INFLUENCE OF CONDITIONED COMPENSATORY RESPONSE ON DRINKING AND DRIVING DECISION MAKING

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A candidate for the degree of
Master of Arts in Clinical Psychology

And hereby certify that, in their opinion, it is worthy of acceptance.

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ABSTRACT

Perceived intoxication is a strong determinant of one’s willingness to drive after drinking alcohol. When contextual cues are conditioned with the administration of alcohol, a compensatory response is elicited that decreases the impairing effects of alcohol and perceived intoxication. The authors hypothesized that a cue-induced compensatory response would decrease perceived intoxication and therefore increase willingness to drive while intoxicated. Young adults (N = 60, 81.7% male) attended a single session during which they were randomly assigned to receive a moderate dose of alcohol via either a familiar or an unfamiliar alcoholic beverage. Following consumption, participants completed cognitive and psychomotor tasks, rated their subjective experience, and reported their willingness to drive. The cues of the familiar alcoholic beverage did not increase the willingness to drive compared to the unfamiliar cues. The groups also had similar subjective experiences and cognitive and psychomotor impairment. These results are inconsistent with previous conditioned compensatory response research. These discrepant results may be a result of the observed group difference in breath alcohol concentration (BrAC), with the familiar alcoholic beverage resulting in a higher BrAC. The group difference in BrAC makes it difficult to interpret these results.
INTRODUCTION

Despite a significant reduction in alcohol-related traffic fatalities in the past 30 years (Hingson & Winter, 2003), drinking and driving remains a serious public health concern, especially for young adults. Alcohol-related driving fatalities accounted for roughly a third of the total traffic fatalities in 2008, and drivers aged 21 to 34 accounted for 65% of all alcohol-related traffic deaths (NHTSA, 2009). This age group also reported the greatest frequency of drinking and driving (Hingson & Winter, 2003). Although considerable research has documented the effectiveness of public policy (e.g., increased minimum legal drinking age) on reducing drinking and driving, research has also demonstrated the importance of interventions involving cognitive factors in drinking and driving decisions. The decision to drive after drinking is influenced by cognitive factors such as perceived blood alcohol concentration (Jaccard & Turrisi, 1987; Lansky, Nathan, & Lawson, 1978; Schuckit, 1984), subjective intoxication (Marczinski, Harrison, & Fillmore, 2008; Portans, White, & Staiger, 1989; Radlow, & Hurst, 1985), and perceived impairment (Marczinski et al., 2008; Tiplady, Franklin, & Scholey, 2004). Conditioned compensatory response (CCR) theory (Siegel, 1975; Siegel, Hinson, & Krank, 1978; for a review, Siegel, Baptista, Kim, McDonald, & Weise-Kelly, 2000), a well-studied model for the development of drug tolerance, may help explain discrepancies between perceived and actual intoxication/impairment. The proposed project will examine the influence of CCR on drinking and driving cognitions and in turn on drinking and driving decisions.

Errors in BAC Estimations and Drinking and Driving
Typically, individuals rely on internal cues (e.g., subjective intoxication) and external cues (e.g., number of drinks consumed) to estimate their ability to drive safely. As per se laws in all U.S. states define the legal limit for driving while intoxicated as a blood alcohol concentration (BAC) of .08 mg%, individuals rely on these cues to estimate whether their BAC is above or below the legal limit. Unfortunately, research has demonstrated that individuals are poor estimators of their BAC when using both internal and external cues (Jaccard & Turrisi, 1987; Lansky et al., 1978; Schuckit, 1984). For example, Turrisi and Jaccard (1991) reported that individuals underestimated their BAC when consuming high quantities of alcohol over long periods of time. Turrisi and Jaccard (1991) demonstrated that estimated BAC alone does not explain individual’s decision to drink and drive. Instead, they concluded that it is the combination of an individual’s estimated BAC and other cognitive factors that determine an individual’s choice to drive after drinking.

Errors in Perceived Intoxication and Drinking and Driving

Another factor used to determine one’s ability to drive safely is estimated level of intoxication, or drunkenness. Similar to estimating BACs, individuals rely on internal and external cues to estimate their level of intoxication. For example, an individual may perceive himself or herself as extremely drunk and, as a result, decide not to drive home. Unfortunately, past research has found that individuals’ estimated level of intoxication is not always analogous to their actual BAC (Marczinski et al., 2008; Nicholson, Wang, Airhihenbuwa, Mahoney, and Maney, 1992; Portans et al., 1989; Radlow, & Hurst, 1985). Marczinski and colleagues (2008) and Portans and colleagues (1989) both posit that this finding may be explained by classical conditioning, in which the pairing of
alcohol cues with alcohol consumption may elicit a drug-opposite, or compensatory, response. As a result, this compensatory response may hinder one’s ability to accurately estimate his or her level of drunkenness.

Errors in Perceived Impairment and Drinking and Driving

Another potential mechanism for errors in estimating one’s ability to drive safely could be that alcohol leads to a misperception of one’s abilities, giving a false sense of competence or ability. For example, in a study examining the effect of different doses of alcohol on judgment, Tiplady, Franklin, and Scholey (2004) found that individuals in a high-dose alcohol group rated their performance on a general knowledge task higher than those in the other groups, despite there being no group differences in performance. These authors posited that misperceptions of impairment might increase the likelihood of engaging in drinking and driving (Tiplady et al., 2004). Unfortunately, no measure of willingness to drive was utilized in this study. Marczinski and colleagues (2008) found that binge drinkers reported less perceived impairment in driving ability after consuming a moderate dose of alcohol compared to non-binge drinkers. These authors suggest that this error in perceived impairment may be one explanation for binge drinkers’ high rates of driving drunk (Marczinski et al., 2008). Clearly, research has provided evidence that individuals lack the ability to accurately estimate their level of intoxication and ability to drive when they are at or above the statutory legal limit, which places them at risk for driving under the influence.

Conditioned Compensatory Response Theory

Siegel’s (1975) conditioned compensatory response (CCR) theory is a classical conditioning model for the development of drug tolerance. According to this theory, cues
that have been repeatedly paired with the administration of a drug come to elicit a preparatory response in the opposite direction of the drug’s effect, which as a result diminishes the effects of the drug (Siegel, 1975; Siegel et al. 1978; for a review, Siegel et al., 2000). Siegel first proposed this CCR theory after observing that rats dosed with morphine in an environment previously paired with the drug administration displayed tolerance to the analgesic effects of morphine (Siegel, 1975). Since its proposal, the CCR theory has been demonstrated with drugs other than opiates, such as alcohol (Birak, Terry, & Higgs, 2010; Larson & Siegel, 1998; Newlin, 1985, 1986; Remington, Roberts, & Glautier, 1997; White, Roberts, & Best, 2002), as well as with both human (e.g., Birak, Terry, & Higgs, 2010; McCusker & Brown, 1990; Remington, Roberts, & Glautier, 1997) and animal subjects (e.g., O’Brien et al., 1980; Siegel, 1975; Siegel et al., 1978; White, Roberts, & Best, 2002). These studies have shown that drug-related cues elicit a compensatory response that counteracts the impairing effects of these drugs on cognitive and psychomotor ability, as well as the drugs’ effect on physiological responses (e.g., heart rate and skin conductance).

At the outset of this line of research, experimenters investigated CCR by repeatedly pairing contextual cues with drug administration, and then testing the drug’s effect in the presence and absence of the contextual cues. McCusker and Brown (1990), however, demonstrated that an opportunistic approach, in which participants’ extra-experimental exposure with a drug, instead of experimental drug-cue pairing, could be employed to test the CCR theory. McCusker and Brown used contextual cues typically associated with a drinking environment along with the sensory cues (e.g., sight, taste) of an individual’s preferred alcoholic beverage to elicit a CCR to the effects of alcohol. The
results revealed that consuming alcohol in a simulated bar via a familiar alcoholic beverage (i.e., two pint glasses of lager) resulted in less cognitive and psychomotor impairment than when consumed in an atypical drinking environment (i.e., office) via an unfamiliar alcoholic beverage (i.e., glass of pure vodka with artificial sweetener). Interestingly, those who received alcohol in a simulated bar were less impaired than a placebo group who drank in the same setting via an identical vehicle (i.e., two pint glasses of nonalcoholic lager). These findings are in line with the results from studies (e.g., Shapiro & Nathan, 1986) that utilized an experimentally conditioned approach to investigate cue-induced compensatory responses to the effects of alcohol.

Remington and colleagues (1997) expanded on these findings by demonstrating that sensory cues alone, rather than in combination with contextual cues, could elicit a CCR to alcohol. Similar to the findings of McCusker and Brown (1990), these authors found that after a moderate dose of alcohol the familiar beverage group was significantly less impaired on both psychomotor and cognitive tasks than the unfamiliar beverage group. Thus, the induction of a compensatory response to the impairing effects of alcohol is not contingent on a combination of contextual and sensory cues. The results from these studies illustrate that alcohol-related cues frequently encountered by individuals during drinking episodes can diminish alcohol’s impairing effects on psychomotor and cognitive functioning.

In addition to supporting the utility of an opportunistic approach, Remington and colleagues (1998) were also the first to examine the effect of a CCR on an individuals’ perceived level of intoxication. They found that participants in the familiar beverage group reported feeling less intoxicated compared to the unfamiliar beverage group.
Participants’ BAC was not measured, however, so it is indeterminable whether the groups had equivalent BACs. In a more recent study (Birak et al., 2010), these findings were replicated with no group difference occurring in BAC. Thus, not only are individuals’ abilities less impaired after the consumption of a familiar alcoholic beverage, but their level of intoxication is also perceived to be less.

*Effect of Cue-Induced Compensatory Response on Drinking and Driving Decision Making*

Cognitive and psychomotor abilities are necessary skills for driving (Tiplady, Bowness, Stien, & Drummond, 2005a); therefore, individuals who perceive these skills to be less impaired may be more apt to drive after drinking. As individuals are less impaired by the acute effects of alcohol when it is consumed in a familiar vehicle (Birak et al., 2010; Remington et al., 1997; McCusker & Brown, 1990), they may in turn overestimate their ability to drive after drinking. The aim of the present study was to test whether or not a cue-induced CCR would affect the decision to drive after drinking. Participants received a moderate dose of alcohol (0.72 g/kg for men; 0.65 g/kg for women) via either a familiar alcoholic beverage (i.e., pure grain-infused beer in a pint glass) or an unfamiliar alcoholic beverage (i.e., glass of pure grain-infused in an atypical mixture). This dose of alcohol was chosen because past research has found it to yield a peak BAC of .08 mg% and impair simulated driving performance (Holloway, 1995). Participants’ breath alcohol concentration (BrAC) was obtained via a breathalyzer. Estimated BAC, subjective intoxication, subjective impairment, and perceived ability to drive were assessed through self-report. Participants’ driving ability was also assessed using three tasks designed to measure skills necessary for driving.
We hypothesized that there would be no group differences in BrACs, but there would be group differences in estimated BAC and subjective intoxication. Due to the errors associated with BAC estimation, we predicted that the familiar beverage group would underestimate their BAC compared to their actual BrAC, whereas the unfamiliar beverage group would overestimate their BAC. With regard to subjective intoxication, we predicted that individuals in the familiar beverage group would report lower levels of intoxication compared to the unfamiliar beverage group, despite no group difference in BrAC.

Similarly, we hypothesized that participants’ subjective and objective impairment would differ according to group membership. We predicted that the familiar beverage group would perceive their performance as less impaired than the unfamiliar beverage group, with the familiar group actually being less impaired than the unfamiliar group. Therefore, participants’ subjective impairment would accurately reflect their actual performance on the tasks. Since subjective effects of alcohol are important to the decision-making process for alcohol-impaired driving, we also predicted that the familiar beverage group would report greater willingness to drive than the unfamiliar beverage group. See Table 1 for a summary of hypothesized group differences.

Certain personality traits (e.g., impulsivity) and drinking and driving cognitions (e.g. attitudes, expectancies) have been identified as risk factors for engaging in drinking and driving (Grube & Voas, 1996; Jonah, 1997; McCarthy, Pedersen, Thompsen, & Leuty, 2006; McMillen, Pang, Wells-Parker, & Anderson, 1991, 1992). Therefore, as an exploratory component of this study, we assessed facets of impulsivity (e.g. sensation seeking, negative urgency) and drinking and driving cognitions (i.e. attitudes,
expectancies) to examine interaction effects on the decision to drink and drive. It is possible that, within groups, individual’s perceived ability to drive and/or subjective level of intoxication is moderated by one of these risk factors.

Finally, it has been found that the effects of alcohol on heart rate are biphasic, with heart rate increasing on the ascending limb of the blood alcohol curve and decreasing on the descending limb (Conrod, Peterson, & Pihl, 2001; Conrod, Peterson, Pihl, & Mankowski, 1997; Martin, Earleywine, Musty, Perrine, & Swift, 1993). As a second exploratory component of this project, we examined the influence of a cue-induced compensatory response on participants’ heart rate while intoxicated. Following the CCR theory, we hypothesized that participants in the familiar beverage group would display a diminished change in heart rate from baseline to post-consumption compared to those in the unfamiliar beverage group. This hypothesis is tentative, however, because past research has found that participants who received alcohol via a familiar beverage reported greater feelings of alertness (Birak et al., 2010), which is contrary to what would be expected if alcohol cues elicited a compensatory response.

Finally, it has been found that individuals may engage in compensatory behavior based on how they expect alcohol to affect them (Marczinski & Fillmore, 2005). To account for this, individual differences in expectancies about alcohol’s impairing effects were controlled for in study analyses.
METHOD

Participants

Sixty-five individuals participated in the present study. Of these participants, three were excluded from analyses due to their inability to adhere to study protocol, another was excluded for not consuming the entire administered dose of alcohol, and one withdrew from the study. The resulting sample \((N = 60)\) was composed of young adults between the ages of 21 and 34 years old. The sample was predominately male (81.7 %) and included 53 Caucasians, 2 African Americans, 2 Asians, and 3 multi-racial participants. A large portion of the sample (81.7 %) was college students.

Participants were recruited from a large, Midwest university and its surrounding area. Methods of recruitment included email advertisements, local circulars, and flyers posted around the campus and in surrounding businesses. Respondents were excluded if they reported either a medical condition or taking a prescription medication for which alcohol use is contraindicated. Respondents were also excluded if they reported a current or lifetime substance abuse disorder (other than caffeine or nicotine), psychiatric disorder, or head trauma. Further, respondents who reported seeking, or having sought, treatment for any substance use disorder or who were currently attempting, or had attempted, to abstain from alcohol were excluded. Females who reported being pregnant or nursing were excluded from participation. Individuals who reported that they had not consumed at least three drinks on one occasion in the past month were excluded to reduce the likelihood of experiencing adverse effects from the administered dose. Participants were also required to report a preference for beer to increase the probability of them being conditioned to beer-related cues extra-experimentally.
Female participants were also required to complete a urine pregnancy test prior to alcohol consumption during the testing session. Two participants were excluded from the study because they refused to complete a pregnancy test. The University of Missouri’s Campus Institutional Review Board approved this study. Participants received $12 an hour for their participation.

**Measures**

*Demographic Information.* Participants reported their age, gender, race, ethnicity, and current occupation.

*Alcohol Use Behavior.* The Drinking Styles Questionnaire (DSQ; Smith, McCarthy, & Goldman, 1995) assessed past month alcohol use behavior. Participants reported (1) the number of times they had consumed alcohol (i.e., drinking frequency); (2) the average number of drinks they had on drinking occasions (i.e., drinking quantity); (3) the number of times they had 5 or more drinks of alcohol at one time (i.e., binge drinking); and (4) the largest number of drinks they consumed on any day (i.e., maximum consumption). The DSQ has demonstrated good reliability and validity with college-aged samples (McCarthy, Miller, Smith, & Smith, 2001).

*Drinking and Driving Attitudes.* Perceptions of the danger of drinking and driving were assessed with three questions asking participants to rate how dangerous they believe it is to drive after 1 drink, 3 drinks, and 5 or more drinks. Participants responded using a 4-point Likert scale ranging from “not at all dangerous” to “very dangerous”. These questions have been found to load onto a single factor that is negatively correlated with drinking and driving behavior (Grube & Voas, 1996). In the present study, participant’s responses were aggregated to generate a total mean score (α = .79).
Drinking and Driving Expectancies. The PEDD-Y (McCarthy et al., 2006) is a 29-item measure designed to assess adolescents’ and young adults’ positive expectancies about drinking and driving. This measure has four factors: Convenience (16 items), Control (5 items), Avoiding Consequences (4 items), and Excitement Seeking (4 items). The PEDD-Y has a 5-point Likert style response format ranging from “disagree strongly” to “agree strongly”. In the present study, the full measure and the Convenience factor were found to have high internal consistency (α = .94), and the other factors were found to have lower, but still sufficient, internal consistency (Control α = .71; Avoiding Consequences α = .79; Excitement Seeking α = .91). The PEDD-Y has been found to be associated with drinking and driving frequency, as well as with other drinking and driving cognitions (e.g., attitudes, normative beliefs; McCarthy et al., 2006).

Alcohol Impairment Expectancies. The cognitive and behavioral impairment subscale from the Comprehensive Effects of Alcohol scale (CEOA: Fromme, Stroot, & Kaplan, 1993) was used to assess participants’ expectancies about the impairing effects of alcohol. This subscale consists of 9 items in which participants responded to each item with a 4-point Likert scale ranging from 1 (“disagree”) to 4 (“agree”). In the present study, participants’ responses were aggregated to create a mean alcohol impairment expectancy score (α = .77).

Impulsivity Traits. The UPPS Impulsive Behavior Scale with the Positive Urgency Measure (UPPS-P: Cyders, Smith, Spillane, Fischer, Annu, & Peterson, 2007; Whiteside & Lynam, 2001) is a 52-item measure designed to assess five impulsive traits (i.e. Positive Urgency, Negative Urgency, (lack of) Premeditation, (lack of) Perseverance, and Sensation Seeking). Each trait was measured by a subset of items, with Positive
Urgency consisting of 14 items, Negative Urgency containing 12 items, (lack of) Premeditation made up of 11 items, (lack of) Perseverance consisting of 10 items, and Sensation Seeking having 12 items. Participants responded to each item using a 4-point Likert-type scale. In the present study, sufficient internal consistency coefficients were found for each trait (Positive Urgency = 0.92; Negative Urgency = 0.80; (lack of) Premeditation = 0.82; (lack of) Perseverance = 0.81; Sensation Seeking = 0.83). The UPPS-P has been shown to be a valid predictor of alcohol use, as well as alcohol-related problems (Cyder et al., 2007; Whiteside & Lynam, 2003; Whiteside, Lynam, Miller, & Reynolds, 2005; Zapolski, Cyders, & Smith, 2009).

*Drinking and Driving Behavior.* Drinking and driving behavior was quantified with three questions, using open-ended response options. Participants reported the number of times in the past three months they had driven after consuming 1 drink, 3 drinks, and 5 or more drinks in a 2 hour time period.

*Breath Alcohol Concentration.* Breath alcohol concentration (BrAC) was measured with a FST Alco-Sensor (Intoximeters, Inc., St. Louis) at baseline and at all post-consumption measurement points.

*Heart Rate.* Heart rate was measured during the practice and experimental portions of the procedure (see below) using a BCI 3301 hand-held pulse oximeter (Smiths Medical PM Inc., Waukesha, WI). The finger sensor was placed on the middle finger of the non-dominant hand, and heart rate readings were recorded every 30 seconds. Recordings were aggregated separately for the practice (α = .98) and experimental (α = .99) portions of the study.

*Subjective Effects Ratings*
Biphasic Alcohol Effects Scale (BAES). Acute subjective responses to alcohol were assessed using the BAES (Martin et al., 1993). The BAES includes 14 adjective items and is partitioned into two subscales. The first subscale consists of 7 adjectives (i.e., elated, energized, excited, stimulated, talkative, up, and vigorous) that describe alcohol’s stimulating effect on the ascending limb of the blood alcohol curve, and the other subscale consists of 7 adjectives (i.e., difficulty concentrating, down, heavy head, inactive, sedated, slow thoughts, and sluggish) that describe the sedative effects of alcohol on the descending limb of the curve. Participants responded to each item using a 10-point Likert scale ranging from 0 (“not at all”) to 10 (“extremely”). This measure has been used in other alcohol administration research to discriminate the stimulating and sedating effects of alcohol (Earleywine & Erblich, 1996). In the present study, participants’ ratings at each measurement point were aggregated to generate mean scores for both stimulation and sedation.

Perceived BAC. Participants were asked to estimate their BAC using a 0 to 200-point scale, with 0 being “completely sober”, 80 being “legal limit”, and 200 being “extremely intoxicated” (Beirness, 1987). Participants’ ratings were divided by 1000 to equate them with participants’ measured BrACs.

Subjective Intoxication. Participants also reported their subjective intoxication using a 10-point Likert scale ranging from 1 (not drunk at all) to 10 (more drunk than I’ve ever been).

Subjective Impairment Rating. Self-evaluation of participants’ impairment on each task was assessed using a visual analogue scale (Harrison & Fillmore, 2005). Participants indicated how much their task performance was impaired by alcohol by
placing a vertical line on a 100 mm visual analogue scale. The visual analogue scale was anchored with “no impairment” (0 mm) and “extreme impairment” (100 mm).

**Perceived Ability to Drive.** Two questions were employed to measure participants’ perceived ability to drive once intoxicated. First, participants indicated whether they would drive home, based on how they felt at the moment, using a dichotomous, yes/no response format. Second, participants reported how dangerous they believed it was to drive at the moment, using a 4-point Likert scale, with 1 signifying “not at all”, 2 signifying “a little”, 3 signifying “somewhat”, and 4 signifying “extremely”.

**Stop-Signal Task.** The Stop-Signal Task (Logan, 1994) is a measure of behavioral inhibition and has been found to be adversely affected by alcohol (Mulvihill, Skilling, & Vogel-Sprott, 1997). During the initial block of trials, a single green arrow (go cue), pointing either left or right, was presented consecutively on a computer monitor, and participants were required to indicate which direction the arrow was pointing using the left and right arrow response keys. After several trials had been completed and a pre-potent, or automatic, response was generated, stop signal cues (e.g. green arrows turning red) were introduced. When a stop signal cue was presented, participants had to inhibit their pre-potent response and not respond. Each trial consisted of the presentation of a single arrow. Participant completed 5 blocks of 64 trials for the experimental portion of the study. A participant’s stop-signal reaction time (SSRT) was used as the dependent measure for this task (see Logan, 1994, for an explanation of SSRT).

**Flanker Task.** The flanker task (Tiplady et al., 2005a) measures attention in the presence of distracters, which is a necessary ability for driving. In this task, participants
were presented with five arrows in the center of a computer monitor. They were required to indicate which way the center arrow was facing by pressing either a left or right arrow response key. The arrows were either congruent (i.e. all the arrows pointing in the same) or incongruent (i.e. outer arrows pointing in the opposite direction of the center arrow). The number of congruent and incongruent trials was equal, as was the number of trials in which the center arrow pointed left and right. A single trial was composed of the presentation of the five arrows. Participants completed 4 blocks of 50 trials for the experimental portion of the study. The dependent measures were the percent correct and reaction time on incongruent trials. Previous research has found a moderate dose of alcohol to disrupt performance on this task (Tiplady, Degia, & Dixon, 2005b).

*Pursuit Rotor Task.* Participants’ psychomotor performance was assessed using a computerized pursuit rotor task (Life Science Associates, Inc., Bayport, New York). On this task, participants tracked a red, circular target (diameter = 1.5 cm) around a rectangular track (height = 11.5 cm; length = 18 cm; width = 1.0 cm) with inclined corners. Participants attempted to keep a crosshair (diameter = 1.5 cm) on the target, using the computer mouse, as the target rotated clockwise around the track at 12 revolutions per minute. One revolution around the track constituted a single trial. Participants completed 6 blocks of 24 trials for the experimental portion of the study. The dependent measure was the percentage of time the participant kept the crosshair on the target, or percentage time on target (%TOT). Previous research has found performance on this task to be impaired by a moderate dose of alcohol (Fillmore, 2003; Harrison & Fillmore, 2005).

*Procedure*
Individuals who responded to advertisements completed a telephone screener, assessing for exclusionary criteria, conducted by a research assistant. The study was purported to be examining the effects of alcohol on performance and decision-making. Those who qualified for the study were scheduled for participation, with all sessions beginning at 16:00 hours. On the day of testing, participants were instructed to refrain from the use of drugs and alcohol for 24 hours and abstain from eating and consuming caffeine for 4 hours.

Study procedures on the day of testing are summarized in Figure 1. Participants were tested individually by a research assistant who was blind to the study’s hypotheses. At the beginning of the testing session, written informed consent was obtained, and compliance to pre-session requisites was assessed. A breath sample was then taken to ensure a BrAC of 0.00 mg %, and a urine pregnancy test was administered to female participants. Participants’ weight was measured to calculate alcohol dose and then all questionnaires were completed.

Task Practice Blocks. Next, participants completed the practice trials for each task on a desktop personal computer. Instructions for each task were provided before each practice block. For the stop-signal task, participants were instructed to respond to the stimuli (i.e., square or circle), using the computer’s keyboard. The practice block for the stop-signal task consisted of one block of 32 trials, with each trial separated by 750 millisecond inter-trial-interval (ITI). For the flanker task, participants were instructed to respond to the direction of the center arrow by pressing the left or right response button while ignoring the direction of the outer arrows. The practice block for the flanker task consisted of 50 trials, with each trial separated randomly by 1100 or 1500 millisecond.
ITI. For the pursuit rotor task, participants were instructed to keep the crosshair on the red, circle target, using the computer’s mouse. The practice block for the pursuit rotor task consisted of 3 blocks of 12 trials, with each trial separated by a 30 second ITI. Task order was randomized and all practice trials were completed in approximately 20 minutes.

*Beverage Administration, Consumption, and Administration.* Participants were randomly assigned to either the familiar beverage or unfamiliar beverage condition. Task performance and subjective ratings were tested under an alcohol dose of 0.72 g/kg body weight for men and 0.65 g/kg for women. This dose of alcohol was chosen because it produces a peak BAC between 0.075 and 0.080 mg% (Sher & Walitzer, 1986). Beverages for the familiar condition were served in Bud Light pint glasses\(^1\) and consisted of four parts non-alcoholic beer (i.e., Busch) to one part pure grain alcohol (95% alcohol per volume). Beverages for the unfamiliar condition were served in black, funnel-shaped coffee mugs\(^2\) and consisted of four parts mixture\(^3\) to one part pure grain alcohol. Beverages for both conditions were equally divided into three of the aforementioned glasses. Participants were allowed 5 to 10 minutes to consume each glass to imitate a more naturalistic drinking situation. Participants then relaxed and completed seek-and-find puzzles for 15 minutes to allow for absorption.

*Post-Absorption.* Next, the experimental blocks for each task were completed, with participants’ BrAC and subjective ratings assessed before each task. Before beginning each task, the instructions for each task were re-explained. After the completion of the final task, participants’ BrAC and subjective ratings were assessed a final time. The duration of each task was approximately 20 minutes. Upon the completion
of the study, participants were debriefed, offered a meal, and allowed to watch movies and/or read magazines while their BrAC descended below 0.020 mg%. Participants were then offered a taxi home or had a friend escort them home.

Analytic Plan

SPSS version 19 (SPSS Inc., Chicago, IL) was used to conduct all analyses. All analyses except those examining group differences in BrAC controlled for drinking frequency and quantity, as well as alcohol impairment expectancies. We first examined the effect of group on BrAC and subjective effects ratings, using generalized estimating equations (GEE; Liang & Zeger, 1986). This approach accounts for the clustering of responses within participants and has less restrictive assumptions than other analyses commonly used for repeated measures (e.g., assumption of compound symmetry for repeated measures analysis of variance). Most dependent variables (except willingness to drive) were continuous; therefore, we specified a normal distribution with an identity link function to obtain unstandardized regression weights for each predictor variable. Since the willingness to drive variable was dichotomous (i.e., yes/no), we specified a binomial distribution with a logit link function to obtain the log odds of willingness to drive for each predictor variable. For all models, we specified an AR(1) autoregressive correlation structure to account for the clustering of responses within participants. This correlation structure specifies that measurement points closer in time are more correlated than those that are distant. However, GEE has been found to be robust to the misspecification of correlation structures (Hubbard et al., 2010). For each model, we entered group membership and gender as factor variables, with the unfamiliar beverage group and
women as references. The unstandardized beta weights for group and gender indicate the
difference in their estimated marginal means for each dependent variable.

Next, we examined group differences on task performance using multivariate
analysis of covariance (MANCOVA). This approach was chosen because it is more
powerful and reduces the likelihood of committing a type I error than conducting separate
univariate tests. Participants’ percent correct for incongruent trials on the flanker task
were transformed using arcsine square root prior to analysis to normalize the data.
Additionally, one SSRT data point was winsorized to reduce its influence as an outlier.
For the analysis, both group and gender was entered as between-subject factors.

We then examined whether group was associated with over- or under-estimation
of impairment and BrAC. To examine this association, we first standardized the
dependent measures from each task, and aggregated these values to create a mean score
for actual impairment. This mean score and subjective impairment ratings were then
standardized and subtracted from one another (i.e., actual impairment – subjective
impairment). Since participants’ actual and perceived BrAC were assessed on similar
scales, we simply subtracted them from one another. For both impairment and BrAC,
positive difference scores were indicative of under-estimation, whereas negative scores
were indicative of over-estimation. Again, separate GEE analyses were conducted to
examine the effect of group on the accuracy of participants’ subjective impairment and
perceived BrAC. Our dependent variables, differences scores for impairment and BrAC,
were continuous; therefore, all specifications (e.g., link function, AR(1) autoregressive
correlation structure) and predictor variables were identical to those previously
mentioned.
For the exploratory portion of this study, we re-conducted the above GEE analyses with an interaction variable between group membership and individual difference variables (i.e., impulsivity traits, positive drinking and driving expectancies, and drinking and driving attitudes) entered into each model. Separate sets of analyses were conducted for each individual difference variable.

Finally, we examined whether group was associated with changes in HR. Six participants had missing heart rate data due to the oximeter malfunctioning and participants removing the finger clip. Therefore, the degrees of freedom for this analysis will differ from the previous analyses. To account for individual differences in HR at baseline, we subtracted participants’ post-consumption HR readings from their pre-consumption readings. Positive difference scores indicated an increase in HR, whereas a negative difference score indicated a decrease in HR. We then used independent-sample $t$-test to test for group differences in HR.
RESULTS

Demographics, Alcohol Use, and Drinking and Driving

Table 2 summarizes the results from independent sample t-test, examining group differences in descriptive variables and alcohol use measures. Results indicated that the age and gender of participants did not differ between groups. There were also no group differences in past month drinking frequency, drinking quantity, binge drinking frequency, or maximum consumption in a single episode.

Overall, a large portion (78.9%) of the sample reported driving at least once after consuming a drink of alcohol. Of those who reported drinking and driving, 77.8% reported driving 2 hours after consuming 3 drinks, and 35.6% reported driving 2 hours after consuming 5 or more drinks. Table 2 also summarizes mean level group differences in drinking and driving behavior. Results indicate that the number of times participants reported driving after having 1 drink, 3 drinks, and 5 or more drinks did not differ between groups.

Breath Alcohol Concentration

Table 3 presents the mean breath alcohol concentrations for the familiar and unfamiliar groups at each measurement point. A significant group difference, $b = .01, p < .05$, was obtained from the GEE analysis testing for group differences in BrAC. On average, the familiar beverage group reached a BrAC that was .01 mg% higher than that for the unfamiliar group; thus, the familiar group was always above the legal limit to drive while the unfamiliar group was not.

Subjective Effects Ratings
A significant main effect for group on stimulation was obtained from the GEE analyses testing the effect of group on subjective ratings, $b = .95, p < .01$. These results indicate that the familiar beverage group reported greater stimulation than the unfamiliar beverage group. There were no group effects on perceived danger ($b = -.05, p = .82$), subjective intoxication ($b = .33, p = .35$), subjective impairment ($b = 5.6, p = .17$), perceived BrAC ($b = .01, p = .22$), or sedation ($b = .49, p < .16$).

A significant main effect of gender on stimulation was also obtained ($b = 1.45, p < .01$), as males reported greater stimulation than females. Additionally, stimulation was significantly predicted by past month drinking quantity ($b = -.22, p < .01$), with greater quantity being associated with lower ratings of stimulation. Results also indicated a main effect of alcohol impairment expectancies on perceived danger and sedation, $b = .45, p < .05$, and $b = 1.26, p = .001$, respectively. This set of results indicate that the stronger one’s alcohol impairment expectancies were the more dangerous they reported it was to drive and the more sedated they reported feeling.

Performance Impairment

Group difference on task performance was tested using a 2 (group) x 2 (gender) mixed effects MANCOVA, with alcohol impairment expectancies entered as a covariate. Results indicated that the groups did not differ in their performance on the tasks, Wilks’ lambda $= .93, F(4, 51) = .91, p = .47, \eta_p^2 = .07$. There was, however, a significant gender effect, Wilks’ lambda $= .81, F(4, 51) = 3.01, p < .05, \eta_p^2 = .19$, with men performing better on the tasks compared to women.

Accuracy of Subjective Impairment and Estimated BrAC
Generalized estimating equations indicated that there were no group effects on the accuracy of subjective impairment \((b = .002, p = .99)\) or estimated BrAC \((b = .00, p = .97)\). The estimated marginal means for these variables indicated that both the familiar and unfamiliar beverage group underestimated their impairment and BrAC.

*Interaction between Group and Individual Difference Variables*

Separate GEE analyses for the subjective effects ratings were conducted with the inclusion of the individual difference variables and their interaction with group. Significant main effects were found for drinking and driving attitudes on perceived danger, subjective intoxication, and subjective impairment, \(b = 1.00, p < .001, b = 1.07, p < .01,\) and \(b = 10.14, p < .05\), respectively. There was also a significant main effect for the PEDD-Y avoiding consequence subscale on sedation ratings, \(b = .53, p < .05\). Gender and past month drinking quantity again had a significant main effect on stimulation over and above the inclusion of the individual difference variables and their interactions with group \((gender: bs from 1.50 to 1.62, ps < .01; drinking quantity: bs from -0.45 to -0.54, ps < .01)\). Of most importance, there were no significant interactions between the individual difference variables and group.

*Heart Rate*

An independent-sample \(t\)-test was conducted to examine group differences in the change of heart rate pre- and post-consumption. Results indicated that the familiar and unfamiliar beverage groups did not significantly differ, \(t(52) = -1.05, p = .30\). The group means for the difference between pre- and post-consumption indicate that the familiar beverage group had a greater increase in heart rate from pre- to post-consumption \((M = -\)
3.31) compared to the unfamiliar beverage group ($M = -1.92$), though the difference did not reach significance.
DISCUSSION

The present study tested the hypothesis that familiar alcoholic beverage cues would elicit a compensatory response that would affect the subjective and impairing effects of alcohol and in turn increase the likelihood of drinking and driving. The findings do not support this hypothesis. The consumption of a familiar alcoholic beverage did not reduce the impairing effects of alcohol on cognitive and psychomotor abilities compared to the consumption of an unfamiliar alcoholic beverage with the same concentration of alcohol. Furthermore, both groups had similar subjective experiences and perceptions about the danger of driving following consumption. These findings are at odds with previous research on the influence of a conditioned compensatory response on the impairing effects of alcohol. One reason for these discrepant results could be the observed group difference in BrAC, with the familiar alcoholic beverage resulting in a higher BrAC. This group difference has not been observed in prior studies and may explain the lack of effect for compensatory response.

There is ample evidence that cues paired with the consumption of alcohol can alter one's cognitive ability and subjective experience when intoxicated (Birak et al., 2010; Larson & Siegel, 1998; Newlin, 1985, 1986; Remington et al., 1997; White et al., 2002). For instance, Birak and colleagues (2010) observed a reduction in cognitive impairment and an increase in alertness when a familiar alcoholic beverage was consumed compared to an unfamiliar beverage. One important detail is that this phenomenon was observed despite there being no group difference in BrAC (Birak et al., 2010). In the present study, there was a significant group difference in BrAC. This difference is likely not due to a compensatory response, as this has not been observed in
previous studies. Additionally, the conditioned compensatory response theory (Siegel, 1975; for a review, Siegel et al., 2000) would predict the opposite effect, that the familiar beverage group would reach a lower BrAC than the unfamiliar group.

The difference in BrAC may be better accounted for by differences in the beverages’ composition. Both the non-alcoholic beer in the familiar beverage and the Mountain Dew in the unfamiliar beverage were comprised of carbonated water. However, the amount of carbonation in the unfamiliar beverage was reduced by the addition of orange juice. Greater levels of carbonation in an alcoholic beverage have been found to produce a higher peak BrAC by accelerating the absorption of the alcohol (Roberts & Robinson, 2007). This is one plausible explanation for the group difference in BrAC and should be taken into account in future studies.

It is possible that a conditioned compensatory response was induced in the present study but was unobservable due to the group difference in BrAC. For instance, dose response studies have demonstrated that the greater one’s blood alcohol concentration the greater impairment one experiences (Duke, Giancola, Morris, Holt, & Gunn, 2011; Tiplady et al., 2005b). There were no group differences in impairment in the present study, despite the fact that the familiar group reached a higher BrAC than the unfamiliar group. The lack of evidence for this dose response in the present study may be a result of a compensatory response; however, other extraneous variables cannot be ruled out.

Our findings also indicated that the familiar beverage group experienced greater stimulation than the unfamiliar beverage group. Though this finding is in line with previous research (Birak et al., 2010), it cannot be discerned whether this was due to a conditioned compensatory response or the group difference in BrAC. Alcohol is both a
stimulant and a depressant (Martin et al., 1993). The familiar group could have experienced greater stimulation due to their higher blood alcohol concentration, rather than a compensatory response. Again, the group difference in BrAC confound our findings, making it impossible to disentangle whether our findings are due to a compensatory response or higher breath alcohol levels.

Another potential explanation for the null results is the use of an opportunistic study design. An opportunistic design relies on contextual cues being conditioned to the effects of alcohol extra-experimentally. Though this design has been utilized in previous studies (Birak et al., 2010; Remington et al., 1997), it is possible that the sensory cues (i.e., color, taste, smell) associated with our familiar beverage differed from those that participants are conditioned to outside of the laboratory (e.g., dark beers vs. light beers). Therefore, it is unclear how conditioned the participants were to the sensory cues for the familiar beverage in the present study. A more in depth assessment of participants’ conditioning to specific cues would reduce the effect of this limitation.

Individuals are inaccurate regarding their perceptions of their ability to drive when alcohol’s effect is obscured as a result of tolerance (Marczinski & Fillmore, 2009). For instance, acute tolerance increases the risk of drinking and driving on the descending limb of the blood alcohol curve compared to the ascending limb (Marczinski & Fillmore, 2009; Marczinski et al., 2008). One goal of the present study was to examine the influence of situation-specific tolerance due to a compensatory response on drinking and driving decision-making. The results from the present study suggest that sensory cues common to alcoholic beverages neither decrease alcohol’s cognitive and motor impairment nor increase the likelihood of drinking and driving. However, the
interpretation of these results is confounded by the difference in BrAC between the two
groups. Given the detrimental impact of drinking and driving, future research
investigating the effect of tolerance (i.e., chronic, acute, situation-specific) on drinking
and driving research is needed.

One direction for future research is to manipulate contextual cues in addition to
sensory cues to test the effect of a conditioned compensatory response on drinking and
driving decision-making. For instance, McCusker and Brown (1990) tested the effect of a
conditioned compensatory response by having participants drink in either a simulated bar
(typical drinking setting) or an office (atypical drinking setting). Drinking and driving is
likely to occur after drinking at venues such as bars (Snow & Landrum, 1986; Tin Tin et
al., 2008). However, it is unclear whether the contextual cues associated with such
drinking venues increase the risk of drinking and driving.

Another direction for future research is to test whether binge drinkers exhibit a
stronger conditioned compensatory response than moderate drinkers. Binge drinkers are
classified as consuming five or more drinks for men or four or more drinks for women on
one occasion (National Institute on Alcohol Abuse and Alcoholism, 200; Wechsler &
Austin, 1998; Wechsler & Nelson, 2001). Recent laboratory studies have demonstrated
that after a moderate dose of alcohol, binge drinkers display greater acute tolerance than
non-binge drinkers (Marczinski & Fillmore, 2009; Marczinski et al., 2008). To our
knowledge, no study has tested whether this difference also holds for situation-specific
tolerance. Binge drinkers may experience a stronger compensatory response because cues
common to their drinking environment have been conditioned to greater alcohol
impairment. How binge drinking interacts with the development of situation-specific
tolerance warrants investigation, especially considering the negative consequences associated with binge drinking (Naimi, Nelson, & Brewer, 2009; Wechsler & Nelson, 2001).
Footnotes

1Pint glasses were used to simulate the typical glasses used at local bars and restaurants to enhance the familiarity of the beverage.

2Coffee mugs were used to further create an atypical drinking situation. The mugs had the same shape and dimensions as the pint glasses used in the familiar beverage condition. The only difference was that the mugs had a handle on the side and were black, whereas the pint glasses did not have a handle and were clear.

3The mixture for the unfamiliar condition consisted of two parts diet non-caffeinated Mountain Dew, one part pulp-free orange juice, and grape Kool-Aide powder (1 tsp/237 mL). This mixture resulted in a greenish-brown color with a froth layer lining the top and had a sweet, grape aroma. The mixture was chosen because its appearance, taste, and smell were unlike other typical mixed alcoholic drinks.
Figure 1. Study Procedure

- Questionnaire Measures (60 mins)
- Alcohol Consumption (15 mins)
- 2nd Measurement Point (7 mins)
- 3rd Measurement Point (7 mins)
- 4th Measurement Point (7 mins)
- 5th Measurement Point (7 mins)
- Tasks Practice Blocks (20 mins)
- Alcohol Absorption (15 mins)
- 1st Task (15 mins)
- 2nd Task (15 mins)
- 3rd Task (15 mins)
Table 1

Table 1. Study Hypotheses

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Familiar Beverage Group</th>
<th>Unfamiliar Beverage Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual BAC</td>
<td>No Group Difference</td>
<td>No Group Difference</td>
</tr>
<tr>
<td>Perceived BrAC</td>
<td>Lower Perceived BAC</td>
<td>Higher Perceived BAC</td>
</tr>
<tr>
<td>Actual vs. Perceived BrAC</td>
<td>Underestimate BAC</td>
<td>Overestimate BAC</td>
</tr>
<tr>
<td>Intoxication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective Intoxication</td>
<td>Less Subjective</td>
<td>Greater Subjective</td>
</tr>
<tr>
<td></td>
<td>Intoxication</td>
<td>Intoxication</td>
</tr>
<tr>
<td>Impairment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Performance Impairment</td>
<td>Less Performance</td>
<td>Greater Performance</td>
</tr>
<tr>
<td></td>
<td>Impairment</td>
<td>Impairment</td>
</tr>
<tr>
<td>Subjective Performance Impairment</td>
<td>Less Impairment</td>
<td>Greater Impairment</td>
</tr>
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<td>Subjective vs. Actual Impairment</td>
<td>No Difference</td>
<td>No Difference</td>
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<tr>
<td>Drinking and Driving</td>
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<tr>
<td>Perceived Ability to Drive</td>
<td>Greater Perceived</td>
<td>Less Perceived Ability</td>
</tr>
<tr>
<td></td>
<td>Ability to Drive</td>
<td>to Drive</td>
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Table 2. Demographic, Drinking, and Drinking and Driving Variables Separated by Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Familiar Beverage (N = 29)</th>
<th>Unfamiliar Beverage (N = 31)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Age</td>
<td>22.14</td>
<td>2.89</td>
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<tr>
<td>Gender (men:women)</td>
<td>21:8</td>
<td></td>
<td>28:3</td>
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<tr>
<td>Past month alcohol use</td>
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<td></td>
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<tr>
<td>Drinking frequency</td>
<td>10.10</td>
<td>4.64</td>
<td>10.45</td>
</tr>
<tr>
<td>Drinking quantity</td>
<td>4.55</td>
<td>2.52</td>
<td>4.29</td>
</tr>
<tr>
<td>Binge frequency</td>
<td>4.40</td>
<td>3.34</td>
<td>4.36</td>
</tr>
<tr>
<td>Max. consumption</td>
<td>10.31</td>
<td>4.03</td>
<td>10.61</td>
</tr>
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<td>Have driven after</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(past 3 month)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 drink</td>
<td>4.02</td>
<td>3.48</td>
<td>4.63</td>
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<tr>
<td>3 drinks</td>
<td>1.86</td>
<td>1.75</td>
<td>2.09</td>
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<tr>
<td>5 or more drinks</td>
<td>0.59</td>
<td>0.82</td>
<td>0.38</td>
</tr>
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</table>
Table 3.

Breath Alcohol Concentrations (BrACs) at Each Measurement Point Separated by Group

<table>
<thead>
<tr>
<th>Measurement Points</th>
<th>Familiar Beverage (N = 29)</th>
<th>Unfamiliar Beverage (N = 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (mg%)</td>
<td>SD</td>
</tr>
<tr>
<td>15 mins. post-consumption</td>
<td>0.082</td>
<td>0.022</td>
</tr>
<tr>
<td>30 mins. post-consumption</td>
<td>0.093</td>
<td>0.019</td>
</tr>
<tr>
<td>45 mins. post-consumption</td>
<td>0.090</td>
<td>0.015</td>
</tr>
<tr>
<td>60 mins. post-consumption</td>
<td>0.086</td>
<td>0.015</td>
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REFERENCES


