant effects of alcohol, was negatively correlated with drinking quantity such that individuals who reported higher sensitivity to the sedative and unpleasant effects of alcohol in the laboratory consumed fewer drinks per drinking episode, on average. Conversely, individuals who were less sensitive to the sedative and unpleasant effects of alcohol, "low responders" based on the work of Schuckit and colleagues (Schuckit, 1984; Schuckit and Smith, 1996, 2001), consumed more drinks per drinking episode. These findings are consistent with previous work demonstrating that low responders to alcohol in the laboratory, measured using the SHAS, drink more heavily and are more likely to develop alcohol problems (Schuckit, 1994; Schuckit and Smith, 2000, 2001). Additionally, the fact that Factor 2 was composed of the SHAS and the Sedation subscale of the BAES is consistent with previous work suggesting that the SHAS is more sensitive to the unpleasant and sedative effects of alcohol (Conrod et al., 2001; Ray et al., 2006; Schuckit, 1985).

Factor 3, in turn, captured the tension-reduction and alleviation of negative mood following alcohol consumption. Scores on this factor were negatively associated with drinking frequency and alcohol problems and these associations reached statistical significance at 2 levels of BrAC, 0.02 and 0.04 g/dl. Specifically, individuals who scored lower on Factor 3, indicating greater alcohol-induced alleviation of tension and negative mood at low levels of intoxication, reported drinking more frequently and having more alcohol-related problems. This is consistent with the tension-reduction and stress-response dampening models of addiction (Levenson et al., 1980; Rutledge and Sher, 2001; Sher and Levenson, 1982; Sher and Walitzer, 1986; Sher et al., 2007) and suggests that the degree to which individuals experience alcohol-induced relief of tension and negative mood may be associated with their drinking pattern.

As reviewed by Sher and colleagues (2005), laboratory-based studies have provided contradictory evidence on the effects of alcohol on negative affect. More specifically, these authors argue that negative affect regulation from drinking may be highly dependent upon intra-individual and situational factors, such as expectancies, genetics, and stressful environments (Sher and Levenson, 1982). For instance, research has shown that alcohol is more likely to reduce stress when initial stress appraisal occurs, consistent with an appraisal-disruption model (Sayette, 1993; Sayette et al., 2001). Review of the research protocol did not reveal any experimental variables that may increase the stress appraisal in this study and unfortunately, direct measures of stress appraisal (other than ratings of tension and mood) were not collected to address this question empirically. Clearly, further research is needed to better understand the predictive utility of the various facets of alcohol intoxication. And importantly, mechanisms of risk may be best captured by a combination of higher sensitivity to the reinforcing effects of alcohol and lower sensitivity to its sedative and unpleasant effects (King and Byars, 2004; Newlin and Thomson, 1990).

These findings should be interpreted in light of the study strengths and limitations. Study strengths include the behavioral pharmacology design involving an in vivo alcohol administration, the use of exploratory factor analytic methods to address the conceptual bases of subjective responses to alcohol empirically, and the focus on widely used measures of subjective intoxication. Moreover, this study examined subjective intoxication at 3 levels of rising BrAC and found the underlying factor structure to be consistent across the 3 levels (measured in a single administration session), thereby lending further support for the results reported herein. Study limitations include the relatively restricted sample comprised of heavy drinkers, which may not generalize to alcohol naïve and/or alcohol dependent samples. This study did not include all of the measures used in the literature to assess subjective responses to alcohol and further work with additional measures seems warranted. The associations to drinking variables were cross-sectional and assessed alcohol use for the past year only; further assessment in longitudinal models would complement these findings. Additional limitations include the fact that the tiered assessment at the 3 time points in the rising BrAC were conducted within the same testing session, therefore making the subjective intoxication ratings across the 3 time points more alike. Analyses of the effects of varying doses of alcohol, including placebo, in different testing session are warranted. Lastly, and perhaps most importantly, the present study consists of a relatively low dose of alcohol and does not account for limb of intoxication. Data from all 3 time points, although obtained within the same assessment suggested that observed factor structure should be stable across levels of BAC, however this clearly needs to be extended in studies utilizing higher target BAC levels. Likewise, the application of CFA in independent samples would greatly enhance the applicability of these initial findings. The issue of limb of BAC also warrants further study, yet a recent investigation of the subjective effects of alcohol and the psychometrics of the BAES has revealed that patterns of correlation between the BAES and other measures of subjective effects (i.e., PANAS [Positive and Negative Affect Scale] and ARCI [Addiction Research Center Inventory]) were similar across limbs of the BAC (Rueger et al., 2009). In short, extending these findings to higher levels of BAC, employing CFA in independent samples, and considering limb of intoxication represent critical steps to future research in this area.

On balance, the present study contributes to the literature on the biobehavioral effects of alcohol by suggesting that a 3-factor model is needed to capture the latent factor structure of subjective intoxication at relatively modest blood alcohol levels. This study also suggests that factor scores may be useful in future alcohol administration studies to reduce the number of comparisons and perhaps increase power to detect meaningful effects. Even though generating factor scores may be a challenge to implement in studies using small sample sizes, these findings suggest that a 3-factor approach at least be considered and evaluated to the extent possible. These implications, theoretical and practical, are all potentially significant, but will depend on a convergence of findings from future studies that can replicate and extend these results.

In summary, this study was the first to examine the latent factor structure of subjective responses to alcohol using exploratory factor analytic methods in the context of an in vivo alcohol administration. Results supported a 3-factor model which captured alcohol-induced stimulation, sedative and unpleasant effects of alcohol, and alcohol-induced alleviation of tension and negative mood, respectively. The tension-reduction factor was most consistently associated with more frequent drinking and alcohol problems in this sample. These findings support the notion that the neuropharmacological and behavioral effects of alcohol are multifaceted and cannot be simply defined dichotomously as reinforcing or punishing. Instead, multiple distinct factors reflecting concurrent positively reinforcing, negatively reinforcing, and punishing effects may be necessary to capture the complex nature of alcohol's biobehavioral effects. Additional research is needed to elucidate the specific neurobiological pathways and neuroanatomical structures involved in each of the specific biobehavioral effects of alcohol, which in turn may help us identify therapeutic targets and risk mechanisms. This is consistent with relevant theoretical work suggesting that further parsing of substance abuse reinforcement, and its underlying neurobiology, may be most useful for understanding addictions (Berridge and Robinson, 2003).

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