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Effects of alcohol sensitivity on alcohol-induced blackouts and passing out: An examination of the alcohol sensitivity questionnaire among underage drinkers

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Abstract

Background: The role of alcohol sensitivity in the experience of blacking out and passing out has not been well established. Here, we examined the relation between individual differences in alcohol sensitivity (i.e., numbers of drinks required to experience various effects of alcohol) and reports of blacking out and passing out in the past year.

Methods: Participants (925 healthy, underage college student drinkers) completed the Alcohol Sensitivity Questionnaire (ASQ) and reported on their past year blacking out and passing out experiences.

Results: The fit of the ASQ's 2-factor structure was fair (CFI = 0.90, RMSEA = 0.09) in this sample of underage drinkers. In unadjusted models, higher ASQ scores (i.e., requiring more drinks to experience effects, indicating lower alcohol sensitivity) were associated with experiencing more blackouts (IRR = 1.68 [1.31–2.15]) and passing out (IRR = 2.25 [1.59–3.18]) in the past year. After controlling for typical consumption, however, higher ASQ scores were associated with fewer past-year blackouts (IRR = 0.76 [0.60–0.98]). Total ASQ scores moderated the relationship between typical alcohol consumption and blackout occurrence (interaction IRR = 0.96 [0.93–0.98]), but not passing out occurrence (interaction IRR = 0.95 [0.89–1.01]), with the quantity of alcohol consumed more strongly associated with blackout occurrence among higher-sensitivity than lower-sensitivity drinkers.

Conclusions: These findings are consistent with prior work suggesting that low sensitivity may act as a paradoxical risk factor for certain heavy drinking effects, contributing to higher levels of alcohol consumption and more frequent negative consequences while also conferring protection (relative to high-sensitivity peers) at a given level of alcohol exposure.

KEYWORDS
alcohol consequences, alcohol sensitivity, blackout, passing out, underage drinkers

INTRODUCTION

Among drinkers, there are substantial individual differences in objective and subjective reactions to a given dose of alcohol (de Wit et al., 1987; Morean & Corbin, 2010; Ray et al., 2016). Sensitivity to

alcohol's effects can decrease as a result of heavy drinking due to acquired tolerance, but sensitivity is not exclusively determined by alcohol exposure history. For example, twin studies indicate that genetic factors account for 40%–60% of the phenotypic variance in alcohol sensitivity (Ray et al., 2010; Viken et al., 2003), and meaningful

variations in level of response to alcohol are reported by young adolescents with very little lifetime drinking experience (Schuckit et al., 2008). Individual differences in sensitivity to alcohol's effects can be measured using one of two approaches. The first approach involves an in-lab alcohol challenge. Robust evidence demonstrates that individuals differ with respect to their degree of sensitivity to objective (e.g., body sway, hormonal response) and self-reported intoxication when receiving a fixed alcohol dose (Marczinski & Fillmore, 2009; Schuckit, 1994; Schuckit et al., 1987). While considered the "gold standard" for assessing alcohol sensitivity, this approach is costly and cannot be administered ethically in some populations (e.g., underage drinkers; those with medical contraindications, including active AUD).

Alternatively, researchers can administer a questionnaire that asks respondents to report the number of drinks they require to experience particular effects from drinking alcohol. The most widely used questionnaire for this purpose is the Self Rating of the Effects of Alcohol (SRE) form. The SRE asks respondents to indicate the number of drinks required to experience up to four effects from drinking alcohol ("any effect"; dizziness or slurred speech; stumbling gait; passing out) during three different time periods (first five drinking episodes, period of heaviest drinking, and most recent consecutive 3-month period during which they drank; Schuckit et al., 1997). The measure used in the current study, the Alcohol Sensitivity Questionnaire (ASQ; O'Neill et al., 2002), queries a larger number and broader range of alcohol effects than the SRE. The ASQ queries nine effects that tend to be experienced after low doses of alcohol (e.g., feeling "buzzed"; feeling more talkative) and six effects generally associated with higher alcohol doses (e.g., feeling dizzy; experiencing a hangover). These two sets of effects were shown to form two correlated factors (ASQ light and ASQ heavy, respectively) in a community sample of adults aged 21 to 34 (Fleming et al., 2016). In that study, participants completed the ASQ and the SRE prior to consuming either a moderate dose of alcohol or a placebo beverage, after which they reported levels of stimulation, sedation, and subjective intoxication as breath alcohol concentration was both rising and falling. ASQ and SRE scores robustly correlated with each other and performed comparably when predicting subjective intoxication, but the ASQ outperformed the SRE at predicting stimulation and sedation, signifying the utility of the measure for capturing individual variability in sensitivity to a range of alcohol's effects (Fleming et al., 2016).

Across both methods of assessment, patterns of alcohol sensitivity have been shown to play an important role in the development of alcohol-related problems (e.g., King et al., 2016; Ray et al., 2016; Schuckit, 1994; Schuckit & Smith, 1996). However, relatively little research has explored the relation of alcohol sensitivity to the experience of specific acute consequences, such as blackouts and passing out. No research to date has examined the possible role of alcohol sensitivity in alcohol-induced passing out, and only a couple studies have explored alcohol sensitivity in relation to blackout. In one study, retrospective reports of stronger stimulating and sedating effects of alcohol at the midpoint of a 21st birthday celebration

predicted the occurrence of blackout during this event (Wetherill & Fromme, 2009). These associations were not reduced after accounting for final estimated blood alcohol concentration. Another study in a sample of college freshmen drew the opposite conclusion, finding that a low level of response to alcohol (i.e., needing more alcohol to experience a given effect during the first five drinking episodes) was predictive of higher rates of blackouts over time, though this effect virtually vanished after accounting for consumption (Schuckit et al., 2016).

The central hypothesis of the current study is that risk for negative consequences of heavy drinking may be associated with either lower or higher levels of alcohol sensitivity, depending on whether consumption is accounted for in analyses. While low sensitivity (particularly to alcohol's sedating effects) generally has been associated with risk for developing alcohol problems (King et al., 2011, 2014; Ray et al., 2016; Schuckit, 1994), those low in sensitivity to alcohol's effects may actually be protected from experiencing certain acute consequences at any given level of alcohol consumption. For example, previous research on alcohol-related regretted sex has shown that after controlling for typical alcohol consumption, women relatively low in alcohol sensitivity were actually less likely to report intoxicated sexual experiences they later regretted (Hone et al., 2017). This is also consistent with findings on hangover, which showed that, when covarying the number of drinks consumed during a given drinking episode, alcohol consumption conferred stronger risk for hangover among high-sensitivity, relative to low-sensitivity drinkers (Piasecki et al., 2012).

While individuals who have lower sensitivity to alcohol tend to consume more during a given drinking occasion (Piasecki et al., 2012; Trela et al., 2016), they are also less likely to be impaired after a given dose of alcohol compared with their high-sensitivity peers. This increased consumption will lead to increased frequency of experiencing adverse consequences, but their relative insensitivity to alcohol also confers some degree of protection at higher levels of consumption. It is unclear whether this pattern is specific to certain effects of heavy drinking (e.g., alcohol-related regretted sex, hangover, and *potentially* blacking out and passing out), or instead reflects a more general pattern that applies across all heavy drinking consequences. Another possibility is that this pattern applies for both milder and heavy drinking consequences of alcohol use. Regardless, heavier drinking effects, including blackouts and passing out, may be of greater interest due to their associations with the experience of other alcohol-related consequences and with the development of AUD (Studer et al., 2019).

The current study examined how individual differences in alcohol sensitivity (as measured by the ASQ)[1] are related to risk for blacking

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[1]We recognize that "alcohol sensitivity" is not necessarily a unitary construct and that important differences in risk profiles have been associated with variability in sensitivity to alcohol's stimulating and sedating effects (i.e., the differentiator model; King et al., 2011, 2014; Newlin & Thomson, 1990). However, the measure of sensitivity used in this study was not designed to assess stimulating and sedating effects, but rather effects associated with lighter versus heavier dose drinking episodes. Thus, we use the more general term "alcohol sensitivity" because it captures the construct as assessed here.

out and passing out among a large sample of college student drinkers aged 17 to 20. We hypothesized that low sensitivity would be associated with higher rates of blackout and passing out. Given that the current sample consists of underage drinkers, a population not included in the original ASQ validation, we also attempted to validate the 2-factor structure of the ASQ in this group and explored whether component factors showed unique relations with the outcomes. Finally, we assessed whether ASQ scores moderated the relationship between alcohol consumption (i.e., typical quantity of alcohol use) and blackout and passing out occurrence. We hypothesized that, although low sensitivity would be associated with higher rates of blackout and passing out, level of alcohol consumption would have a greater effect on risk for blacking out and passing out among high-sensitivity drinkers compared with low-sensitivity drinkers, consistent with earlier work examining other adverse consequences of heavy drinking (Hone et al., 2017; Piasecki et al., 2012).

MATERIALS AND METHODS

Participants

Students enrolled in introductory psychology courses at a large Midwestern university earned course credit for completing an online survey assessing various alcohol use behaviors and consequences. In total, 1141 undergraduates aged 17 to 20 completed the survey in fall 2019. Analyses were restricted to those participants who reported drinking in their lifetime, resulting in a final sample size of 925. Of these participants, 66.27% were female, and most were college freshmen (82.81%), with a mean age of 18.28 years (SD = 0.58). Study participants were representative of the broader state population in terms of race and ethnicity (United States Census Bureau, 2018); 80.4% of participants were white, 9.1% were of mixed race/ethnicity, 5.3% were Black/African American, 2.6% were Asian/Pacific Islander, 1.7% were Hispanic/Latino, and <1% were "other." Some of the data using this sample (not including the ASQ data) have been included in a previous publication (Davis et al., 2021).

Measures

Alcohol use

Participants were asked to report the age when they first began drinking. Typical quantity of alcohol use during the past year was assessed with an item asking, "During the last 12 months, how many alcoholic drinks did you have on a typical day when you drank alcohol?" Response options ranged from "1 drink" to "25 or more drinks." Frequency of use was assessed with the question: "During the last 12 months, how often did you usually have any kind of drink containing alcohol?" Response options ranged from "1 or 2 times in the past year" to "every day." Quantity frequency (QF) was calculated by

multiplying the numeric values of responses to these 2 questions. Due to a high degree of skewness, the resulting QF variable was log-transformed for analyses. After transformation, the QF variable had a skewness of −0.33 and a kurtosis of 0.003. To calculate the number of drinking days in the past year, the past year alcohol frequency variable was converted to a days per year scale (i.e., "once a month" becomes "12" and "every day" becomes "365"). Participants also reported the maximum number of drinks they had consumed in a single day in their lifetime. High-intensity drinking, which is a form of extreme binge drinking, was assessed by asking participants if they had consumed eight or more drinks (for women) or 10 or more drinks (for men) on a single occasion in the past year. Finally, participants also completed the 10-item Alcohol Use Disorders Identification Test (AUDIT), which is a validated screener for risky alcohol use (Saunders et al., 1993).

Blackout and passing out

Blackout was assessed with an item asking, "During the last 12 months, approximately how many times have you had an alcohol-related blackout where you forgot parts of a drinking episode (e.g., not remembering how you got home, forgetting something you said to others while drinking, etc.)?" Response options ranged from "0" to "More than 10." Participants who had experienced a blackout were asked to recall how many drinks they had consumed on the most recent occasion resulting in a blackout. Passing out was assessed with an item asking, "During the last 12 months, approximately how many times have you passed out from drinking alcohol?" Response options were the same as those for blackout. Similarly, participants who had passed out were asked how many drinks they had consumed on the most recent occasion resulting in passing out.

Alcohol Sensitivity Questionnaire

The ASQ is a 15-item measure of sensitivity to various alcohol-related effects that yield a total score and scores for two subscales (O'Neill et al., 2002). Nine of the ASQ's items query effects typically associated with lower alcohol doses or lighter drinking episodes (ASQ_light subscale; e.g., feeling more talkative, more flirtatious, or buzzed). Respondents report whether they have experienced each effect from drinking alcohol, and if yes, they are asked to estimate the minimum number of drinks they would have to consume in order to experience it. The six remaining items query effects typically associated with higher alcohol doses or heavier drinking episodes (ASQ_heavy subscale; e.g., getting a hangover, vomiting, or feeling nauseous). For these items, respondents report whether they have experienced each effect, and if yes, are asked to indicate the maximum number of drinks they could consume *without* experiencing the effect. The ASQ's items were selected from a pool of subjective alcohol effects (the ASQ_light items) and drinking experiences associated with intoxication (the ASQ_heavy items) in an attempt to capture a broader

spectrum of responses to alcohol than are captured by the SRE (Schuckit et al., 1997).[2]

Scores on each subscale and total ASQ scores were calculated using standardized person-mean imputation (Lee et al., 2015). Within the ASQ (and other self-report measures of alcohol sensitivity), items assessing effects of heavier alcohol consumption (e.g., hangover) are more likely to be missing compared with items assessing effects that are experienced at lower levels of consumption (e.g., buzzed). If scores are summed across completed items in such a situation, the values for responses of less-experienced drinkers will have a downward bias, which can substantially affect findings (Lee et al., 2015). This effect is likely more pronounced among younger drinkers, who typically have less experience with alcohol and may not have experienced all effects. The standardized person-mean imputation approach used in the current study avoids this downward bias by transforming the survey items to a standardized scale prior to taking the mean of the completed items.

Given that the ASQ includes items assessing blackout and passing out, these items were excluded from calculations of scale and total scores used when predicting the two consequences to avoid criterion contamination. The ASQ_heavy subscale had high internal consistency following exclusion of the blackout and passing out items (α = 0.94), as did the overall ASQ scale (α = 0.92). Similarly, the ASQ_light subscale had high internal consistency (α = 0.90) in the sample.

Data analysis

Confirmatory factor analysis (CFA) of the ASQ was conducted within Amos (Arbuckle, 2006) to evaluate the fit of the previously validated 2-factor model (Fleming et al., 2016) in a novel sample of underage drinkers. This 2-factor model consists of nine light drinking items and six heavy drinking items, along with two correlated error terms. Fit of this previously validated 2-factor model was then compared with a 1-factor model. Model fit was assessed using chi-square difference tests, comparative fit index (CFI) values, and root mean square error of approximation values (RMSEA). For a good fitting model, we sought CFI values ≥0.95 and RMSEA values ≤0.06; models with CFI values ≥0.90 and RMSEA values ≤0.10 were deemed to be fair fitting models (Hu & Bentler, 1999). Model fit was also assessed after excluding the blacking out and passing out items.

To evaluate the role of sensitivity in blackout and passing out, unadjusted and fully adjusted (i.e., including all covariates) negative binomial regressions were conducted within SAS v9.4 predicting the number of past year blackout and passing out experiences from ASQ total and scale scores. The following variables were included as

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[2]ASQ scores likely reflect a combination of innate sensitivity that antedates drinking experience, and tolerance acquired over accumulated alcohol exposures. Early research (O'Neill et al., 2002) found that ASQ scores and items tapping acquired tolerance correlated $r \approx 0.50$–0.60 (depending on how tolerance items were scored), suggesting some overlap—but also some independence—in these constructs.

covariates in fully adjusted models: (1) biological sex, (2) body weight in pounds, (3) fraternity/sorority membership, (4) age of first drink (AFD), and (5) past year quantity frequency of alcohol use. Prior to fitting models, variance inflation factors (VIF) were inspected to ensure an absence of multicollinearity (all VIF values were 1.66 or below, well below the commonly used threshold of five to indicate problematic levels of multicollinearity). In these models, ASQ_heavy and ASQ_total scores were calculated after excluding the blackout and/or passing out items, as relevant. Given that we conducted several regression analyses, a conservative alpha level of 0.01 was used for assessing significance of predictors to avoid improper inflation of type I error. Potential sex differences in the effects of alcohol sensitivity on blackout and passing out were examined by including an ASQ score by sex interaction term in models. When controlling for sex or testing for potential sex differences, analyses were restricted to self-reported cisgender participants in the sample (n = 922, 99.68%).

Finally, we examined whether ASQ scores moderated the relationship between typical past year consumption and occurrences of blackouts and passing out. We formally tested for moderation effects by including an interaction term between ASQ total scores and typical past year consumption. Significant interaction effects were explored by examining the predicted number of past year blackouts and/or passing out experiences as a function of ASQ scores and typical alcohol consumption. We also conducted secondary descriptive analyses examining the amount of alcohol consumed prior to the most recent blackout or passing out event reported by subgroups of participants with different ranges of ASQ scores.

RESULTS

On average, participants initiated drinking around age 16 (M = 16.06, SD = 1.48) and reported drinking alcohol two to three times a month in the past year. During a given drinking day, participants consumed between four and five drinks on average (M = 4.40, SD = 3.34). Over one-third reported experiencing a blackout in the past year (37.80%), and about one in five (20.93%) had passed out after drinking in the past year. Lower alcohol sensitivity was associated with substantially higher levels of alcohol consumption, higher AUDIT scores, and with greater numbers of alcohol-induced blackouts and passing out in the past year (see Table 1). Figure 1 presents unstandardized mean ASQ scale scores within the sample.

In this underage sample, the previously validated 2-factor structure of the ASQ fit significantly better than a 1-factor model ($\Delta\chi^2(1) = 645.86$, $p < 0.0001$). Fit for the 2-factor model was fair ($\chi^2(88) = 704.07$, CFI = 0.90, RMSEA = 0.09; see Figure 2), which was equivalent to the results obtained from the previous study of 21- to 34-year-old drinkers (Fleming et al., 2016). After excluding the blackout and passing out items, fit for the 2-factor structure remained fair ($\chi^2(63) = 606.71$, CFI = 0.90, RMSEA = 0.10). Scores on the two

TABLE 1 Sample demographics and drinking patterns

	Full sample	Association with ASQ scores		ASQ ≥+1 (low sens.)	ASQ ≤−1 (high sens.)
	% (*n*) or *M* (SD)	OR or *r*	*p*-value or CI	% (*n*) or *M* (SD)	% (*n*) or *M* (SD)
Age	18.28 (0.58)	0.06	0.09	18.34 (0.60)	18.21 (0.51)
Gender identity					
Male	33.41% (309)	ref	—	83.78% (62)	28.23% (35)
Female	66.27% (613)	**0.16**	**(0.12, 0.21)**	14.86% (11)	70.97% (88)
Other	0.32% (3)	*	*	*	*
Year in school					
Freshman	82.81% (766)	ref	—	81.08% (60)	85.48% (106)
Sophomore	14.59% (135)	0.92	(0.66, 1.28)	17.57% (13)	12.90% (16)
Junior	2.49% (23)	1.27	(0.60, 2.70)	1.35% (1)	1.61% (2)
Senior or above	0.11% (1)	*	*	0%	0%
Fraternity/sorority					
Current involvement	39.41% (361)	1.15	(0.90, 1.46)	50.68% (37)	33.06% (40)
No involvement	60.59% (555)	ref	—	49.32% (36)	66.94% (81)
Racial/ethnic background					
White	80.43% (744)	ref	—	82.43% (61)	79.03% (98)
Two or more races	9.08% (84)	0.82	(0.55, 1.22)	5.41% (4)	4.03% (5)
Black/African American	5.30% (49)	0.73	(0.41, 1.30)	1.35% (1)	10.48% (13)
Asian/Pacific Islander	2.59% (24)	0.87	(0.42, 1.82)	4.05% (3)	2.42% (3)
Hispanic/Latino	1.73% (16)	1.40	(0.58, 3.41)	4.05% (3)	3.23% (4)
Other	0.86% (8)	*	*	2.70% (2)	0.81% (1)
Alcohol use					
Age of first drink	16.06 (1.48)	**−0.23**	**<0.0001**	15 (1.78)	16.82 (1.31)
Lifetime max drinks	9.60 (8.39)	**0.61**	**<0.0001**	21.54 (11.95)	4.45 (4.36)
Drinking days (past year)	47.66 (60.44)	**0.39**	**<0.0001**	105.99 (93.23)	22.85 (36.38)
High-intensity drinking (past year)	50.66% (460)	**0.44**	**<0.0001**	95.83% (69)	14.78% (17)
AUDIT total score	6.59 (4.81)	**0.45**	**<0.0001**	12.01 (6.50)	3.68 (4.07)
Drinks per drinking day	4.40 (3.34)	**0.61**	**<0.0001**	9.44 (5.09)	2.46 (3.05)
Pass out (past year)	20.93% (190)	**0.27**	**<0.0001**	42.47% (31)	12.71% (15)
Blackout (past year)	37.8% (344)	**0.23**	**<0.0001**	61.11% (44)	15.25% (18)

Abbreviations: ASQ, alcohol sensitivity questionnaire; AUDIT, Alcohol Use Disorders Identification Test; CI, confidence interval; M, mean; OR, odds ratio; r, Pearson correlation; SD, standard deviation; sens, sensitivity.

*Indicates that association was not performed due to small sample size in category. Bold indicates a significant association with total ASQ scores.

ASQ subscales were highly correlated with one another ($r = 0.70$, $p < 0.0001$). Three alternate CFA model results are presented in the Supplementary Materials; these models were a 3-factor model separating the ASQ_light factor into positive and negative subscales, a 2-factor model excluding the "sleepy" and "sluggish" items from the ASQ_light factor, and a 2-factor model excluding the 2 poorest fitting items of the ASQ_light scale (impairments in driving and feeling buzzed). Modest improvements in fit were found for some alternative factor structures, but associations with blackout and passing out did not markedly differ. Therefore, results are presented here using the previously established ASQ scoring (Fleming et al., 2016).

In initial unadjusted models, higher total scores on the ASQ (i.e., overall low sensitivity to alcohol) were associated with higher
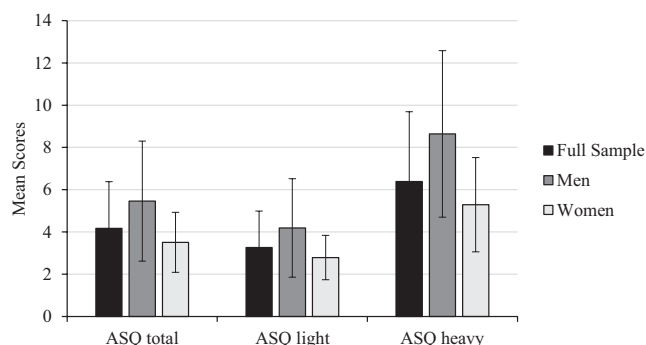

FIGURE 1 Mean unstandardized Alcohol Sensitivity Questionnaire scale scores. *Note*: Error bars represent standard deviation
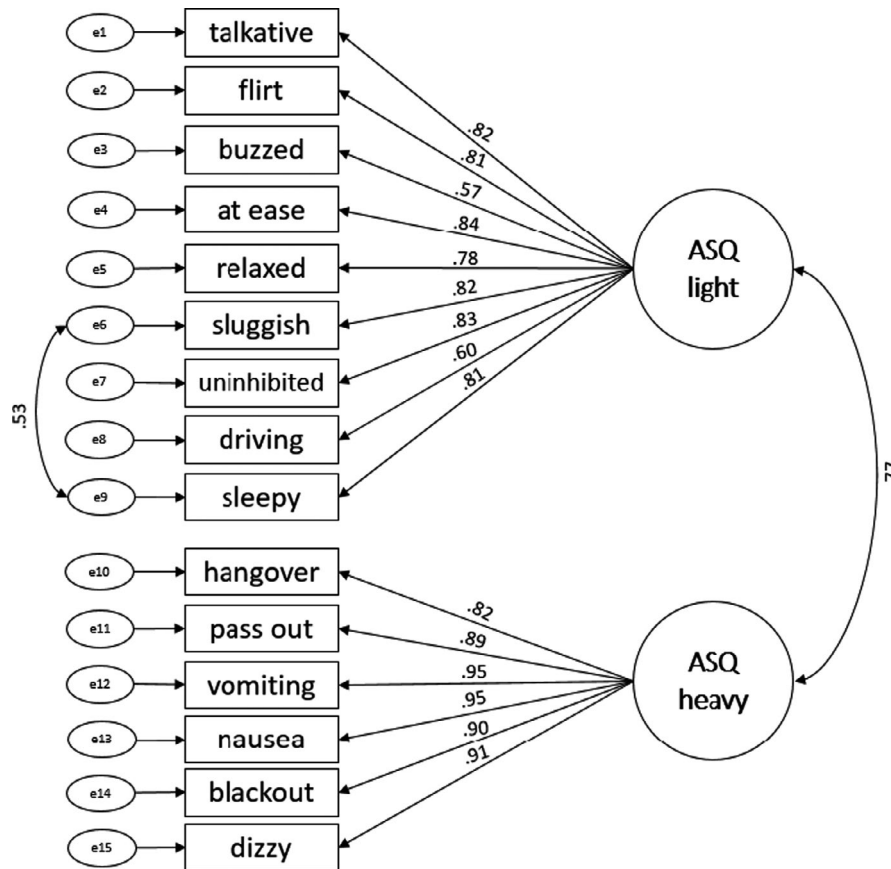
FIGURE 2 Replication of the 2-factor structure of the Alcohol Sensitivity Questionnaire via confirmatory factor analysis among underage drinkers. *Note*: The ASQ's 2-factor structure was originally evaluated in a sample of 21- to 34-year-old drinkers (Fleming et al., 2016). Fit of the replicated 2-factor structure within the current sample was fair (χ^2(88) = 704.07, CFI = 0.90, RMSEA = 0.09)

rates of past year blackouts (IRR = 1.68 [1.31–2.15]) and passing out (IRR = 2.25 [1.59–3.18]). Similar results were obtained in unadjusted analyses examining ASQ subscale scores (see Table 2). However, once typical consumption patterns and demographic characteristics were accounted for, the relationship between alcohol sensitivity and blackout rates reversed, such that at a given level of consumption, lower-sensitivity drinkers had *lower* rates of past year blackouts (IRR = 0.76 [0.60–0.98]). ASQ subscale scores were not significant predictors of blackout in fully adjusted analyses. Passing out did not exhibit the same pattern (IRR = 1.06 [0.72–1.57]); instead, higher ASQ_heavy scores (indicating lower sensitivity to high-dose alcohol effects) remained predictive of higher passing out rates (IRR = 1.46 [1.03–2.05]). In expanded models testing for possible sex differences, sex did not moderate the effects of total ASQ scores on blackout and passing out rates (blackout: interaction β = −0.26 [99% CI = −0.84 to 0.32]; passing out: interaction β = −0.40; 99% CI = −1.18 to 0.37).

A final set of analyses tested whether ASQ scores interacted with typical alcohol consumption in predicting blacking out or passing out. Total ASQ scores significantly moderated the association between typical past year alcohol consumption (quantity) and blackout rates (interaction IRR = 0.96 [0.93–0.98]; see Figure 3), but not rates of passing out (interaction IRR = 0.95 [0.89–1.01]). To further characterize

associations among alcohol sensitivity, consumption patterns, and consequences, we compared the number of drinks reported after the most recent blackout or passing out event across extreme groups formed by setting cut scores on Total ASQ score. Among those with higher overall sensitivity (−1 SD or more from mean Total ASQ score), blacking out and passing out tended to occur after 10 to 12 drinks, while for those with lower sensitivity (+1 SD from mean ASQ score), approximately 18 drinks were consumed during drinking episodes resulting in blackout and passing out (see Figure 4). These differences in consumption patterns were statistically significant (blackout: t(59) = 4.58, p < 0.0001; passing out: t(46) = 3.93, p = 0.0003).

DISCUSSION

The purpose of the current study was two-fold: (1) to examine associations between alcohol sensitivity and the experience of blacking out and passing out, both of which put drinkers at serious risk of harm (Hingson et al., 2016; McCauley et al., 2009; Mundt et al., 2012; Valenstein-Mah et al., 2015) and (2) to attempt to replicate the factor structure of the ASQ in a sample of underage, college student drinkers. Based on previous research on the role of alcohol sensitivity in other adverse consequences of acute heavy alcohol use,

TABLE 2 Results of negative binomial regression models predicting the number of past year blackout and passing out experiences among 925 underage drinkers

	Base model		Fully adjusted model	
	IRR (99% CI)		IRR (99% CI)	
	Blackout	**Passing out**	**Blackout**	**Passing out**
ASQ total	**1.68 (1.31–2.15)**	**2.25 (1.59–3.18)**	**0.76 (0.60–0.98)**	1.06 (0.72–1.57)
Sex (F = 1, M = 2)	—	—	0.82 (0.53–1.27)	1.42 (0.74–2.71)
Weight	—	—	0.99 (0.99–1.00)	0.99 (0.98–1.00)
Greek status	—	—	1.22 (0.90–1.66)	**1.99 (1.25–3.17)**
Typical consumption	—	—	**4.48 (3.22–6.03)**	**3.15 (2.08–4.76)**
Age of first drink	—	—	0.93 (0.83–1.05)	0.97 (0.81–1.15)
ASQ heavy	**1.61 (1.31–1.98)**	**2.01 (1.50–2.64)**	0.90 (0.71–1.14)	**1.46 (1.03–2.05)**
Sex (F = 1, M = 2)	—	—	0.77 (0.49–1.20)	1.19 (0.62–2.29)
Weight	—	—	0.99 (0.99–1.00)	0.99 (0.98–1.00)
Greek status	—	—	1.10 (0.81–1.50)	**2.07 (1.29–3.33)**
Typical consumption	—	—	**3.94 (2.87–5.43)**	**2.48 (1.66–3.70)**
Age of first drink	—	—	0.94 (0.84–1.06)	1.03 (0.87–1.23)
ASQ light	**1.58 (1.24–2.01)**	**1.98 (1.41–2.79)**	0.81 (0.64–1.02)	0.95 (0.67–1.35)
Sex (F = 1, M = 2)	—	—	0.80 (0.52–1.23)	1.50 (0.79–2.84)
Weight	—	—	0.99 (0.99–1.00)	0.99 (0.98–1.00)
Greek status	—	—	1.23 (0.91–1.68)	**1.96 (1.24–3.11)**
Typical consumption	—	—	**4.31 (3.22–5.77)**	**3.34 (2.22–5.01)**
Age of first drink	—	—	0.94 (0.84–1.05)	0.96 (0.81–1.14)

Abbreviations: CI, confidence interval; F, female; IRR, incidence rate ratio; M, male.
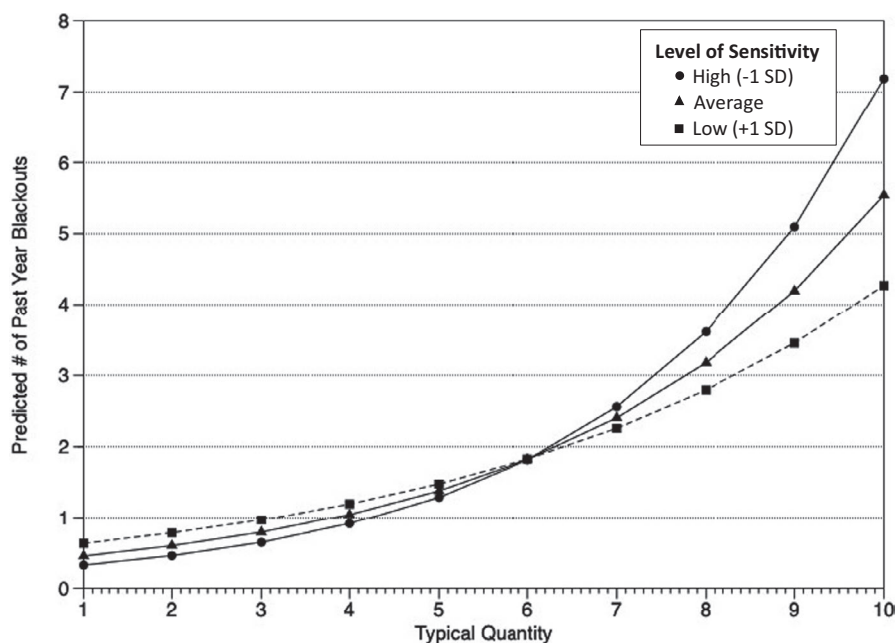

FIGURE 3 Predicted number of past year blackouts as a function of participants' level of alcohol sensitivity and typical quantity of consumption. *Note*: Level of sensitivity is based on total ASQ scores (excluding the blackout item)

including hangover (Piasecki et al., 2012) and regretted sex (Hone et al., 2017), we predicted that lower sensitivity would be associated with increased likelihood of experiencing past year blackouts and passing out, but that the likelihood of these consequences would be reduced at a given level of consumption for lower-relative to higher-sensitivity drinkers. These hypotheses were largely borne out, though the predicted protective effect of lower sensitivity at a given level of consumption was limited to blackouts.
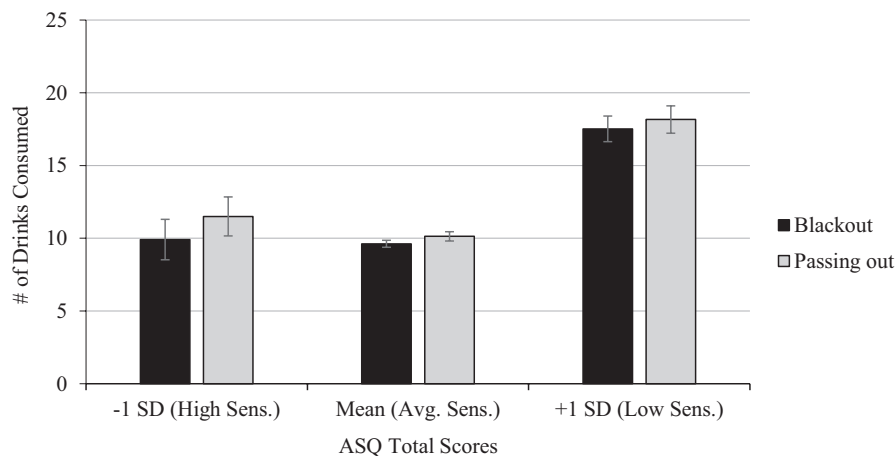
FIGURE 4 Average number of drinks consumed prior to participants' last blackout or passing out experience across levels of alcohol sensitivity as measured by the Alcohol Sensitivity Questionnaire. *Note*: Error bars represent standard deviations. Sens. = sensitivity, Avg. = average

The ASQ's 2-factor structure showed a similar degree of fit within this underage sample as within the previous sample of 21- to 34-year-old drinkers (Fleming et al., 2016). However, both the current and previous studies yielded only a model of fair or marginal fit, failing to find a good fitting model for the ASQ (e.g., CFI ≥ 0.95, RMSEA ≤ 0.06; Hu & Bentler, 1999). This finding suggests that the ASQ would benefit from additional measurement development work, which currently is in progress. It is interesting to note that, of the alternate CFA models conducted on the ASQ (see Supplemental Materials), the best fitting one separated the low-dose effects (ASQ_light scale) into those with generally positive versus negative connotations. Using this alternate structure, we found that having greater sensitivity to positive, low-dose effects at a given level of alcohol consumption were associated with increased frequency of blackout, while sensitivity to negative, low-dose effects were not related to blackout frequency (see Table S1); this exploratory finding and the observed improvements in model fit suggest potential utility in separating these low-dose effects by valence in the future.

As predicted, general levels of alcohol sensitivity, as measured by the ASQ, were associated with blackouts and passing out. In unadjusted models, higher total ASQ scores (i.e., lower overall levels of alcohol sensitivity) were associated with more past year blackout and passing out experiences. Similar results were obtained for the 2 ASQ subscales, which were highly correlated (r = 0.70). Once consumption was accounted for, there were differential effects of alcohol sensitivity on blackout and passing out experiences, in that lower alcohol sensitivity was associated with a *decreased* risk for blacking out. This finding aligns with previous research on 21st birthday drinking and blackouts, which found that experiencing more intense alcohol effects during a night of drinking (i.e., being higher in sensitivity to alcohol) was associated with a greater likelihood of experiencing a blackout (Wetherill & Fromme, 2009).

The effects for alcohol sensitivity were reversed (for blackout) or significantly attenuated (by ~25% for passing out) once typical

alcohol consumption level was covaried. Although this attenuation may be at least partially explained by acquired tolerance (i.e., heavier drinking leading to lower sensitivity), it may also be explained by innate differences in alcohol sensitivity directly contributing to inter-individual variability in consumption (i.e., lower sensitivity leading to more drinking). Therefore, typical drinking might be conceived of as an intermediate variable in the causal chain between sensitivity levels and drinking-related consequences, rather than as a confounding variable. Low-sensitivity drinkers are at higher risk for acute consequences because they are prone to drinking heavily (Table 1), providing more opportunities to experience those consequences. But, if low-sensitivity drinkers are compared with higher-sensitivity peers at the same level of exposure, low-sensitivity drinkers are afforded some protection.

Compared to higher-sensitivity drinkers, individuals lower in overall alcohol sensitivity reported consuming approximately seven or eight more drinks prior to their last blackout or passing out experience. In formal testing, alcohol sensitivity moderated the association between typical past year consumption and the experience of a blackout: While lower-sensitivity drinkers were more likely to experience blackouts, they were less likely than higher-sensitivity drinkers to experience a blackout at a given level of consumption. Therefore, low sensitivity to alcohol's effects acted as a paradoxical risk factor for blackouts, contributing to higher levels of alcohol consumption and more frequent blackouts, but also potentially protecting drinkers from experiencing adverse acute consequences in specific instances.

It is possible that, compared to their more sensitive peers, lower-sensitivity drinkers may be more likely to experience *any* consequence of drinking despite tending to be *less vulnerable* to consequences at a given level of exposure. This pattern has been observed in prior research on hangover (Piasecki, et al., 2012) and sexual experiences later regretted (Hone, et al., 2017). In the current study, comparable effects were not observed in the prediction of passing out. Lacking assessments of additional consequences, we were not

able to comprehensively evaluate the form of sensitivity effects across outcomes. Further research is needed to determine whether distinct alcohol consequences show divergent relations with alcohol sensitivity.

Given the often social nature of alcohol use, higher-sensitivity drinkers may feel pressure to keep up with their lower-sensitivity counterparts who are able to drink more alcohol without experiencing unpleasant effects. Research consistently finds evidence for this kind of social imitation of drinking (Larsen et al., 2009, 2010) and for deliberate induction of tolerance by emerging adults (Haeny et al., 2017; Martinez et al., 2010). Furthermore, research on the relationship between peer drinking and popularity has shown that young adults (particularly men) who conform to their peer group's consumption patterns tend to experience benefits to their popularity within the social group (Balsa et al., 2011). High-sensitivity drinkers who are unable to resist the pressure to conform their alcohol use to their peers may experience more consequences than less-sensitive drinkers who are consuming the same amount. Interventions to reduce alcohol-related harms among young adults may derive additional benefit from assessing sensitivity and providing personalized feedback to increase awareness of the effects of individual differences in alcohol sensitivity on the experience of consequences (Savage et al., 2015). For high-sensitivity drinkers, interventions may include promoting the use of drink refusal skills and protective behavioral strategies. For low-sensitivity drinkers who may not experience as many warning signs of heavy intoxication, mindful awareness while drinking may help promote more responsible consumption and reduce consequences.

Limitations

The current study suffered from four main limitations. First, the reports of blackout and passing out were obtained retrospectively, as were reports of the number of drinks consumed prior to participants' most recent blackout and pass out events. Given that both blackout and passing out are characterized by failure to maintain conscious awareness, it is likely that these reports contain some degree of imprecision. Nevertheless, participants' estimates of the number of drinks they could consume without blacking out ($M = 8.30$) were highly consistent with findings from other studies in the literature that have assessed the number of drinks consumed prior to blackouts, including event-level data (Mallett et al., 2006; Merrill et al., 2019). We know of no comparable event-level data for passing out. More research is needed using prospective reporting at the event level to examine the association between sensitivity and the experience of alcohol-related consequences. Research in this domain has already established the importance of alcohol sensitivity for craving reactivity in daily life (Trela et al., 2018) and for pace of consumption (Trela et al., 2016), a risk factor associated with blackout occurrence (Goodwin et al., 1969; Ryback, 1970).

Retrospective recall is also inherent in the ASQ, which asks participants to estimate the maximum number of drinks they can consume without blacking out or passing out based on prior drinking experiences. Error in these estimates could have affected the factor analyses, but not the prediction of consequences because these items were omitted from the ASQ composite scores used in regression models. With respect to the validity of the ASQ, the accuracy in estimating maximum numbers of drinks that can be consumed prior to blacking or passing out is less important than relative differences across participants in their estimated numbers of drinks. Thus, as long as any estimation bias was generally similar across individuals, ASQ scores will be unaffected by systematic error (rather, bias would contribute more-or-less equally to error terms across individuals).

A second limitation was that no definition of passing out was provided for participants, in part because currently there is no standard definition of alcohol-induced passing out available in the literature. For example, passing out has been defined for participants as falling asleep after drinking (as it is in the TWEAK, a measure of alcohol-related risk in pregnancy; Russell, 1994), or as falling asleep *without intending to* after drinking (as in the SRE). In the Health and Social Support (Korkeila et al., 2001) and Finnish Public Sector (Kivimäki et al., 2007) studies, passing out was defined as losing consciousness due to heavy alcohol consumption (Kivimäki et al., 2020), which likely sounds more severe to participants than the former two definitions. The lack of an explicit definition for passing out in the current study, similar to some other commonly used consequences instruments (Read et al., 2006), likely introduced uncertainty regarding participants' understanding of the construct, such that some participants may have considered times they simply fell asleep after drinking while others considered a more severe definition of passing out. Imprecise assessment could be one explanation for why the pattern of findings differed for passing out relative to blacking out. Because of these varying conceptualizations, a standard definition of passing out is needed to aid future research on the topic.

Third, the current study examined sensitivity as a moderator of the association between *typical* consumption and consequences, but future studies would benefit from examining event-level measures of consumption, as was done by Piasecki et al. (2012) in relation to hangover. Nonetheless, we were able to examine effects of differences in general levels of alcohol sensitivity at the event-level based on participants' retrospective reporting of consumption during a prior drinking episode resulting in blackout/passing out.

Finally, the modest fit of the 2-factor model suggests the ASQ could be further refined. In its current form, the ASQ confounds response type (i.e., minimum drinks needed to experience vs. maximum drinks without effect) and type of alcohol response. Future work should investigate whether harmonizing response types improves model fit. The scale could also be expanded to assess more types of alcohol responses. This might allow better differentiation of subscales and improve alignment of the instrument with the kinds of subjective response domains assessed in alcohol challenge work. Fleming et al. (2016) found that ASQ scores were robustly associated with reports of stimulation and sedation during alcohol challenge. Model-fit comparisons indicated a strong preference for ASQ-Heavy subscale as the best predictor

of laboratory-rated sedation and the ASQ-Light subscale as the best predictor of stimulation. This differential prediction provides some support for the current factor structure. Notably, though, the *direction* of the associations differed in the two analyses. ASQ scores and laboratory ratings were consistent in analysis of sedation—drinkers who reported a lower sensitivity to high-dose effects on the ASQ showed corresponding diminished sedation responses under alcohol. In contrast, drinkers who reported low sensitivity to ASQ low-dose effects displayed relatively *enhanced* stimulation after alcohol consumption. One possible explanation for this discrepancy is that the ASQ measures drinkers *perceived* sensitivity to alcohol effects and that these perceptions may not be especially accurate for low-dose effects, perhaps being biased by degree of response to higher-dose experiences. Another possibility is that the ASQ does not have sufficient coverage of the stimulation domain. Expanding assessment of stimulating effects would allow investigation of these issues and could clarify how the low sensitivity construct assessed by the ASQ articulates other lines of theory and evidence concerning individual difference in subjective alcohol response and risk for AUD (e.g., King et al., 2011, 2014; Newlin & Thomson, 1990).

Future research might also leverage alternative assessment tools to investigate whether differential patterns of sensitivity to specific classes of alcohol effects may be related to consequences. For example, the Anticipated Effects of Alcohol Scale queries 22 alcohol effects that encompass stimulating/sedating effects as well as positive/negative valence effects and asks respondents to imagine how they would feel after a binge drinking episode (Morean et al., 2012). Another measure, the Anticipated Biphasic Alcohol Effects Scale (Earleywine & Martin, 1993; Fridberg et al., 2017) asks respondents to imagine the extent to which they would feel a variety of effects immediately after consuming four drinks within 1 hour. It would be worthwhile in the future to revisit associations between blackout, passing out, and alcohol response using these scales, though both may have issues capturing more severe effects of alcohol, such as blacking out and passing out, which tend to require heavier drinking than is assessed by either measure at present.

The ASQ has two other benefits over these alternative measures as they currently stand. First, the ASQ assesses effects only in those who have experienced them, which should increase the reliability of participants' reports compared with guessing about experiences one has never had. Second, the ASQ's responses are scaled in terms of the number of drinks needed to experience an effect, rather than the intensity of an effect after a set number of drinks. This is a more objective assessment of response to alcohol than is provided by a rating scale, which can be interpreted differently by each person (although estimating numbers of "drinks" is itself somewhat ambiguous, given the differing %ABV across drink types and differences in subjective experiences associated with different drink types; e.g., Smart, 1996; Pedersen et al., 2010). Regardless, there are several issues of concern across the current self-report measures of alcohol sensitivity (including the ASQ), and additional measurement development work is needed.

CONCLUSIONS AND FUTURE DIRECTIONS

These findings are consistent with prior work suggesting that low sensitivity may act as a paradoxical risk factor, contributing to higher levels of alcohol consumption and overall risk while simultaneously conferring protection (relative to high-sensitivity peers) from some consequences that may accompany heavy drinking events at a given level of alcohol exposure. Future research might evaluate whether a similar pattern exists for other severe consequences, such as legal problems and alcohol-related injuries, and for milder consequences of alcohol use. The fact that alcohol-induced passing out did not show this pattern may suggest some degree of specificity for this pattern, but it is also possible that this was due, in part, to the lack of a clear definition of this consequence. Regardless, further work examining this question among a broader array of alcohol consequences and effects is needed before drawing conclusions on the generality or specificity of this pattern.

In future work, reliance on participant recall in studies of blackout and passing out might be minimized by using: (a) daily diary studies, (b) transdermal ethanol monitoring that could capture objective estimates of alcohol exposures during consequence-producing drinking bouts, or (c) combining in-lab alcohol challenge (to objectively determine levels of alcohol sensitivity) with diary studies and transdermal alcohol monitoring to assess blackouts, passing out, and other consequences. In addition, it will be important to determine whether the current study's findings are applicable to other age groups and to emerging adults not enrolled in college.

CONFLICT OF INTEREST
The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.