# Differences in Subjective Response to Alcohol by Gender, Family History, Heavy Episodic Drinking, and Cigarette Use: Refining and Broadening the Scope of Measurement

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ABSTRACT. **Objective:** Subjective response to alcohol (SR) has been shown to differ by gender, family history of alcoholism, drinking status, and cigarette smoking status. However, the requisite statistical basis for making mean-level comparisons (scalar measurement invariance; MI) has not been established for any SR measure, making it impossible to determine whether observed differences reflect true differences or measurement bias. Secondary data analyses were conducted to evaluate (a) MI of the Subjective Effects of Alcohol Scale (SEAS) by gender, family history, heavy drinking status, and cigarette smoking status using multigroup confirmatory factor analysis; and (b) the impact of these group-level variables on SR using multivariate general linear modeling. A central strength, the SEAS assesses novel high arousal negative (HIGH−; e.g., aggressive) and low arousal positive effects (LOW+; e.g., relaxed) in addition to commonly assessed high arousal positive [HIGH+; e.g., sociable] and low arousal negative effects [LOW−; e.g., woozy]). **Method:** A total of 215 young adults reported on SR during a placebo-controlled alcohol administration study in a simulated bar setting (target blood alcohol concentration = .08%). **Results:** Scalar MI was achieved for each group. After consuming alcohol, family history–positive individuals reported stronger HIGH− effects and female smokers reported weaker LOW+ effects than their counterparts. Heavy episodic drinkers and family history–positive females reported weaker LOW− effects than their counterparts. **Conclusions:** The SEAS permits meaningful SR comparisons within several important groups. SR differences largely were observed on the novel SEAS subscales, highlighting the importance of assessing a full range of SR. (*J. Stud. Alcohol Drugs, 76,* 287–295, 2015)

SUBJECTIVE RESPONSE TO ALCOHOL (SR) reflects individual differences in the experience of acute alcohol effects and confers risk for heavy drinking and alcohol-related problems (King et al., 2011; Morean & Corbin, 2010; Schuckit et al., 2009). Research identifying mean-level differences in SR that differentiate members of high-risk groups from low-risk groups (e.g., family history–positive versus family history–negative individuals) has been used to generate two primary theories about patterns of SR that confer the greatest alcohol-related risk: The Low Level of Response Model (LLR; Schuckit, 2009) posits that a blunted experience of all alcohol effects confers risk, whereas the Differentiator Model (DM; Newlin & Thomson, 1990) argues that a heightened experience of positive effects as blood alcohol levels rise and a dampened experience of negative effects as blood alcohol levels fall confers risk.

Despite the prominence of these models, several considerations merit note. First, studies supporting the LLR or DM often have not evaluated SR to a comprehensive range of alcohol effects, and SR measures have been confounded with the two theories. Studies in support of the LLR largely have relied on the Subjective High Assessment Scale (SHAS; Schuckit et al., 2000), which primarily assesses negative, sedative alcohol effects (e.g., sedation), whereas studies in support of the DM almost exclusively have relied on the Biphasic Alcohol Effects Scale (Martin et al., 1993), which assesses positive stimulant (e.g., sociability) and negative sedative effects (e.g., sedation). Studies examining group-level differences in SR to the full range of alcohol effects (i.e., high arousal positive [sociability]; low arousal positive [relaxation]; high arousal negative [aggression]; and low arousal negative [sedation]) using a psychometrically sound SR measure have been absent until recently (e.g., Morean et al., 2013). At this point, it remains unclear whether the tenets of the LLR and DM may be challenged by advances in the assessment of SR.

A second important limitation is that studies finding full support for the tenets of either model, irrespective of measurement issues, are rare (for a review, see Morean & Corbin, 2010). For example, Quinn and Fromme (2011) found that risk associated with family history status was consistent with the LLR, whereas risk associated with heavy drinking was consistent with the DM. To reconcile these findings, Quinn and Fromme (2011) proposed that risk at-

tributable to family history and heavy drinking, respectively, may operate through independent pathways, resulting in different risk profiles.

A third important limitation is that differences in SR have been identified based on several other alcohol-related risk factors, including gender (e.g., Luczak et al., 2002; Miller et al., 2009), race (Pedersen & McCarthy, 2013; Plebani et al., 2011), and cigarette smoking status (e.g., Cooney et al., 2001; McKee et al., 2008). However, study findings have been inconsistent, making it difficult to identify distinct profiles of risk associated with these demographic characteristics. For example, regarding gender, Luczak and colleagues (2002) found that Asian men reported stronger SR of "high, nauseated, and uncomfortable" on the SHAS than Asian women, whereas Miller and colleagues (2009) found that women reported significantly stronger subjective intoxication than did men in a sample of young adult social drinkers (race/ethnicity data were not provided). Adding to the complexity, other studies have found no gender differences in SR; Schuckit and colleagues (2000) found that family history–positive women and men reported similarly LLR on the SHAS, and McCance-Katz et al. (2005) found no differences in SR to alcohol based on gender in a sample of individuals who were using cocaine and alcohol.

Similar inconsistencies have been observed with regard to the effects of nicotine on SR. Some studies have found that nicotine (administered via smoking, intranasally, or by transdermal patch) reduces craving for alcohol (Cooney et al., 2001) and attenuates the experience of intoxication and/or reduces ad libitum drinking (McKee et al., 2008), whereas others suggest that nicotine use increases subjective intoxication and craving (Kouri et al., 2004) and, for men, results in increased self-administration (Acheson et al., 2006).

In sum, SR has been shown to confer risk for heavy drinking and related problems, but identifying specific SR patterns that are reliably associated with negative alcohol outcomes has proven difficult. Inconsistent research findings, like those reviewed above, may be attributable, at least in part, to a critical limitation of previous SR measures. Evaluating mean-level differences in SR within groups of interest (e.g., heavy vs. light drinkers) is common in the literature and forms the basis of the most prominent theories of SR. However, scalar invariance (i.e., the statistical basis necessary to make mean-level comparisons of SR) has not been established for any extant SR measure for the purposes of assessing SR differences by gender, family history, drinking, or smoking status. In addition to the classic indicators of reliability and validity (e.g., internal consistency; test-criterion validity), a measure must demonstrate scalar measurement invariance (MI) (i.e., MI of intercepts) in addition to configural (i.e., MI for latent structure) and metric invariance (i.e., MI for factor loadings; Steenkamp & Baumgartner, 1998;

Vandenberg & Lance, 2000). Establishing scalar MI ensures that SR is assessed comparably within groups of interest and that observed SR differences reflect "true" (latent) group differences rather than systematic measurement error that has not been taken into account.

In the absence of explicitly established scalar MI, it is impossible to interpret mean comparisons confidently because it is unclear what exactly is accounting for the observed findings (e.g., Chen, 2008). The fact that scalar MI has not been established for any measure of SR jeopardizes the quality of the findings that have formed the basis of our models of alcohol-related risk attributable to SR. Thus, some of the inconsistencies identified across studies may be attributable to undetected measurement error that has compromised our ability to make valid mean-level comparisons. Evaluating MI is a critical step toward maximizing the integrity of the assessment of SR and, consequently, our theoretical understanding of the construct and its relation to heavy drinking and alcohol-related problems.

To address these issues, the current study had two aims. First, we conducted a secondary data analysis (Morean et al., 2013) to evaluate MI of the Subjective Effects of Alcohol Scale (SEAS) by gender, family history of alcoholism, heavy episodic drinking status, and smoking status. We chose the SEAS over other measures of SR because it permits the assessment of a wide range of alcohol effects (i.e., HIGH+, HIGH−, LOW+, LOW− effects) and previously has been shown to demonstrate solid psychometric properties in this sample, including a confirmable and replicable latent factor structure; scalar MI by beverage condition (i.e., alcohol vs. placebo) and limb of the blood alcohol curve (i.e., ascending vs. descending); internal consistency; and test-criterion relationships with alcohol use and alcohol-related problems (Morean et al., 2013). We anticipated that the SEAS subscales would provide evidence of scalar MI within each of the groups of interest, permitting statistically supported mean-level comparisons of SR to be made within these groups.

The second aim of the study was to evaluate the extent to which membership in each of the groups for which scalar MI could be established was associated with SR. We anticipated that the SEAS's coverage of a broad range of alcohol effects would permit a more informative evaluation of MI and would improve the specificity of identified group-level differences in SR. However, we did not outline any specific hypotheses regarding relationships between group membership and SR, given the inconsistency of findings generated using previous measures of SR for which scalar MI was not established. Although the current study was, therefore, exploratory in nature, the findings may have important implications for identifying high-risk populations and for developing behavioral and/or pharmacological interventions designed to target unique patterns of SR associated with alcohol-related risk.

## Method

We provide a brief description of study participants and procedures below as context for the current study. For further details, see Morean et al. (2013). All study procedures were approved by the Institutional Review Boards of Yale and Arizona State Universities.

### Participants

Two hundred fifteen drinkers ages 21–30 years participated in a placebo-controlled alcohol administration study designed to assess the impact of alcohol consumption on gambling behavior in a simulated bar laboratory setting ($M_{age}$ = 22.84, $SD$ = 2.37; 74.40% male; 75.30% White; 23.7% smokers; 39.5% frequent heavy episodic drinkers; 26.5% family history–positive). Participants were recruited from college campuses and the communities of New Haven, CT ($n$ = 112) and Tempe, AZ ($n$ = 103). To be eligible, participants had to report drinking at least three drinks once per week to ensure that the amount of alcohol served during the study protocol would not exceed their typical consumption. Exclusion criteria included contraindications/adverse reactions to alcohol, current/past enrollment in abstinence-based alcohol treatment, and pregnancy. Given the gambling focus of the larger study, participants had to have played poker at least once in the past year and could not be enrolled in abstinence-based gambling treatment.

### Procedure

Participants attended a beverage administration session (starting at 5:00 P.M.) and a follow-up session conducted 2 weeks later. Before session one, participants abstained from alcohol and nonprescription drug use (24 hours) and from eating (4 hours). A breath alcohol analysis test confirmed the absence of alcohol at baseline. Participants completed a baseline assessment of SR before consuming three drinks over the course of 30 minutes (a target breath alcohol concentration [BrAC] of .08% in the alcohol condition). Participants subsequently completed five SR assessments (separated by 20 minutes each). At the conclusion of the study protocol, participants were debriefed about the beverage conditions (i.e., alcohol and placebo). Placebo participants were provided transportation home via taxicab or university shuttle at the end of the study protocol. Alcohol participants were provided transportation home once their BrAC fell below .02%.

### Measures

*Demographics.* We assessed gender, age, and race.
*Fagerström Test for Nicotine Dependence (Heatherton et al., 1991).* The first item (i.e., "Do you smoke cigarettes?") was used to create a dichotomous smoking variable.

*The Family Tree Questionnaire (Mann et al., 1985).* Participants reported on the drinking behavior of their parents, siblings, and grandparents (response options included *never drank, social drinker, possible problem drinker, definite problem drinking, no relative,* and *don't know/don't remember*). Definitions were provided for each of the categories (e.g., *definite problem drinkers* were defined as "persons who either are known to have received treatment for an alcohol problem, including being a member of Alcoholics Anonymous, or who have experienced several alcohol-related consequences like being convicted of drinking and driving"). Participants were coded as family history–positive if they reported that the following relatives were definite problem drinkers: (a) two or more grandparents, (b) one or both parents, or (c) one or more siblings.

*Subjective Effects of Alcohol Scale (Morean et al., 2013).* Participants rated their experience of 14 alcohol effects using an 11-point rating scale with response options ranging from *not at all* to *extremely.* SR was assessed at baseline and at five times over the course of the drinking episode. The SEAS has four subscales: HIGH+ (e.g., funny), HIGH− (e.g., rude), LOW+ (e.g., calm), and LOW− (e.g., woozy). The SEAS demonstrates excellent internal consistency, scalar invariance by beverage condition and limb of the blood alcohol concentration (BAC), and test-criterion validity with drinking outcomes and alcohol-related problems.

*Timeline Followback (Sobell & Sobell, 2003).* During an interview with study staff members, participants reported the quantity and frequency of alcohol use during the past month. On average, participants had consumed 59.70 (48.42) drinks, and 87.9% had engaged in at least one *heavy drinking episode* (defined as consuming four or more drinks for women or five or more drinks for men). Given that the sample comprised moderate to heavy drinkers, we categorized drinkers based on the frequency of engaging in heavy episodic drinking. Participants coded as frequent heavy drinkers reported six or more heavy drinking episodes in the prior month.

### Data analytic plan

To determine whether mean-level comparisons of SR could be made reliably by gender, family history, drinking, and smoking status, we used a multigroup confirmatory factor analysis (CFA) approach to evaluate MI of the SEAS scores for the groups of interest. We evaluated configural, metric, and scalar invariance. Multivariate general linear model (GLM) analyses were then conducted to evaluate whether SR on the four SEAS subscales differed based on categorical variables reflecting group membership and beverage condition. The primary results of interest in these analyses were interactions between group membership and beverage condition, such that group membership (e.g. family history–positive) uniquely was related to SR to alcohol (relative to placebo). Given that two GLMs were run, a Bon-

TABLE 1. Evaluation of measurement invariance (baseline through post–beverage administration) by sex, family history of alcoholism, heavy drinking status, and cigarette smoking status)

| Level of MI established | Sex Model fit indices | | | | Family history Model fit indices | | | | Heavy drinking Model fit indices | | | | Cigarette smoking Model fit indices | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CFI | TLI | RMSEA | SRMR | CFI | TLI | RMSEA | SRMR | CFI | TLI | RMSEA | SRMR | CFI | TLI | RMSEA | SRMR |
| Configural invariance | .936 | .930 | .049 | .053 | .945 | .929 | .063 | .073 | .934 | .915 | .070 | .068 | .944 | .929 | .063 | .060 |
| Metric invariance | | | | | | | | | | | | | | | | |
| Step 1. Model fit | .935 | .920 | .052 | .062 | .943 | .932 | .062 | .080 | .933 | .920 | .068 | .075 | .941 | .932 | .061 | .069 |
| Step 2. Change in fit from configural model | -.001 | -.010 | .003 | .009 | -.002 | .003 | -.001 | .007 | -.001 | .005 | -.002 | .007 | -.003 | .003 | -.002 | .009 |
| Scalar invariance | | | | | | | | | | | | | | | | |
| Step 1. Model fit | .926 | .916 | .053 | .064 | .943 | .936 | .060 | .080 | .929 | .921 | .067 | .076 | .927 | .923 | .069 | .071 |
| Step 2. Change in fit from metric model | -.009 | -.004 | .001 | .002 | .000 | .004 | -.002 | .000 | -.004 | .001 | -.001 | .001 | -.014 | -.009 | .008 | .002 |

*Notes:* MI = measurement invariance; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

ferroni-corrected alpha value of .025 was used to evaluate the statistical significance of main effects and interactions.

## Results

### Measurement invariance by gender

*Configural invariance (i.e., invariance of latent structure).* A two-group CFA model was specified in Mplus 7 in which the previously identified four-factor SEAS structure was simultaneously fit to men and women. Maximum likelihood estimation with robust standard errors was specified. Factor metrics were set to 1. Factor means were set to 0. The remaining model parameters were estimated freely (e.g., factor loadings, intercepts). The model fit the data well, suggesting that the same conceptual structure was present for both men and women (see Table 1 for model fit indices and changes in model fit between models for gender, family history, heavy drinking status, and smoking status).

*Metric invariance (i.e., invariance of factor loadings).* Factor loadings of matching SEAS items were constrained to equality for men and women (e.g., loadings of "aggressive" were set to be equal). Latent factor means were set to 0. Model fit indices for the model testing metric invariance were compared to fit indices from the configurally invariant model, with decrement in fit exceeding standardized root mean square residual (SRMR) $\geq$ .030, root mean square error of approximation (RMSEA) $\geq$ .015, or comparative fit index (CFI) $\geq$ -.01 indicating variance (Chen, 2007). Based on these cutoffs, the resulting model did not show evidence of significant decrement in fit when compared with the configurally invariant model. As such, metric invariance was achieved; SEAS items related to their respective latent factors comparably for men and women.

*Scalar invariance (i.e., invariance of intercepts).* Both factor loadings and intercepts (item means) of matching SEAS items were constrained to equality for men and women while allowing the latent factor means to be estimated freely. Chen (2007) suggested that a unique change in

fit indices be considered when evaluating scalar invariance, with changes in CFI $\geq$ -.010 accompanied by a change in SRMR $\geq$ .010 or RMSEA $\geq$ .015 indicating variance. Based on these indices, the resulting model did not demonstrate significant decrement in fit when compared with the model testing metric invariance, indicating that scalar invariance was achieved and mean-level comparisons of SR based on gender were statistically justifiable.

### Measurement invariance by family history, heavy drinking, and smoking status

MI was independently evaluated for family history, heavy drinking, and smoking status using the same CFA approach outlined above. The SEAS scores show configural, metric, and scalar invariance within each group.

### Multivariate general linear modeling

After we demonstrated scalar invariance for all groups, we ran multivariate GLM analyses to evaluate relationships between participant characteristics and SR on the ascending and descending limbs of the blood alcohol curve, respectively. Beverage condition (for which scalar MI was established previously), participant characteristics, and baseline SEAS scores were included as model covariates. Two- and three-way interactions between beverage condition and participant characteristics, respectively, also were included (e.g., beverage condition by sex was included in the model, but sex by smoking status was not). Higher-level interactions were excluded because of lack of statistical power. Main effects are noted briefly in the text that follows, but the presentation of the results focuses on interactions between beverage condition (i.e., placebo vs. alcohol) and group membership, as these relationships are most informative with respect to understanding group-level differences in pharmacological response to alcohol.

*Subjective Effects of Alcohol Scale (ascending limb).* Because higher-level interactions may serve to qualify

lower-level interactions or main effects observed in the models, we first reported the highest level interactions (three way), followed by two-way interactions and main effects. When describing two-way interactions and main effects, we noted when these effects were qualified by higher-level interactions.

Using Pillai's trace ($V$), two significant three-way interactions emerged when SEAS ascending limb effects were examined as the outcome (see Figure 1 for a depiction of all significant interactions). First, there was a three-way interaction among condition, sex, and smoking status, $V = 0.100$, $F(8, 344) = 2.269$, $p = .022$, partial $\eta^2 = .050$, with a significant between-subjects effect emerging for LOW+ effects, $F(2, 173) = 3.715$, $p = .026$, partial $\eta^2 = .041$. Decomposition of the three-way interaction indicated that there was a significant interaction between beverage condition and smoking for women, $V = 0.076$, $F(4, 171) = 3.522$, $p = .009$, but not for men, $V = .023$, $F(4, 171) = 0.991$, $p = .414$. Simple effects indicated that female smokers reported weaker LOW+ effects than female nonsmokers after consuming alcohol, $F(1, 174) = 5.627$, $p = .019$, but not after consuming placebo, $F(1, 174) = 0.855$, $p = .866$.

There was also a three-way interaction among condition, family history status, and sex, $V = 0.110$, $F(8, 344) = 2.530$, $p = .011$, partial $\eta^2 = .056$, with a significant between-subjects effect emerging for LOW− effects, $F(2, 173) = 3.769$, $p = .025$, partial $\eta^2 = .042$. Decomposition of the three-way interaction indicated that there was a significant interaction between beverage condition and family history status for women, $V = 0.105$, $F(4, 171) = 4.996$, $p = .001$, but not for men, $V = 0.034$, $F(4, 171) = 1.499$, $p = .204$. Simple effects indicated that family history–positive women experienced weaker LOW− effects than family history–negative women after drinking alcohol, $F(1, 174) = 6.104$, $p = .014$, but not after drinking placebo, $F(1, 174) = 0.008$, $p = .928$.

A pair of significant two-way interactions between beverage condition and intrapersonal factors also emerged when predicting ascending limb SR. First, there was a significant condition by family history status interaction in predicting SR, $V = 0.078$, $F(4, 171) = 3.616$, $p = .007$, partial $\eta^2 = .078$. Although a three-way interaction qualified the two-way interaction between condition and family history status for SR overall, the three-way interaction was for LOW− effects, whereas the two-way interaction was for HIGH− effects, $F(1, 174) = 5.228$, $p = .023$, partial $\eta^2 = .029$. Examination of simple effects indicated that family history–positive individuals reported stronger HIGH− effects than family history–negative individuals after consuming alcohol, $F(1, 174) = 3.898$, $p = .049$, but not after consuming placebo, $F(1, 174) = 1.309$, $p = .254$.

Second, there was a significant condition by heavy drinking status interaction in predicting SR, $V = 0.089$, $F(4, 171) = 4.15$, $p = .003$, partial $\eta^2 = .089$, with significant univariate effects emerging for LOW+ effects, $F(1, 174) = 6.549$,

$p = .011$, partial $\eta^2 = .036$, and LOW− effects, $F(1, 174) = 4.45$, $p = .036$, partial $\eta^2 = .025$. Examination of simple effects indicated that, after consuming alcohol, frequent heavy drinkers reported significantly weaker LOW− effects and nonsignificantly stronger LOW+ effects relative to lighter drinkers, LOW− $F(1, 174) = 9.469$, $p = .002$; LOW+ $F(1, 174) = 3.435$, $p = .060$. Participants reported similar LOW− and LOW+ effects after consuming placebo irrespective of heavy drinking status, LOW− $F(1, 174) = 0.246$, $p = .620$; LOW+ $F(1, 174) = 0.099$, $p = .753$.

Main effects were noted for condition, $V = 0.090$, $F(4, 171) = 4.233$, $p = .003$, partial $\eta^2 = .090$, and sex, $V = 0.107$, $F(4, 171) = 5.127$, $p = .001$, partial $\eta^2 = .107$. Significant univariate effects indicated that participants in the alcohol condition reported stronger HIGH+, HIGH−, and LOW− effects than participants in the placebo condition, HIGH+, $F(1, 174) = 13.936$, $p < .001$, partial $\eta^2 = .077$; HIGH−, $F(1, 174) = 6.037$, $p = .015$, partial $\eta^2 = .035$; LOW−, $F(1, 174) = 7.054$, $p = .009$, partial $\eta^2 = .040$). Whereas main effects of condition were qualified by higher-level interactions for HIGH− and LOW− effects, main effects of beverage condition on HIGH+ effects were consistent across all subgroups of participants. Regarding gender main effects, men reported stronger LOW+ effects than women, $F(1, 174) = 9.729$, $p = .002$, partial $\eta^2 = .053$, although this main effect was qualified by the three-way interaction between condition, sex, and smoking status.

*Subjective Effects of Alcohol Scale (descending limb).* Using Pillai's trace ($V$), a significant three-way interaction among beverage condition, sex, and family history status emerged when predicting descending limb SR, $V = 0.112$, $F(8, 344) = 2.548$, $p = .010$, partial $\eta^2 = .056$, with significant between-subjects effects emerging for LOW+ and LOW− effects, LOW+, $F(2, 174) = 3.573$, $p = .030$, partial $\eta^2 = .039$; LOW−, $F(2, 174) = 6.274$, $p = .002$, partial $\eta^2 = .067$. Decomposition of the three-way interaction indicated that there was a significant interaction between beverage condition and family history status for women, $V = 0.078$, $F(4, 171) = 3.629$, $p = .007$, but not for men, $V = 0.030$, $F(4, 171) = 1.300$, $p = .272$. Simple effects indicated that family history–positive women experienced significantly weaker LOW− effects and nonsignificantly stronger LOW+ effects than family history–negative women after drinking alcohol, LOW−, $F(1, 174) = 9.290$, $p = .003$; LOW+, $F(1, 174) = 3.088$, $p = .061$, but not after consuming placebo, LOW−, $F(1, 174) = 1.264$, $p = .262$; LOW+, $F(1, 174) = 1.775$, $p = .184$.

No two-way interactions emerged on the descending limb, but main effects were again noted for condition, $V = 0.172$, $F(4, 171) = 8.889$, $p < .001$, partial $\eta^2 = .172$, and sex, $V = 0.083$, $F(4, 171) = 3.882$, $p = .005$, partial $\eta^2 = .083$. Significant univariate effects indicated that participants in the alcohol condition reported stronger HIGH+, HIGH−, and LOW− effects than participants in the placebo condi-
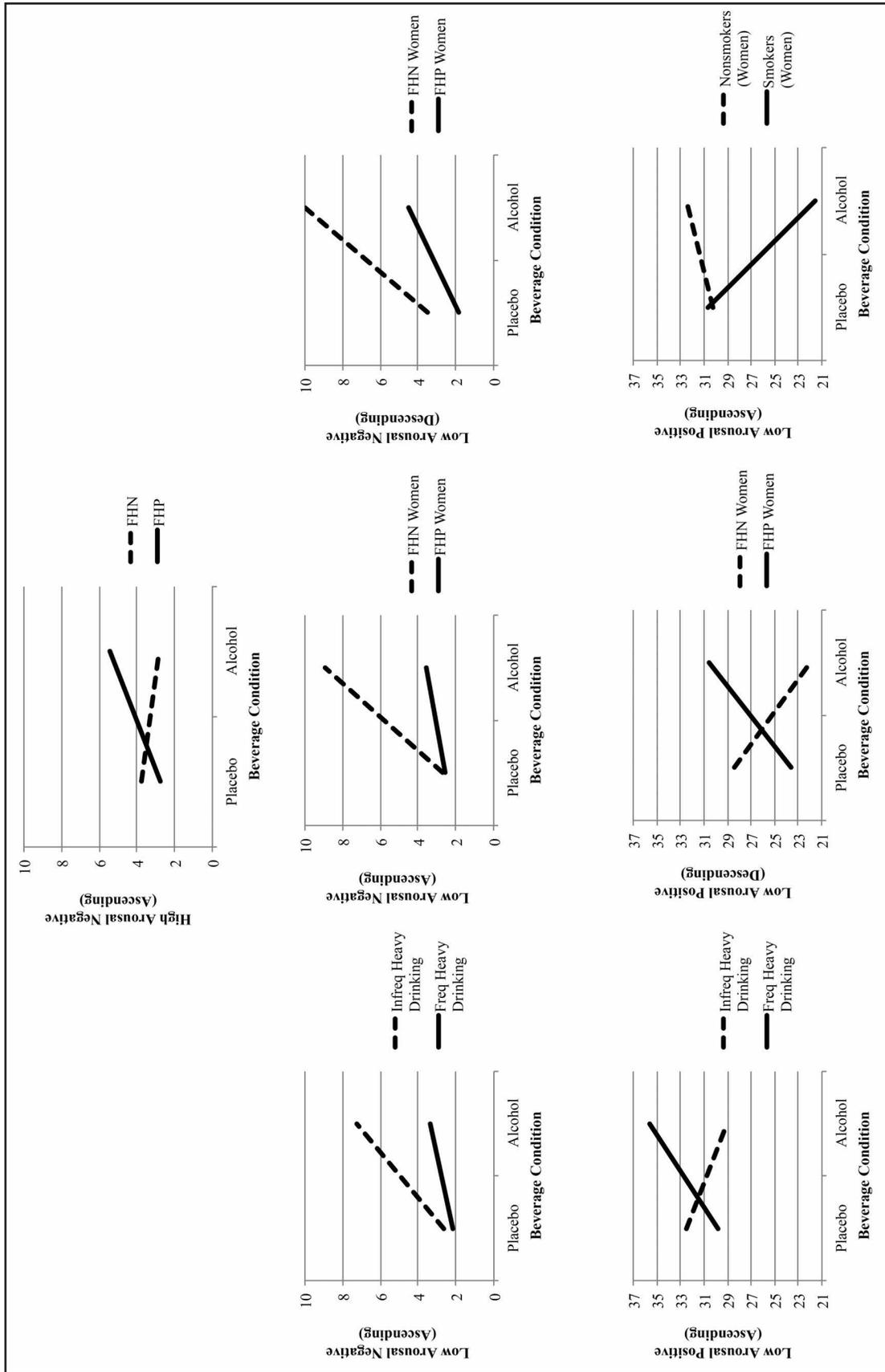
FIGURE 1.   Interactions between beverage condition and participant demographic characteristics are associated with differential patterns of subjective response. *Notes:* FHN = family history–negative; FHP = family history–positive; infreq = infrequent; freq = frequent.

tion, HIGH+, $F(1, 174) = 8.014$, $p = .005$, partial $\eta^2 = .044$; HIGH−, $F(1, 174) = 8.603$, $p = .004$, partial $\eta^2 = .047$; LOW−, $F(1, 174) = 21.178$, $p < .001$, partial $\eta^2 = .109$). The main effect for LOW− effects was qualified by the three-way interaction, whereas main effects for HIGH+ and HIGH− effects were consistent across all subgroups. With respect to gender main effects, men reported stronger HIGH+ effects, $F(1, 174) = 4.875$, $p = .029$, partial $\eta^2 = .027$, and weaker LOW− effects than women, $F(1, 174) = 8.506$, $p = .004$, partial $\eta^2 = .047$, although the main effect for LOW− effects was qualified by the three-way interaction.

## Discussion

Using advances in test theory and statistical approaches, the current study establishes scalar MI for the SEAS subscale scores by sex, family history of alcohol problems, heavy drinking status, and smoking status. As such, we ensure, for the first time, the ability to make valid mean-level comparisons of SR within these important groups.

Furthermore, the results of the current study indicate that group membership was associated with three patterns of SR to the effects of alcohol (vs. placebo), with significant effects observed for HIGH− effects, LOW− effects, and LOW+ effects. First, individuals with a positive family history of alcoholism experienced a unique increase in HIGH− alcohol effects on the ascending limb, a pattern that conferred risk for heavy drinking and alcohol-related problems in our prior work (Morean et al., 2013). It is worth noting that these findings are inconsistent with both the LLR model of alcohol use, which suggests that a blunted response to alcohol is associated with increased risk for negative alcohol outcomes, and with the DM, which posits that a mixed pattern of SR characterized by strong experiences of HIGH+ effects on the ascending limb and weak experiences of LOW− effects on the descending limb confers alcohol-related risk. However, it also is important to note that neither the LLR nor the DM directly speaks to potential group differences in HIGH− effects, largely because of the prior lack of an SR measure that assesses HIGH− effects. In light of the current findings, addressing HIGH− effects may be important when examining family history of alcoholism as a risk factor, especially when HIGH− effects are experienced early in a drinking episode.

Characteristic of the second pattern of SR that we observed, weaker LOW− alcohol effects were endorsed by frequent heavy drinkers (ascending limb) and by family history–positive women (both limbs) relative to their respective counterparts. Although simple effects for LOW+ failed to reach statistical significance, both frequent heavy drinkers and family history–positive women endorsed stronger LOW+ effects at a trend level (frequent heavy drinkers [ascending limb]; family history–positive women [descending limb]). The emergence of this overall pattern merits note, given that it previously was shown to confer risk for heavy drinking and

for driving after drinking in this sample (Morean et al., 2013). To some extent, this pattern of results is consistent with the LLR (i.e., weaker negative effects) and the DM (i.e., stronger positive effects and weaker negative effects). However, the results diverge from the DM in two important ways.

First, the experience of low arousal effects was not confined to the descending limb, as specified by the DM; group differences in low arousal effects were observed on both limbs. Similarly inconsistent with the DM, King and colleagues (2011) found that stronger positive and weaker negative effects conferred risk for heavy drinking irrespective of BAC limb. Taken together, these findings call into question the extent to which alcohol-related risk conferred by specific patterns of SR is limb specific, as outlined by the DM.

A second divergence from the DM is that heavy drinkers experienced LOW+ effects on the ascending limb, as opposed to the types of HIGH+ effects posited by the DM. Admittedly, it is difficult to place these preliminary findings regarding LOW+ effects clearly within the context of the DM, given that LOW+ effects have not been examined in most prior studies of risk associated with SR. However, the lack of significant group differences in HIGH+ effects clearly is inconsistent with the DM. It is worth noting that the absence of HIGH+ effects in the current study was surprising, given that we previously demonstrated strong correlations between the SEAS HIGH+ subscales and an alternative measure of positive stimulant effects (i.e., the stimulation subscale of the Biphasic Alcohol Effects Scale) in our prior work ($r = .80$ [ascending limb]; $r = .83$ [descending limb]; Morean et al., 2013). Among other concerns, the lack of findings regarding HIGH+ effects raises questions about the potential role of response bias in prior research. Studies examining MI of the Biphasic Alcohol Effects Scale are needed to determine whether group differences in prior studies can be interpreted meaningfully.

The third pattern of SR that we observed indicated that female smokers experienced weaker LOW+ effects on the ascending limb than did female nonsmokers, a pattern that previously was associated with risk for driving after drinking in this data set and that is consistent with the LLR. However, it is somewhat difficult to place these findings in the context of prior research for two reasons: (a) studies examining differences in SR by smoking status are scant, and (b) significant effects emerged for LOW+ effects, which have not been widely studied, particularly in women. It is worth noting that the observed pattern could be driven, at least in part, by a differential experience of nicotine withdrawal in women, although it was not possible to test this possibility explicitly in the current study. Future studies evaluating the effects of smoking status on SR alone and in combination with other risk factors are needed to replicate and extend our findings.

Although the current findings contribute to the existing literature on SR in a number of important ways, they must be considered in light of several study limitations. First, we

had limited statistical power to detect statistically significant three-way interactions because of sample size. As such, these results should be interpreted as preliminary, and replication within a larger sample is needed. Second, the study was cross-sectional in nature. As such, it is unclear whether the different SR patterns associated with group membership in the current study translate into risk for future negative alcohol-related outcomes. Longitudinal research is needed to evaluate whether the observed group differences in SR prospectively predict drinking outcomes. Third, the study sample comprised relatively heavy drinkers who were recruited to take part in a larger study designed to evaluate relationships between alcohol consumption and gambling behavior on a simulated video poker task. Fourth, the study sample represented a restricted age range (21–30 years) and comprised primarily college students (90.2%). Thus, it is possible that the group-level differences in SR observed in the current study are specific to the sample.

The extent to which the current pattern of results would generalize to lighter drinkers, nongamblers, populations of different ages (e.g., adolescents, the elderly), and/or to comparably aged individuals who are not in college is unclear. Further research is needed to determine the generalizability of the current findings. Finally, the measure of race/ethnicity included in the current study lacked sufficient sensitivity to permit meaningful evaluations of SR by race/ethnicity (i.e., 75% White; 13% "other"), and future research is needed on this topic.

Despite its limitations, the current study provides solid psychometric evidence that an SR measure (i.e., the SEAS) can be used to evaluate differences in SR based on sex, family history of alcoholism, heavy drinking status, and smoking status with a sufficient degree of statistical confidence. Before the current study, research largely had focused on identifying group-level differences in SR using measures that restricted assessments of SR to HIGH+ and/or LOW− effects and for which scalar MI had not been established. The results of the current study suggest that the unique ability of the SEAS to assess a comprehensive range of alcohol effects has significant value, as several of the observed group-level differences in SR were for the novel SEAS subscales (i.e., HIGH− and LOW+). Future research is needed to determine whether the different patterns of SR that were observed based on group membership in the current study (a) are replicable, (b) generalize to other populations of drinkers (e.g., lighter drinkers, older drinkers), and (c) predict alcohol-related behavior in real-world settings.

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