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Anxiety, Sedation, and Simulated Driving in Binge Drinkers

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Abstract

The current study evaluated the relationships among trait anxiety, subjective response to alcohol, and simulated driving following a simulated alcohol binge. Sixty drinkers with a binge history completed the State Trait Anxiety Inventory (STAI), the Alcohol Use Questionnaire, and subsequently completed a driving simulation. Participants were then administered 0.2 g/kg ethanol at 30 minute intervals (cumulative dose 0.8 g/kg). Following alcohol consumption, the Biphasic Alcohol Effects Scale (BAES) and visual analog scales of subjective impairment and driving confidence were administered, after which simulated driving was re-assessed. Due to the emphasis on simulated driving after drinking in the current study, subjective response to alcohol (i.e., self-reported sedation, stimulation, impairment, and confidence in driving ability) was assessed once following alcohol consumption, as this is the time when drinkers tend to make decisions regarding legal driving ability. Alcohol increased driving speed, speeding tickets, and collisions. Sedation following alcohol predicted increased subjective impairment and decreased driving confidence. Subjective impairment was not predicted by sensitivity to stimulation or trait anxiety. High trait anxiety predicted low driving confidence after drinking and this relationship was mediated by sedation. Increased speed after alcohol was predicted by sedation, but not by trait anxiety or stimulation. Anxiety, combined with the sedating effects of alcohol, may indicate when consumption should cease. However, once driving is initiated, sensitivity to sedation following alcohol consumption is positively related to simulated driving speed.

Keywords

alcohol drinking; simulated driving; anxiety; biphase alcohol effects

Alcohol is one of the most extensively abused drugs in the United States. Nearly ten percent of Americans meet DSM-IV criteria for alcohol abuse or dependence (Grant et al., 2004).

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Conflict of Interest

No conflicts of interest are reported.

High levels of trait anxiety increase risk for problematic alcohol use (Poikolainen, 2000), and studies have consistently reported comorbidity between anxiety disorders and alcohol dependence (Helzer & Pryzbeck, 1988; Kushner, Sher, & Beitman, 1990; Winokur & Holemon, 1963; Woodruff, Guze, & Clayton, 1972). Trait anxiety is also positively related to alcohol craving (McCusker & Brown, 1991), the prediction of future alcohol dependence (Heath et al., 1997), and the tendency to engage in risky driving behaviors (Shahar, 2009). In a study of drivers with low, medium, or high levels of anxiety, high-anxious individuals caused more motor vehicle accidents and reported significantly more episodes of driving while intoxicated than their low- and medium-anxious counterparts (Shahar, 2009). Thus, anxiety and binge alcohol consumption may interact to facilitate negative alterations in driving performance. However, the impact of trait anxiety on driving behavior while under the influence of alcohol has not been widely researched. Because consumption of alcohol often results in self-reported sedation, decisions regarding driving may be influenced unpredictably. Some investigators have proposed that sensitivity to the sedating effects of alcohol may be protective (King, de Wit, McNamara, & Cao, 2011), or may discourage driving while under the influence (Marczinski, Harrison, & Fillmore, 2008), although these hypotheses have not been directly investigated.

Response to the effects of alcohol can change over the course of a drinking episode as blood alcohol concentration (BAC) rises and declines. Alterations in alcohol response may impact confidence in driving ability, as well as actual driving performance. Participants report experiencing the effects of alcohol biphasically, such that stimulation is experienced on the ascending limb of the blood alcohol curve, and subsequent sedation is reported while BAC is descending (Martin, Earleywine, Musty, Perrine, & Swift, 1993). The stimulating effects of alcohol are considered to be positive and often prompt further consumption (Corbin, Gearhardt, & Fromme, 2008). Alcohol's sedative effects, however, are often considered to be negative (Morean & Corbin, 2010), though may facilitate the ability to cease consumption. Individual differences in the biphasic response to alcohol consumption may be related to variations the level of alcohol use. Compared to non-bingers, binge drinkers are less sensitive to the sedating effects of alcohol (Ray, MacKillop, Leventhal, & Hutchison, 2009; Rose & Grunsell, 2008). Past research suggests that decreased response to the sedating effects of alcohol are associated with insensitivity to interoceptive cues to cease drinking, ultimately resulting in excessive consumption (Schuckit, 1994). Such repeated episodes of excessive consumption in drinkers with a dampened response to the biphasic effects of alcohol often lead to the development of alcoholism (Schuckit, 1994).

In contrast to diminished response to the sedating effects of alcohol, heavy drinkers report a heightened response to the stimulating effects associated with the ascending limb (Holdstock, King, & de Wit, 2000; King, Houle, de Wit, Holdstock, & Schuster, 2002). Increased stimulation following alcohol consumption predicts subsequent binge drinking, and is likely characteristic of drinkers at risk for escalation of heavy consumption over time (King et al., 2011). Because binge drinkers experience increased stimulation following alcohol consumption, while subsequent sedation is muted during the descending limb, these drinkers may exhibit elevated confidence in driving, and may be more willing to drive despite intoxication (Marczinski et al., 2008). Consequently, these individuals likely lack

internal cues to cease consumption at a normative level, and thus may be at risk for driving under the influence.

Biphasic response to alcohol varies depending on several factors including history of binge drinking (King et al., 2011) and alcohol tolerance (Holdstock et al., 2000). Due to enhanced perception of internal cues and sensations, experience of sedation and stimulation may be amplified in drinkers with higher anxiety compared to those with low anxiety. Additionally, while some researchers have investigated the impact of anxiety on driving ability (Dula, Adams, Miesner, & Leonard, 2010; Shahar, 2009), these studies have not delved into potential mediating factors that may influence the relationship between trait anxiety and confidence in driving ability. Sedation after alcohol consumption is common in situations which may produce state anxiety (Levenson, Sher, Grossman, Newman, & Newlin, 1980), thus drinkers with higher levels of trait anxiety likely experience heightened sedation after drinking as well. Söderpalm and de Wit (2002) examined the interactive effects of stress and alcohol consumption on mood and found that nondependent subjects reported stimulation after experiencing stress while sober, but reported enhanced sedation when stress was combined with alcohol. Some drinkers consume alcohol when they anticipate stress or feel depressed, therefore it is likely that such drinkers place importance on the stress-relieving properties of drinking, and endorse alcohol-induced sedation (Wilkie & Stewart, 2005). Sedation is generally experienced on the descending limb of the blood alcohol curve, primarily during the time when decisions are made regarding legal driving ability (Weafer & Fillmore, 2012). Enhanced sedation after drinking may facilitate safer decisions regarding driving by allowing more accurate appraisal of driving ability (Marczinski et al., 2008). Drinkers with relatively high anxiety may be more likely to experience elevated sedation following alcohol consumption, thus anxiety and sedation may be protective as they influence personal attitudes and perceived consequences from engaging in dangerous behaviors.

Trait anxiety is related to driving performance and likely plays a role in self-reported driving confidence after alcohol consumption as well. Furthermore, while sedation after alcohol is associated with both trait anxiety and driving confidence, the mediating influence of sedation on the relationship between anxiety and confidence in driving ability has not yet been investigated. One goal of this study was to examine the relationship between trait anxiety and sedation after alcohol, and in turn evaluate the impact of this relationship on simulated driving performance and confidence in driving in binge drinkers. Self-reported stimulation following alcohol consumption was assessed as well, as sensitivity to stimulation can greatly impact driving confidence. While sensitivity to stimulation has not traditionally been measured on the descending limb in previous research, the current study sought to investigate whether persisting feelings of stimulation following cessation of drinking were related to subjective impairment or driving confidence. The National Institute of Alcohol Abuse and Alcoholism (NIAAA) defines a binge as consumption of four drinks (females) or five drinks (males) within a two-hour period, along with the intention to reach 0.08%, or the legal limit for driving in the United States (2004). To model the NIAAA definition, the current study employed a simulated alcohol binge consisting of four 0.2 g/kg beverages at 30-minute intervals over a two-hour period for a total dose of 0.8 g/kg. The behavioral measure of driving used in the current study has been shown to be sensitive to

this alcohol dose and administration paradigm (Bernosky-Smith, Shannon, Roth, & Liguori, 2011). This study tested three primary hypotheses concerning the relationships among trait anxiety, subjective response to alcohol, and simulated driving. First, it was predicted that subjective impairment would be positively associated with sedation and trait anxiety, and negatively associated with stimulation. Second, it was hypothesized that confidence in driving following alcohol consumption would be negatively predicted by trait anxiety, and that this relationship would be mediated by sedation. Confidence in driving, however, would be positively predicted by subjective stimulation. Third, it was hypothesized that simulated driving speed after alcohol would be negatively predicted by sedation and positively predicted by trait anxiety and stimulation.

Method

Participants

Sixty healthy adults (40 males, 20 females) between 21 and 45 years of age were recruited from the Winston-Salem community via television advertisements and internet postings for a study investigating the behavioral effects of multiple alcohol drinks in a short time. The mean ($\pm$ SD) age of the current sample was 26 ± 6 years. This sample included eight African Americans, one Hispanic, and 51 Caucasians. Participants consumed a mean ($\pm$ SD) of 12 ± 9 drinks per week (range = 2 – 39). Normative moderate drinking is defined by the United States Department of Agriculture and Department of Health and Human Services as consumption of one drink per day for females and two drinks per day for males (2010). Heavy consumption, however, is consuming an excess of two drinks per day for males, and exceeding one drink per day for females (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010). Thus, 45% of the participants recruited for the current study would be considered heavy drinkers. An initial interview was conducted over the telephone to assess medical history, illicit drug use, and current drinking habits. Eligible participants were required to report at least one binge episode in the past three months. A binge episode was classified as four (females) or five (males) drinks consumed within a two hour period (National Institute of Alcohol Abuse and Alcoholism, 2004). Potential participants attended the laboratory for a screening visit. All participants gave informed consent prior to study commencement. Participants were administered the modified Structured Clinical Interview for DSM-IV Disorders (First, Spitzer, Gibbon, & Williams, 2002), Wechsler Abbreviated Scale for Intelligence (Wechsler, 1999), Alcohol Use Disorders Identification Test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001), Alcohol Use Questionnaire (Mehrabian & Russell, 1978), and the Spielberger State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970). A urine sample was collected to test for the presence of illicit drugs (Multi-drug 6 line urine screen; Innovacon, Inc., San Diego, CA) and for pregnancy in females (QuickVue; Quidel, San Diego, CA).

Participants were included in the study if they had an AUDIT score ≥ 12 , did not meet criteria for any Axis-I disorder within the last six months, did not have an IQ below 80, and reported no psychoactive medication use within the last six months. All procedures were approved by the Institutional Review Board of Wake Forest University School of Medicine.

All participants were financially compensated for their time. Data on the relationship between the subjective effects of alcohol and impulsive behavior have been published from a subset of the participants included in the current study (Shannon, Staniforth, McNamara, Bernosky-Smith, & Liguori, 2011).

Study Design

Participants who met inclusion criteria attended the laboratory a second time for alcohol administration. Upon arrival, a urine sample was collected and tested for the presence of illicit drugs and for pregnancy in females. Additionally, an expired air sample was collected and tested to confirm the absence of alcohol (Intoxilyzer SD-5; CMI Inc., Owensboro, KY). Participants completed a simulated driving task (*STISIM Drive*TM; Systems Technology, Inc., Hawthorne, CA), after which alcohol administration commenced. Immediately following alcohol administration, participants completed the driving simulator once more, in addition to the Biphasic Alcohol Effects Scale (BAES; Martin, Earleywine, Musty, Perrine, & Swift, 1993). Participants were paid \$115 upon study completion.

Alcohol Administration

Alcohol administration was designed to simulate an alcohol binge according to the definition proposed by NIAAA (2004). Participants consumed four 0.2 g/kg 95% alcohol drinks, each with tonic water vehicle (946 ml total volume) over a two-hour period. Alcohol content was reduced by 8% for females to equate breath alcohol across sex (Hindmarch, Kerr, & Sherwood, 1991). The two-hour period contained four 30-minute segments comprised of 10 minutes for drinking followed by 20 minutes for absorption. Breath alcohol readings were taken every 20 minutes following the consumption period until BrAC descended to 0.03% or less. After completing a field sobriety test incorporating finger-to-nose, heel-to-toe walking, and alphabet recitation, participants were permitted to leave the laboratory with a designated driver.

Self-Report Measures

Biphasic effects of alcohol and subjective response to alcohol were measured 50 minutes following completion of the simulated alcohol binge session. Self-report data were collected on the descending limb as this is when decisions regarding driving ability frequently occur.

Biphasic Effects of Alcohol—Self-reported stimulation/sedation following alcohol consumption was measured via the Biphasic Alcohol Effects Scale (Martin et al., 1993), a visual analog scale (VAS) comprising 14 descriptors of subjective feelings. Seven of the descriptors are associated with the stimulant-like effects of alcohol (*talkative, up, elated, stimulated, vigorous, excited, and energized*), and the other seven are related to sedative-like effects (*heavy head, sedated, slow thoughts, down, inactive, sluggish, and difficulty concentrating*). Each descriptor is rated by placing a mark along a 100-mm line anchored at the ends with the statements “not at all” or “extremely”. Scores were calculated as the distance in millimeters from the left of the line to the intersecting line marked by the participant. Total stimulation and sedation scores were determined by adding all respective descriptor ratings.

Subjective Response to Alcohol—Two VAS items were employed to assess participants' subjective response to alcohol consumption. Subjective impairment was measured by participants' response to a VAS that stated "*I feel impaired*". Confidence in driving was measured by participants' response to a VAS that stated "*I am confident in operating a vehicle*".

Simulated Driving

The *STISIM Drive*TM (*Systems Technology, Inc., Hawthorne, CA*) is a personal computer-based interactive driving simulator designed to represent a range of psychomotor, divided attention, and cognitive tasks involved in a rushed commute. Participants were instructed to start the car and drive through the course, while maintaining all posted speed limits. Various locations throughout the course were established as random speed traps. Any participant driving more than 9 miles above the speed limit heard a siren when they passed the designated speed traps, and each siren resulted in one speeding ticket. Participants who completed the nine-mile task in 16.5 minutes or less with no penalties earned a \$20 bonus. Participants were penalized \$2 from this bonus for each off-road accident, collision, pedestrian hit, speeding ticket, traffic light ticket, failure to heed posted signs, centerline crossing, and road edge excursion. Any participant with ten or more penalties did not receive a bonus but lost no additional compensation (Bernosky-Smith, Aston, & Liguori, 2012; Bernosky-Smith et al., 2011). Simulated driving was completed 60 minutes following alcohol administration.

Data Analyses

Independent samples *t* tests were used to analyze potential sex differences in BrAC. Multiple student *t* tests were used to compare measures of driving pre- and post-alcohol administration. To minimize the number of tests (and potential for Type I errors), while allowing for identification of specific behavioral impairments, the two most frequently occurring simulated driving errors across all subjects were selected for analyses. Pearson correlations quantified relationships among trait anxiety (STAI), subjective effects of alcohol (BAES Stimulation, Sedation, subjective impairment, and confidence in driving), and simulated driving (change in mean speed post- minus pre-alcohol consumption). Three multiple regression models were used to examine the influence of trait anxiety (STAI), Sedation (BAES Sedated Total), and Stimulation (BAES Stimulated Total) on the subjective effects of alcohol (subjective impairment and confidence in driving) and simulated driving (change in mean speed post- minus pre-alcohol consumption). Secondary analyses were conducted to examine the impact of trait anxiety (STAI) on Sedation (BAES Sedated Total) and Stimulation (BAES Stimulated Total) via two additional linear regression models. Post-hoc analyses were conducted to determine if BAES Sedation mediated the relationship between STAI and confidence in driving. Mediation analyses were conducted following confirmation that the independent variable (STAI), potential mediator (BAES Sedation), and dependent variable (confidence in driving) were significantly correlated with one another. Three linear regression analyses were performed to test each mediation effect (a. independent variable and dependent variable; b. independent variable and mediator; c. mediator and dependent variable). Following verification of significant relationships for all three regressions, a multiple linear regression was performed with confidence in driving as

the dependent variable, and STAI and BAES Sedation as independent variables (Baron & Kenny, 1986). The relationship between the mediator (BAES Sedation) and the dependent variable (confidence in driving) remained significant after controlling for the independent variable (STAI) which no longer significantly contributed to the dependent variable (confidence in driving). Consequently, Baron and Kenny's criteria for full mediation effect were supported, and the Sobel test of mediation was conducted to determine the significance the full mediation effect (Sobel, 1982). Data analyses were conducted using SigmaPlot software (Systat Software, Inc., San Jose, CA). Regression models were analyzed using IBM SPSS Statistics 22. Statistical significance was defined as $\alpha < 0.05$.

Results

Mean ($\pm$ SD) BrAC level immediately prior to testing (40 minutes post-binge) was 0.081% (0.021%). There were no significant sex differences in mean BrAC level. Post-binge BrAC is reported in Figure 1. The mean ($\pm$ SD) STAI score in the present sample was 31 ($\pm$ 6; range = 20 – 51).

Simulated Driving

Alcohol significantly increased mean ($\pm$ SD) simulated driving speed (pre: 33.0 ± 1.6 mph; post: 33.5 ± 1.2 mph; $p=0.015$). The two most commonly penalized errors post-alcohol administration were speeding tickets (35% of errors) and collisions (31%). Alcohol significantly increased mean ($\pm$ SD) collisions (pre: 1.2 ± 1.3 ; post: 2.0 ± 1.8 ; $p=0.002$) and speeding tickets (pre: 1.7 ± 1.6 ; post: 2.2 ± 1.6 ; $p=0.05$). Twenty-nine of the 60 participants in this sample received a bonus for driving simulator performance. Of the participants who received a bonus, the mean ($\pm$ SD) bonus earned was \$10.76 ($\pm$ \$4.09).

Correlational Relationships Among Study Variables

Intercorrelations among trait anxiety (STAI), subjective effects of alcohol (BAES Stimulation, Sedation, subjective impairment, and confidence in driving), and simulated driving (change in mean speed post- minus pre-alcohol consumption) are presented in Table 1. STAI was positively correlated with Sedation ($p<0.001$) and negatively correlated with confidence in driving ($p<0.05$). There were no significant correlations between STAI and measures of BAES Stimulation, subjective impairment, or change in mean simulated driving speed. BAES Stimulation was positively correlated with confidence in driving ($p<0.05$). There were no significant correlations between BAES Stimulation and measures of BAES Sedation, subjective impairment, or change in mean simulated driving speed. BAES Sedation was positively correlated with subjective impairment ($p<0.001$), confidence in driving ($p<0.001$), and change in mean simulated driving speed ($p<0.01$). Subjective impairment was negatively correlated with confidence in driving ($p<0.001$) and positively correlated with change in mean simulated driving speed ($p<0.05$). There was no significant correlation between confidence in driving and change in mean simulated driving speed.

Multiple Regression Analyses

In the model of predictors of Subjective Impairment, BAES Sedated Total, but not STAI Total or BAES Stimulated Total, predicted Subjective Impairment ($F(3,56) = 5.34$, $p=0.001$,

$R^2 = 0.222$; see Table 2). In the model of predictors of Confidence in Driving, BAES Sedated Total, but not STAI Total or BAES Stimulated Total, predicted Confidence in Driving ($F(3,56) = 8.82, p=0.001, R^2 = 0.321$; see Table 3). In the model of predictors of Change in Mean Simulated Driving Speed, BAES Sedated Total, but not STAI Total or BAES Stimulated Total, predicted Change in Mean Simulated Driving Speed ($F(3,56) = 4.27, p=0.001, R^2 = 0.186$; see Table 4).

Secondary Analyses

Linear regression analyses revealed that STAI Total predicted Sedation ($F(1,58) = 15.36, p<0.001, R^2 = 0.209$). STAI Total was not a significant predictor of BAES Stimulated Total (data not shown).

Post-Hoc Mediation Analysis

STAI negatively predicted Confidence in driving ($F(1,58)=6.20, p=0.016, R^2=0.097; \beta=-0.31$; Figure 2, Panel A) and positively predicted BAES Sedated Total ($F(1,58)=15.36, p<0.001, R^2=0.209; \beta=0.46$; Figure 2, Panel B). Confidence in driving was also negatively predicted by BAES Sedated Total ($F(1,58)=23.14, p<0.001, R^2=0.285; \beta=-0.53$; Figure 2, Panel C). Multiple R was statistically significant for confidence in driving ($F(2,57) = 11.68, p<0.001, R^2=0.291$). BAES Sedated Total ($p<0.001; \beta=-0.50$), and not STAI ($p=0.506; \beta=-0.08$), contributed significantly to confidence in driving. Thus, Baron and Kenny's (1986) criteria for full mediation were met as the significant relationship between STAI and confidence in driving was eliminated by the mediating influence of BAES Sedated Total. The Sobel test (1982) confirmed mediation by BAES Sedated Total (Sobel= $-2.784; p=0.0054$).

Discussion

After engaging in a simulated alcohol binge, participants in the current study reporting high ratings of subjective impairment displayed sensitivity to the sedating effects of alcohol, partially supporting our first hypothesis. Contrary to our first hypothesis, neither post-alcohol stimulation nor trait anxiety predicted subjective impairment. Our second hypothesis was supported as participants in the current study with comparatively high trait anxiety reported low confidence in their driving ability prior to the commencement of simulated driving. The negative relationship between trait anxiety and driving confidence was mediated by ratings of sedation after alcohol, providing further support for the role of sedation as a valuable cue to cease or limit consumption. While there was a positive correlational relationship between confidence in driving and ratings of stimulation after alcohol, sensitivity to the stimulating effects of alcohol did not predict confidence in driving in the multiple regression model. Our third hypothesis, however, was not supported by the results. Once simulated driving was initiated, high levels of sedation and anxiety were not related to cautious behavior, while elevated ratings of sedation led to an increase in driving speed after drinking. This finding may be explained by the positive association between sedation and subjective impairment following alcohol consumption. Contrary to our hypothesis, simulated driving performance following alcohol consumption was not predicted by trait anxiety or stimulation.

The positive association between trait anxiety and self-reported sedation in the current study suggests that participants with high trait anxiety were attending to the sedating effects of alcohol. Enhanced subjective sedation after alcohol consumption may serve as a protective mechanism by acting as an internal cue to cease or limit drinking (King et al., 2011). Similarly, sensitivity to sedation following alcohol consumption may also deter against driving by facilitating accurate assessments of driving ability (Marczinski et al., 2008). Interoceptive ability, which is characterized by self-awareness and comprehension of one's own physiological sensations and symptoms (Craig, 2002), is positively associated with trait anxiety (Paulus & Stein, 2010). Research suggests that interoception contributes to cautious and self-preserving behavior because it is characterized by meticulous attention, scrupulous appraisal of environment, and planning of future actions (Paulus & Stein, 2010). In this regard, it is possible that high anxious participants in the current investigation were able to recognize that feelings of sedation reflected alcohol-induced impairment. It is probable that anxiety also played a protective role by increasing awareness of cognitive and motor deficits through enhanced interoceptive ability. Consequently, sensitivity to sedation and interoception likely contributed to reduced confidence in the ability to drive after drinking.

Ultimately, higher levels of self-reported sedation and anxiety may shield individuals under the influence from engaging in potentially hazardous behaviors, such as driving, by increasing caution and self-preserving behaviors while under the influence of alcohol. While previous research has indicated that trait anxiety is associated with frequent participation in hazardous behaviors, results from the current study suggest that trait anxiety has the propensity to deter involvement in dangerous activities in some drinkers. Traditionally, high anxiety has been comorbid with alcohol problems, and generally heavy drinking can lead to potentially deleterious behavior. However, participants in the current study were not alcohol-dependent, thus it is plausible that trait anxiety manifests as a protective mechanism in non-dependent drinkers. Enhanced interoceptive ability in non-dependent drinkers likely facilitates accurate appraisal of alcohol-induced impairment, though the connection between trait anxiety and interoception may rapidly fade as drinkers become more dependent on alcohol.

Although sedation following alcohol was associated with low driving confidence in the current investigation, when these participants were required to drive, sedation was linked with an increase in driving speed compared to baseline. Change in simulated driving speed (post- minus pre-alcohol consumption) increased with subjective impairment, and high self-reported impairment was associated with sensitivity to the sedating effects of alcohol. Thus, drinkers with low self-reported sedation tended to reduce driving speed after alcohol consumption, while individuals who were more sensitive to sedation increased their driving speed. Similar findings have been reported in a study that incorporated co-administration of a benzodiazepine (midazolam) with an opioid analgesic (pethidine), two drugs with comparable pharmacological properties to alcohol. Compared to baseline driving ability, participants who received midazolam and pethidine experienced greater driving impairment following sedation characterized by increased lane deviations, missed stoplights, slower reaction time, and significantly more time in excess of the speed limit (Riphaus, Gstettenbauer, Frenz, & Wehrmann, 2006). The results from the current study suggest that the cautionary effect of sedation on driving confidence does not carry over to actual driving

performance. Whether or not this mechanism is capable of protecting against the decision to drive while under the influence of alcohol is worthy of further investigation. Future studies of the effect of anxiety and biphasic response to alcohol on simulated driving should give participants the decision to drive, or require them to report whether they would drive outside the laboratory given their subjective perception of intoxication.

There was a positive correlation between confidence in driving and stimulation following a simulated alcohol binge, however, stimulation did not predict confidence in driving in the multiple regression model. Timing of BAES administration may have contributed to the nonsignificant predictive relationship between stimulation and confidence in driving. In the current study, the biphasic response to alcohol was measured at the beginning of the descending limb of the blood alcohol curve, when decisions are generally made about legal driving ability. However, sensitivity to the stimulating effects of alcohol has typically been reported on the ascending limb of the blood alcohol curve. Although stimulation and sedation appear to be opposite states experienced independently, there may be overlap between the two states as sensitivity to the stimulating effects of alcohol transitions into sensitivity to sedation (Hendler, Ramchandani, Gilman, & Hommer, 2013). The correlational relationships among stimulation, sedation, and confidence in driving support this hypothesis. Administration of the BAES across multiple time points during laboratory alcohol administration studies may help to clarify the relationships among these subjective variables.

The sample in this study was self-selected, and anxious drinkers were not targeted for recruitment. The STAI trait anxiety scores in this investigation (mean $\pm$ SD: 31 ± 6 ; range = 20 – 51) were significantly lower than recently published norms for this measure (mean $\pm$ SD: 36 ± 11 ; range = 20 – 78; Crawford, Cayley, Lovibond, Wilson, & Hartley, 2011). Thus, the cautious driving behavior exhibited by participants with the highest levels of trait anxiety is likely a fraction of what might occur in a clinically anxious sample of drinkers. Despite the modest trait anxiety scores in the current study, moderate anxiety scores have the propensity to significantly impact driving behavior. Shahar (2009) conducted a study assessing the driving behavior of a self-selected sample of 120 male participants similar in age (mean $\pm$ SD age = 32 ± 7 ; range = 22–50) to participants included in the current study. The mean ($\pm$ SD) STAI score in the 2009 study was 34 ± 7 (range = 20–49), and despite this low reported STAI mean, trait anxiety was positively associated with risky driving behaviors. Consequently, sampling from a population with higher levels of trait anxiety may enhance the relationships among anxiety, driving confidence, and sedation following alcohol consumption.

While this study does illustrate the effects of expecting and receiving alcohol on simulated driving and confidence in driving, a key limitation is the absence of a placebo or no-beverage condition. Expectancy of alcohol has the propensity to impact driving and response to alcohol consumption. Expecting alcohol has been shown to decrease risky decision-making during a simulated driving task regardless of whether or not alcohol was actually received (Burian, Hensberry, & Liguori, 2003). Consequently, alcohol expectancy should be included in future studies of post-alcohol subjective response and driving performance.

These data have clinical relevance with regard to driving after alcohol consumption. Higher levels of trait anxiety and sensitivity to the sedating effects of alcohol may contribute to low confidence in driving ability. However, if the decision to drive is made, sedation predicts elevated driving speed, and thus is no longer protective. Although driving was required in this study, providing an option not to drive after alcohol administration may elicit further evidence of the protective effect of elevated trait anxiety and sensitivity to sedation. Granting participants the decision to drive following alcohol consumption would be extremely informative in determining whether the protective effects of sedation and anxiety extend to the decision to refrain from driving.

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Figure 1.

Mean breath alcohol concentration readings following the simulated alcohol binge session. Biphasic Alcohol Effects Scale (BAES) and visual analog scales (VAS) were completed 50 minutes post-binge. Simulated driving was completed 60 minutes post-binge. Error bars represent SEM.

Figure 2.

Mediation analysis: Significant predictors of subjective response to alcohol. Linear regressions reflect the significant relationships among STAI Score, BAES Sedated Total, and Confidence in Driving. STAI Score predicted Confidence in Driving ($R^2=0.097$, $p=0.016$; panel A), as well as BAES Sedated Total ($R^2=0.209$, $p<0.001$; panel B), and BAES Sedated Total, in turn, predicted Confidence in Driving ($R^2=0.285$, $p<0.001$; panel C).

Table 1
Intercorrelations Among Measures of Trait Anxiety, Subjective Effects of Alcohol, and Simulated Driving

Variables	BAES Stimulated Total	BAES Sedated Total	Subjective Impairment	Confidence in Driving	Change in Mean Speed (Post - Pre ETOH)
STAI Total	-0.18	0.46***	0.21	-0.31*	0.04
BAES Stimulated Total	-	-0.25	-0.04	0.31*	-0.06
BAES Sedated Total	-	-	0.47***	-0.53***	0.40**
Subjective Impairment	-	-	-	-0.49***	0.29*
Confidence in Driving	-	-	-	-	-0.14

* $p < .05$,

** $p < .01$,

*** $p < .001$

Table 2

Predictors of Subjective Impairment

Model	Unstandardized Coefficients		t	p Value
	B	Std. Error		
Intercept	15.875	19.138	.830	.410
STAI Total	.029	.528	.055	.956
BAES Stimulated Total	.147	.222	.660	.512
BAES Sedated Total	1.002	.281	3.567	.001

($F(3,56) = 5.34$, $R^2 = 0.222$)

Table 3

Predictors of Confidence in Driving

Model	Unstandardized Coefficients		t	p Value
	B	Std. Error		
Intercept	69.397	19.685	3.525	.001
STAI Total	-.305	.543	-.562	.576
BAES Stimulated Total	.360	.228	1.576	.121
BAES Sedated Total	-1.048	.289	-3.628	.001

 $(F(3,56) = 8.82, R^2 = 0.321)$

Table 4

Predictors of Change in Mean Simulated Driving Speed

Model	Unstandardized Coefficients		t	p Value
	B	Std. Error		
Intercept	.248	1.447	.171	.864
STAI Total	−.051	.040	−1.282	.205
BAES Stimulated Total	.004	.017	.232	.818
BAES Sedated Total	.075	.021	3.531	.001

 $(F(3,56) = 4.27, R^2 = 0.186)$