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Alcohol effects on simulated driving performance and self-perceptions of impairment in DUI offenders

Nicholas Van Dyke and **Mark T. Fillmore***
University of Kentucky, Department of Psychology, 171 Funkhauser Dr. Lexington KY 40506-0044, USA

Nicholas Van Dyke: Nicholas.Vandyke@uky.edu

Abstract

Drivers with a history of driving under the influence (DUI) of alcohol self-report heightened impulsivity and display reckless driving behaviors as indicated by increased rates of vehicle crashes, moving violations, and traffic tickets. Such poor behavioral self-regulation could also increase sensitivity to the disruptive effects of alcohol on driving performance. The present study examined the degree to which DUI drivers display an increased sensitivity to the acute impairing effects of alcohol on simulated driving performance and overestimate their driving fitness following alcohol consumption. Adult drivers with a history of DUI and a demographically-matched group of drivers with no history of DUI (controls) were tested following a 0.65 g/kg alcohol and a placebo. Results indicated that alcohol impaired several measures of driving performance and there was no difference between DUI offenders and controls in these impairments. However, following alcohol DUI drivers self-reported a greater ability and willingness to drive compared with controls. These findings indicate that drivers with a history of DUI might perceive themselves as more fit to drive after drinking which could play an important role in their decisions to drink and drive.

Keywords

Simulated driving; alcohol; DUI; subjective effects; driving ability

Introduction

Driving while intoxicated leads to an estimated 120 million occurrences of impaired driving per year (Evans, 2004). The most recent reports indicate that alcohol was a factor in 10,322 motor vehicle fatalities in the US, or an average of one alcohol-related fatality every 51 minutes (NHTSA, 2013). In the United States, a “per se” law determines the legal blood alcohol concentration (BAC) for which a driver can operate a motor vehicle. The current legal limit in all 50 states is 80 mg/100 mL (0.08%). Driving under the influence of alcohol (DUI) is a criminal offense defined as driving with a BAC in excess of 0.08% (Insurance

*Corresponding author. Tel.: +1 859 257 4728; fax: +1 859 323 1979. fillmore@uky.edu (M.T. Fillmore).

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Institute for Highway Safety, IIHS, 2013). Research has shown that approximately 1 in every 127 licensed drivers is arrested for DUI and over one-third of DUI offenders will re-offend within a three year period (Nochajski & Stasiewicz, 2006). Research also indicates that DUI offenders with multiple offenses (i.e., recidivists) are overrepresented in the costs associated with alcohol-related traffic crashes (Evans, 2004). Thus, research has focused on identifying characteristics of DUI offenders in order to improve existing treatment and prevention efforts and reduce rates of recidivism.

Driving records indicate that DUI offenders are involved in more accidents and commit more moving traffic violations (e.g., swerving or speeding) than individuals without a history of DUI (Bishop, 2011; McMillen, Pang, Wells-Parker, & Anderson, 1992). Increased traffic accidents and violations could reflect tendencies to act impulsively or take risks while driving. Survey and personality inventories have continually identified traits of impulsivity in the DUI offender (Chalmers et al., 1993). Broadly defined, impulsivity refers to a pattern of under-controlled behavior in which the individual lacks the ability to delay gratification and seek rewards without forethought or consideration of potential punishment or other negative consequences. Multiple studies have linked impulsivity with impaired driving, reduced perceptions of one’s surroundings while in control of a motor vehicle, accidents, and drunk driving (e.g., Hansen, 1988; McCarthy, Niculete, Treloar, Morris, & Bartholow, 2012; Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996).

Laboratory studies of simulated driving performance clearly demonstrate that alcohol impairs several aspects of driving performance that are critical to the safe operation of a motor vehicle. Alcohol impairs the ability to maintain stable position in the lane, and slows braking time and reduces the ability to detect potential hazards on the roadway (for reviews see Liguori, 2009; Martin, Solbeck, Mayers, Langille, Buczek, & Pelletier, 2013; Ogden & Moskowitz, 2004). Moreover, these disruptive effects can be reliably observed at BACs that are below the legal limit of 0.08%. Driver simulations have also linked measures of trait impulsivity to risky driving behavior. For example, one study showed that drivers who reported high levels of sensation-seeking displayed riskier driving behaviors than drivers who reported low levels of sensation-seeking (Schwebel, Severson, Ball, & Rizzo, 2006). Such a relationship might be especially evident when the driver is intoxicated. A study of alcohol effects on simulated driving performance in our laboratory showed that drivers whose impulse control was most impaired by alcohol also tended to display the poorest driving performance under the drug (Fillmore, Blackburn, & Harrison, 2008).

Impulsivity also might be especially relevant to driving in situations that emphasize response conflict (Fillmore et al., 2008). Response conflict refers to the simultaneous occurrence of any two competing response tendencies, such as approach and avoidance (Kanfer & Karoly, 1972). In the case of driving, opposing tendencies can be simultaneously activated when drivers are rewarded and punished for displaying a specific driving behavior, such as speeding. There may be a strong instigation to speed in order to arrive at a destination on time. Conflicting with this tendency is the incentive to avoid speeding and risky driving behaviors as these behaviors could result in traffic citations or personal injury. Drivers with high levels of impulsivity might be most likely to display reckless driving under such conflict as they would respond to the potential rewards for speeding while failing to consider the potential negative consequences that would otherwise temper the impulse to speed.

Response conflict can also heighten reactions to alcohol. Studies show that the disinhibiting effects of alcohol can be exacerbated by response conflict (Conger, 1956; Curtain & Fairchild, 2003; Fillmore & Vogel-Sprott, 2000). With respect to driving, alcohol might be most likely to produce reckless driving behavior when the driver is operating the vehicle in a situation of response conflict. Indeed we have shown in the laboratory that the impairing effects of alcohol on simulated driving performance are increased in situations of response conflict where speeding resulted in monetary rewards but also led to conflicting monetary losses (Fillmore et al., 2008).

Taken together these findings implicate impulsivity as a risk factor for risky/reckless driving, and possibly greater disruptive effects of alcohol on driving performance. Given that such impulsive tendencies are commonly ascribed to DUI offenders, it is likely these individuals would engage in risky driving behavior in driving simulations in the laboratory. Moreover, such impulsivity among DUI offenders could increase their sensitivity to the disruptive effects of alcohol on driving performance, especially in situations of response conflict.

It is also important to consider factors that can influence the decision to drive following a drinking episode. Decisions to drive after drinking are based on both environmental factors and interoceptive cues within an individual. One important interoceptive cue that has been examined in research is perceived intoxication (Beirness, 1987). Self-evaluations of intoxication are made based on subjective and behavioral changes, such as sedation and slurred speech, and self-evaluations of these cues can contribute to the drinker’s decision to drive or not to drive (Marczinski & Fillmore, 2009). In the laboratory, self-reported levels of subjective intoxication are often measured using rating scales (e.g., 100 mm visual analogue). Overall, research has shown that people are often inaccurate at estimating levels of intoxication following doses of alcohol. Early studies required participants to estimate their BACs at different time points and found that participants often underestimated their BAC (Ogurzsoff & Vogel-Sprott, 1976). Beirness (1987) assessed intoxication by asking participants to evaluate their perceived ability to drive a vehicle following alcohol and found that perceived ability to drive became less accurate as BAC increased. More recent studies show that participants often underestimate their BAC and amounts of alcohol consumed (Marczinski, Combs, & Fillmore, 2007). Together, these findings support the general assumption that drivers are poor evaluators of interoceptive cues of intoxication, and therefore could perceive themselves fit to drive despite being legally impaired. To date, no laboratory studies have examined DUI offenders to determine their ability to accurately appraise their intoxication following alcohol consumption and how such self-appraisals could affect their decisions to drive. DUI offenders could self-report less subjective intoxication and perceived impairment leading them to more readily drive under the influence of alcohol, which could account for their DUI offense.

The current study compared a group of drivers with a history of DUI to a non offending control group of drivers and examined their simulated driving performance and their perceptions of driver fitness and intoxication following a 0.65 g/kg dose of alcohol and a placebo. Driver performance was tested in two different driving scenarios. One scenario emphasized driving precision and vigilance where drivers navigated winding, rural roads while maintaining proper lane control and adhering to apre-determined speed limit. The other scenario emphasized driver response conflict where drivers earned monetary rewards for finishing the drive in the shortest time but also incurred monetary losses for failing to adhere to traffic laws (i.e., failing to stop at red lights). Given that DUI offenders report traits of impulsivity, it was predicted they would display poorer performance on multiple aspects of driving (e.g., lane position, steering rate, line crossings) in the sober state and under alcohol compared with control drivers. The impairing effects of alcohol were expected to be most pronounced in the conflict driving scenario where impulsive actions may be exacerbated by the presence of monetary incentives. Thus, it was expected that the largest differences between DUI offenders and controls would be evident under response conflict. With regard to self-perceptions of driver fitness and intoxication, DUI offenders were expected to report greater willingness and ability to drive and less subjective intoxication under alcohol compared with controls.

Methods

Recruitment and Screening

Fifty adults between the ages of 21 and 34 participated in the study. Volunteers consisted of 25 DUI offenders (7 women and 18 men) and 25 non-offending controls (7 women and 18 men). We expected more men in the DUI group, as data estimates the ratio of male to female offenders as 4:1 (U.S. DOT, 2005). Thus, the DUI group was recruited first, and indeed, was comprised of 2.5 times as many males as females (18 men and 7 women). To maintain a comparable sex makeup among the groups, the same sex composition of participants was recruited for the control group. Online postings and fliers placed around the greater Lexington community advertised for the recruitment of individuals for studies on the effects of alcohol on behavioral and mental performance. Some of the advertisements directly targeted individuals arrested for a DUI offense. DUI offenders had to have at least one alcohol-related conviction in the past five years whereas control subjects could not have had any prior DUI convictions or license revocations. All DUI convictions were verified by State District Court Record Reporting Systems (e.g., Courtnet©). Interested individuals called the laboratory and underwent a telephone screening during which information on demographics, drinking habits, drug use, and physical and mental health was gathered. Individuals reporting any psychiatric disorder, CNS injury, or head trauma were excluded from participation. Those reporting a substance use disorder other than alcohol were also excluded. All volunteers were current consumers of alcohol, but were excluded if their current alcohol use met dependence/withdrawal criteria as determined by the substance use disorder module of the *Structured Clinical Interview for DSM-IV* (*SCID-IV*). Individuals consuming fewer than two standard drinks per month were also excluded from participation. All volunteers had to hold a valid driver's license for the past three years and had to drive on a weekly basis. No participant reported the use of any psychoactive prescription medication and recent use of amphetamines (including methylphenidate), barbiturates, benzodiazepines, cocaine, opiates, and tetrahydrocannabinol was assessed by means of urine analysis. Any volunteer who tested positive for the presence of any of these drugs during any test session was excluded from the study. No female volunteers who were pregnant or breast-feeding participated in the research, as determined by self-report and urine human chorionic gonadotrophin levels. The University of Kentucky Medical Institutional Review Board approved the study. All study volunteers provided informed consent and received $110 for their participation.

Apparatus and Materials

Simulated driving task (STISIM Drive, Systems Technology Inc., Hawthorne, CA)—A computerized driving simulator was used to measure driving performance. The simulation placed the participant in the driver seat of the vehicle which was controlled by steering wheel movements and manipulations of the accelerator and brake pedals. At all times, the participant had full view of the road surroundings and instrument panel, which included an analog speedometer. Buildings, animals, and trees in addition to other cars, which required no passing or slowing on the part of the participant, were present in each scenario. Crashes, either into another vehicle or off the road, resulted in the presentation and sound of a shattered windshield. The program then reset the driver in the center of the right lane at the point of the crash. The program provided measurements of the deviation of lane position, steering rate, line crossings, and average speed across a drive test.

Precision drive—This 15-minute simulated driving course consisted of 80,000 feet or approximately 15.15 miles and was conducted on a rural, two-lane highway with overcast skies and few buildings designed to mimic what a driver might encounter driving through the countryside. Drivers were instructed to accelerate to and maintain a constant speed of 55 mph while remaining in the center of the right lane for the entire duration of the drive. The drive scenario included both straight and winding roads, requiring vigilance on the part of the driver in order to maintain the center of the lane and the required speed throughout. The drive task has been used in other research and has shown to be sensitive to the impairing effects of alcohol (e.g., Harrison et al., 2007; Marczinski & Fillmore, 2009).

Conflict drive—This 5–10 minute simulated driving course consisted of 31,100 feet (5.9 miles) conducted during the daytime on a busy, urban street. Participants were instructed to obey all traffic laws while driving through 20 intersections equipped with traffic lights. Red lights were present at five intersections requiring the driver to stop until the light turned green. At all of the other intersections the light was either green or yellow as the car passed and did not require any action on the part of the driver. Response conflict was introduced by providing monetary rewards for completing the drive in the shortest time while drivers were penalized 50 cents for failing to stop at each red light. Participants earned $5 for completing the drive in less than 5 minutes, $4 for finishing in 6–7 minutes, $3 for 7–8 minutes, $2 for 8–9 minutes, $1 for 9–10 minutes, and 50 cents if the driver finished in greater than 10 minutes. Participants were informed of these incentives prior to completing the drive test and the rewards earned on the drive were revealed to the participants at the end of each session. This drive scenario has been used in other research and has shown sensitivity to the impairing effects of alcohol (e.g., Fillmore et al., 2008; Marczinski, Harrison, & Fillmore, 2008).

Perceived driver fitness—Participants self-evaluated their willingness and ability to drive a motor vehicle on 100 mm visual-analogue scales that ranged from 0 "not at all" to 100 "very much."

Perceived intoxication and BAC estimation—Participants evaluated their level of intoxication on 100 mm visual-analogue scales with anchors of 0 "not at all" to 100 "very much." Participants also evaluated their current BAC on a scale ranging from 0 to 160 mg/100 ml. Information about the current legal driving limit in the US (i.e. 80 mg/100 ml) was provided to each participant. These scales have been used in other alcohol studies of driving and are sensitive to the effects of the drug (e.g., Harrison & Fillmore, 2005; Harrison, Marczinski & Fillmore, 2007).

Driving History and Experience Questionnaire – DHEQ (Harrison & Fillmore, 2005)—This self-report questionnaire gathered information on driving history and behaviors. Included in the questionnaire are measures of driving experience such as length of time holding a driver's license and number of days and miles driven per week. The questionnaire also gathered information about participants' driving behaviors, such as license revocations, presence and number of DUI citations and punishments, traffic accidents, traffic tickets, typical driving environment (rural, urban, and interstate), and the type of vehicle transmission (manual, automatic, or both).

Drinking and driving questionnaire—This self-report questionnaire gathered information on individuals' drinking and driving history. The questionnaire asked participants to respond to questions about drinking and driving history on 4 or 5 point Likert scales. The questionnaire included a measure of frequency of drinking and driving and typical quantity of alcohol consumed before driving. The items were obtained from a scale reported by McCarthy et al. (2012).

Recent Drinking Habits—Recent patterns of alcohol use were measured by the Timeline Follow-back (TLFB, Sobell & Sobell, 1992). The TLFB assessed daily patterns of alcohol consumption over the past 3 months. The measure is structured with prompts to facilitate participants' recall of past drinking episodes to provide a more accurate retrospective account of alcohol use during that time period. Multiple aspects of alcohol consumption over the past 3 months are measured including the total number of drinking days, the total number of drinks consumed, drinking days that they felt drunk (drunk days), and binge drinking episodes. A binge was defined as a drinking episode in which the individual drank to achieve a resultant BAC that was equal to or greater than 80 mg/100 ml (legal limit for operated a motor vehicle in the United States). The resultant BAC was estimated for each drinking episode based on the participant's reported number of drinks, the duration of the episode, and the participant's gender and body weight. Estimated BACs were calculated using well-established, valid anthropometric-based BAC estimation formulae which assume an average clearance rate of 15 mg/dl per hour of the drinking episode (McKim, 2007; Watson, Watson, & Batt, 1981).

Drug Abuse Screening Test – DAST (Skinner, 1982)—This 28-item self-report questionnaire screened for drug abuse problems. A score of six or more has been suggested as indicative of a drug use disorder (Skinner, 1982).

Alcohol Use Disorder Identification Test – AUDIT (Babor et al., 1989)—This 10-item self-report questionnaire was used to assess consequences of harmful drinking. Higher total scores indicate greater problems with alcohol.

Barratt Impulsiveness Scale – BIS-11 (Patton et al., 1995)—This 30-item self-report questionnaire is designed to measure the personality dimension of impulsivity. Participants rated 30 different statements on a 4-point Likert-type scale ranging from “Rarely/Never” to “Almost Always/Always”. Higher total scores indicate higher levels of self-reported impulsiveness (score range 30–120).

Blood alcohol concentrations (BACs)—BACs were determined from breath samples measured by an Intoxilyzer, Model 400 (CMI Inc., Owensboro, KY).

Procedure

The study was conducted in the Behavioral Pharmacology Laboratory of the Department of Psychology at the University of Kentucky and all volunteers provided informed consent. Volunteers were informed that the purpose of the study was to examine the effects of alcohol on driving performance and other cognitive and behavioral tasks. Participants were tested individually and completed an initial familiarization session to become acquainted with laboratory procedures, practice the simulated driving tasks, and gather background information.

Participants were tested under 0.65 g/kg alcohol and a placebo on separate days and the dose order was counter balanced across volunteers and groups. Sessions were separated by a minimum of one day and a maximum of one week. All participants were required to abstain from alcohol for 24 hours and food for 4 hours prior to each session. The alcohol dose was calculated based on body weight and administered as absolute alcohol mixed with three parts carbonated soda. Participants consumed the dose in six minutes. The dose produces an average peak BAC of 80 mg/100 ml approximately 60–70 minutes after consumption. The placebo dose (0.0 g/kg) consisted of a volume of carbonated mix that matched the total volume of the 0.65 g/kg alcohol drink. A small amount (i.e., 3 ml) of alcohol was floated on the top of the beverage and each glass was sprayed with an alcohol mist that provided a strong alcoholic scent as the beverage was consumed.

Testing began 20 minutes post-beverage consumption. Participants first completed the precision drive test followed by the conflict drive test. Drive tests were separated by a 5 minute inter-test interval. Timing and test order were identical across each dose session. At 70 minutes post-beverage, participants were moved to another room where they were allowed to relax at leisure within the laboratory. During this time, they provided self-evaluations of their perceived driving fitness and intoxication beginning at 70 minutes post-beverage and again every 45 minutes until 250 min post-beverage. BAC readings were taken at 20, 40, 60, 70, 115, 160, 205, and 250 minutes. At 250 minutes the majority of participants had BACs at or below 20 mg/100 ml and they were allowed to leave. If not, participants remained in the laboratory until their BAC fell below 20 mg/100 ml upon which they were paid and debriefed. Participants in the placebo dose session were kept in the laboratory until 250 minutes post beverage consumption in order to gather subjective ratings across the declining limb and maintain the experimental blind. Transportation home was provided after the sessions.

Criterion Measures

Several measures of driving performance were chosen for analysis in each driving task. The measures were intended to provide a profile of the driving behaviors typically impaired as a result of alcohol intoxication and were chosen on the basis of their established sensitivity to the disruptive effects of alcohol as demonstrated in previous research (Harrison & Fillmore, 2005).

Deviation of lane position—Within-lane deviation was determined by the lane position standard deviation (LPSD) of the driver's mean vehicular position within the lane, measured in feet. The within-lane deviation measure is an indicator of the degree of adjustment by the driver to maintain a desired position within the lane. Greater within-lane deviation indicates poorer driving performance. A single lane position standard deviation (LPSD) score for a test was obtained by averaging deviation measures sampled at each foot of the driving test.

Steering rate—This is a measure of the rate with which the driver turns the steering wheel in order to maintain the vehicle's position on the road. Sober drivers typically maintain their position on the road by executing continuous, smooth steering wheel movements. Alcohol-impaired drivers can be slow to make adjustments to their road position requiring them to execute quick, abrupt manipulations to the steering wheel. These late corrections are reflected by an increased steering rate value. Steering rate was measured in terms of the average degree change per second in the steering wheel during a test.

Centerline and road edge crossings—A line crossing occurred when the vehicle moved outside the lane, either crossing over the centerline into oncoming traffic or the road edge line onto the shoulder of the road. The total number of line crossings was recorded for each test.

Drive speed—Drive speed was measured in terms of miles per hour (mph) and speed was measured as the average mph of the vehicle during a test.

Time to finish and stop fails—Drivers' time to finish and the total number of failures to stop at red lights on the conflict drive were recorded.

Data analyses—The performance measures on the driving tests were each analyzed individually by a 2 Group (DUI vs. control) × 2 Dose (0.0 g/kg vs. 0.65 g/kg) × Sex (men vs. women) mixed-design analysis of variance (ANOVA). Measures of self-reported driving fitness and perceived intoxication following the active dose (0.65 g/kg) were analyzed individually by 2 Group (DUI vs. control) × 5 Time (70, 115, 160, 205, and 250 minutes) × 2 Sex mixed ANOVAs. BACs under alcohol were analyzed by a 2 Group (DUI vs. control)

× 8 Time (20 minutes – 250 minutes) × Sex mixed ANOVA. There was no sex difference in BAC or driving performance and none of the analyses revealed significant interactions involving sex. Therefore the sex factor is not included in the analyses reported in the Results section.

Results

Demographics, drinking and driving history, and other drug use

Table 1 lists the demographic and other background characteristics of drivers in the DUI and control groups. The racial makeup of the DUI group was 80% Caucasian, 16% African-American, and 4% Hispanic. Three participants in the DUI group were recidivist offenders; two individuals reported having 2 previous offenses and one individual reported 4 previous offenses. In the control group, 84% of the participants self-reported Caucasian, 8% African-American, 4% American Indian/Alaskan Native, and 4% Other. Driving experience was determined based on years of licensed driving, number of driving days per week, total weekly miles driven, number of traffic tickets, and number of accidents in which the participants was the driver of the vehicle. Comparisons between DUI and control drivers using post-hoc, two-sample t tests showed no group differences on any measure of driving experience (*ps* > .21).

In terms of drinking history, DUI offenders did not differ from controls in total number of drinks consumed, $t(48) = 0.43$, $p = .67$, number of drinking days, $t(48) = 0.41$, $p = .97$, number of binge episodes, $t(48) = 0.48$, $p = .64$, or self-reported drunk days in the past 3 months, $t(48) = 1.01$, $p = .32$. When examining driving following drinking, DUI offenders reported a greater lifetime frequency of drinking and driving, $t(48) = 2.17$, $p = .04$. However, there were no group differences in the typical quantity of alcohol consumed before driving or past year drinking and driving habits (*p*s > .14).

In terms of other drug use, four subjects in the DUI group and five control subjects reported using cannabis an average of 2 days in the past month. However, no subject tested positive for THC at testing. Fourteen subjects in the control group (*M* = 30.79, *SD* = 24.61) and 8 subjects in the DUI group (*M* = 29.13, *SD* = 27.56) reported using nicotine in the past month. No other drug use was reported. In terms of problems associated with the use of alcohol and other drugs DUI offenders scored higher on the AUDIT, $t(48) = 2.22$, $p = .03$, but did not differ from controls on DAST scores ($p = .50$). The groups did not differ on impulsivity as measured by the BIS (p = .39).

Blood alcohol concentrations

BACs under alcohol were examined by a 2 (Group) × 8 (Time) ANOVA. A main effect of time owing to the rise and decline of BACs during the course of testing was found, $F(7, 330) = 147.71$, $p < .001$, $\eta_p^2 = 0.76$. No main effect of group or interaction was observed, ps > .23). Because BACs did not differ between DUI offenders and controls, readings at each time point were averaged across the entire sample. The mean BACs mg/100 ml at each interval were as follows: 20 min = 49.0 (*SD* = 18.6); 40 min = 62.4 (*SD* = 16.4); 60 min = 64.7 (*SD* = 15.4); 70 min = 72.0 (*SD* = 16.5); 115 min = 57.2 (*SD* = 11.1); 160 min = 44.9 (*SD* =

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10.4); 205 min = 34.3 (*SD* = 10.2); 250 min = 23.4 (*SD* = 9.6). No detectable BACs were observed in the placebo condition.

Simulated driving performance

Figure 1 plots the mean driving performance measure for each group following placebo and alcohol during the precision drive test. 2 (Group) × 2 (Dose) ANOVAs revealed significant dose effects on lane position standard deviation, $F(1, 48) = 8.32$, $p = .006$, $\eta_p^2 = .15$, steering rate, $F(1, 48) = 11.74$, $p = .001$, $\eta_p^2 = .20$, and line crossings, $F(1,48) = 4.52$, $p = .039$, $\eta_p^2 = .09$. The figure shows that, compared with placebo, alcohol increased drivers' lane position standard deviation, steering rate, and number of line crossings. No significant main effects of group or interactions were found for any of these measures (*ps* > .41). An ANOVA of drive speed found no significant main effects or interactions (*ps* > .10).

For the conflict drive similar results were found. 2 (Group) × 2 (Dose) ANOVAs revealed significant dose effectson lane position standard deviation, $F(1, 48) = 29.78$, $p < .001$, $\eta_p^2 = .39$, and line crossings, $F(1, 48) = 14.834$, $p < .001$, $\eta_p^2 = .24$. Compared with placebo, alcohol increased drivers' lane position standard deviation and the number of line crossings in a similar fashion as the precision drive test. ANOVAs of steering rate and drive speed found no significant main effects or interactions (*ps* > .17). An ANOVA of drivers' time to finish the drive test found no significant main effects or interactions (*p*s > .26). An ANOVA of failures to stop at traffic lights revealed a significant main effect of dose, $F(1, 48) = 13.05$, $p = .001$, $\eta_p^2 = .22$, with more failures to stop under alcohol. No main effect of group or interaction was obtained (*p*s > .51).

In sum, although alcohol impaired multiple aspects of driving performance in both driving scenarios, DUI offenders and controls did not differ in impairment or in overall driving performance.

Perceived driver fitness and intoxication

2 (Group) × 5 (Time) ANOVAs of willingness, ability, intoxication, and BAC estimation under placebo revealed no group differences. As expected when drivers were in the sober state (i.e., in the placebo condition), their initial self-reports of willingness and ability to drive were high and remained elevated over all time periods while reports of their subjective intoxication and BAC estimation were relatively low at each time point. Therefore, subsequent analyses are reported under alcohol only.

Perceived willingness and ability—A 2 (Group) × 5 (Time) ANOVA of self-reported willingness to drive revealed a significant main effect of time, $F(1, 48) = 84.863$, $p < .001$, $\eta_p^2 = .64$. This effect was qualified by a significant time × group interaction, $F(4, 189) = 3.05$, $p = .027$, $\eta_p^2 = .06$. These effects are plotted in Figure 2. Willingness to drive generally increased as BAC declined, and the groups reported similar levels of willingness to drive at 70 min post-beverage when BAC was at peak. However, DUI offenders reported greater willingness to drive compared to controls at all subsequent time points as BAC descended. Post-hoc two-sample *t* tests indicated that DUI offenders reported significantly greater willingness to drive 205 minutes (t[48] = 2.70, p = .010) and 250 minutes (t[48] = 2.76, p = .008) post-beverage.

A 2 (Group) × 5 (Time) ANOVA of self-reported ability to drive a motor vehicle revealed a significant main effect of time $F(4, 189) = 133.166$, $p < .001$, $\eta_p^2 = .74$. No main effect or interaction involving group was found (*ps* > .12). Figure 2 plots the effect. The figure indicates that perceived ability to drive increased as BAC declined. DUI offenders and control drivers reported similar levels of ability to drive at the peak BAC, however, DUI offenders reported a greater ability to drive across the declining limb of the BAC curve. Post-hoc *t* tests indicated that DUI offenders reported a significantly greater ability to drive 205 minutes (t[48] = 2.18, p = .034) and 250 minutes (t[48] = 2.48, p = .017) post-beverage.

Subjective intoxication and BAC estimation—2 (Group) × 5 (Time) ANOVAs revealed significant main effects of time for subjective intoxication, $F(4, 189) = 114.70$, $p < .001$, $\eta_p^2 = .71$, and estimated BAC, $F(4, 189) = 192.49$, $p < .001$, $\eta_p^2 = .80$. No significant group effects or interactions were observed for either measure (ps > .26). Figure 3 shows that drivers' subjective intoxication and their estimated BAC declined as observed BACs declined. The figure also shows that DUI offenders and controls reported similar levels of intoxication and provided similar estimates of their BACs.

The accuracy of drivers' estimated BACs was examined by correlating their estimated BACs to their observed BACs at each time point. No significant correlations were obtained (ps > . 61). The mean overall percentage accuracy of drivers' BAC estimation was 57.2%.

Correlations of impulsivity on simulated driving performance and willingness to drive—Bivariate correlations were conducted to examine the relationship of drivers' self-reported impulsivity scores to their simulated driving performance (LPSD and steering rate) under alcohol in precision and conflict drives, and to their willingness to drive, at the peak BAC. Given that the groups did not differ on self-reported impulsivity, the correlations were conducted based on the sample as a whole. Results indicated that drivers' impulsivity scores were not related to their driving performance measures in either drive or to their willingness to drive (*p*s > .27).

Discussion

The present study examined the acute impairing effects of alcohol on the simulated driving performance and the self-evaluations of driving fitness and perceived intoxication in DUI offenders and a control group of drivers without a history of DUI. The dose of alcohol produced an average peak BAC of 72 mg/100 ml and impaired multiple aspects of driving performance on each simulated driving test. Compared with placebo, alcohol increased the deviation of lateral position of the vehicle within the lane, increased driver-initiated manipulations to the steering wheel, and resulted in a greater number of centerline and road edge crossings. However, there were no group differences in the degree to which alcohol impaired driving performance. The results showed DUI offenders and controls displayed similar degrees of impairment in response to alcohol in all measures of driving performance. With regard to self-evaluations of driving fitness and perceived intoxication, there were group differences across the declining limb. Compared with controls, DUI offenders reported greater willingness and ability to drive a motor vehicle as BACs declined. However, there were no differences between DUI offenders and controls with respect to their levels of subjective intoxication or estimated BACs at any time point during the declining limb.

The finding that DUI offenders did not differ from control drivers on any measure of simulated driving performance on either drive test indicates that they may not necessarily display increased sensitivity to the disruptive effects of alcohol on driving performance. That is, DUI offenders might be just as impaired while driving a vehicle following a dose of alcohol as drivers without a DUI history. However, a key reason to predict that DUI offenders might display riskier driving and greater impairment from alcohol is that they are characterized by heightened impulsivity. But this was not confirmed in the current study, at least not by the BIS that was used to measure trait impulsivity in the drivers. It is not clear why this sample of DUI offenders failed to report heightened impulsivity compared with controls. The study took care to verify the DUI offense record of the sample and we also showed that DUI offenders indeed reported more instances drinking and driving compared with controls. However, the DUI group was comprised primarily of first-time offenders and some research has shown that it is recidivist offenders who are most likely to possess cognitive dysfunctions and heightened levels of impulsivity (Ouimet et al., 2007). Indeed, we have recently shown that repeat offenders differ from first-time offenders in their reactions to alcohol stimuli which indicate self-regulatory deficits specific to the repeat offender (Miller & Fillmore, in press). As such, it might be the recidivists, and not necessarily first-time offenders, who display heightened impulsivity which would sub-serve a pattern risky driving behavior.

In addition to a lack of group differences in impulsivity, we also found that the BIS measure of trait impulsivity was not correlated with any measure of simulated driving performance or willingness to drive. It is possible that a more extensive personality assessment of impulsivity that includes related constructs, such as reward sensitivity and sensation-seeking would better predict patterns of risky driving behavior among DUI offenders. It is also worthwhile considering that trait impulsivity might be too broad to reliably predict driving behavior in specific situations. Impulsivity is multi-faceted construct and researchers have pointed to a need to deconstruct the behavioral components of this construct to better understand the behavioral profile of the DUI offender (Fillmore, 2012; McCarthy et al., 2012). Laboratory assessments of specific behavioral mechanisms involved in impulsive behavior, such as inhibitory control and reward sensitivity, could reveal important behavioral characteristics of DUI offenders.

With regard to understanding decisions to drink and drive, the current study provides some of the first pieces of evidence that, in the intoxicated state, DUI offenders might overestimate their willingness and ability to drive a motor vehicle, suggesting that these individuals might be more likely to drive after drinking. This raises the important question as to why DUI offenders report greater ability and willingness to drive compared with controls. Some studies show that certain at-risk populations, such as binge drinkers, adults with ADHD, or individuals characterized by traits of impulsivity, over-estimate their ability when intoxicated (Marczinski, Harrison, & Fillmore, 2008; Weafer, Camarillo, Fillmore, Milich, & Marczinski, 2008). Drinkers likely use several factors to make judgments about their driving fitness after drinking. Judgments might be based, in part, on one's perceived behavioral impairment. In the current study, simulated driving performance on each drive test likely served as cues about the drivers' level of impairment following alcohol. Given that DUI offenders and controls were equally impaired by alcohol on their driving performance, this source of potential feedback seems unlikely to explain why DUI offenders reported greater ability and willingness to drive. Moreover, laboratory studies find that, unless drinkers are given explicit feedback about their performance under alcohol, they tend to be poor evaluators of their own degree of impairment (Aston & Liguori, 2013; Bois & Vogel-Sprott, 1974). Other factors in the drinking situation, such as interoceptive stimuli (e.g., light-headed, dizziness, sedation), might also serve as cues by which drinkers self-appraise their ability and their willingness to drive. Again, however, DUI offenders self-reported similar levels of subjective intoxication and estimated similar BACs as controls. Thus, it does not seem as though perceived intoxication can explain the greater perceived ability and willingness to drive in DUI offenders.

Another possible explanation is that the DUI offenders might simply ascribe to a deviant set of social norms that includes a permissive attitude towards drinking and driving. However, if this were the reason, then one might expect the DUI drivers in our study to consistently report a greater willingness to drive under alcohol regardless of the time under the dose that willingness was assessed. But, instead the study showed that greater willingness to drive among DUI offenders only became evident towards the end of the declining limb of the BAC curve. At the peak BAC and initial portion of the declining limb, DUI offenders were just as cautious as control drivers in terms of their self-reported ability and willingness to drive. This suggests that pharmacokinetics could be important in determining when, during the time-course of a dose, DUI offenders might be more apt to over-estimate their driving fitness. It might be that DUI offenders only over-estimate their ability on the declining limb, or more generally anytime BAC is low. This latter possibility would suggest DUI offenders might also over-estimate their ability during the early phase of the ascending limb of the blood alcohol curve. Over-estimations in one's ability while BAC is ascending could be especially risky. If an individual makes the decision to drive as BAC ascends, it is possible that their BAC could rise to or exceed the legal limit by the time they get behind the wheel. Therefore it is important to examine DUI offenders' perceived ability and willingness to drive during the early phase of drinking as BACs are ascending.

The current study is not without limitations. First, as mentioned above the DUI group is composed of first-time and recidivist offenders. Future studies should consider recidivist DUI offenders as a group distinct from first-time offenders. The fact that the study examined the effects of only one dose of alcohol is another limitation. The dose of alcohol was designed produce a BAC at that would approximate the current legal limit for driving (80 mg/100 ml) in the United States. With recent recommendations to reduce the legal driving limits in the United States and current limits around the world ranging from 20–50 mg/100 ml, it will be important for future studies examining the effects of alcohol in DUI offenders to include multiple doses that could provide additional information how behavioral impairments might differ in this high-risk population. To conclude, the findings point to the need for future laboratory studies to identify the cognitive and behavioral factors that underlie increased perceived driver fitness among DUI offenders in the intoxicated state which could play an important role in their decisions to drive after drinking.

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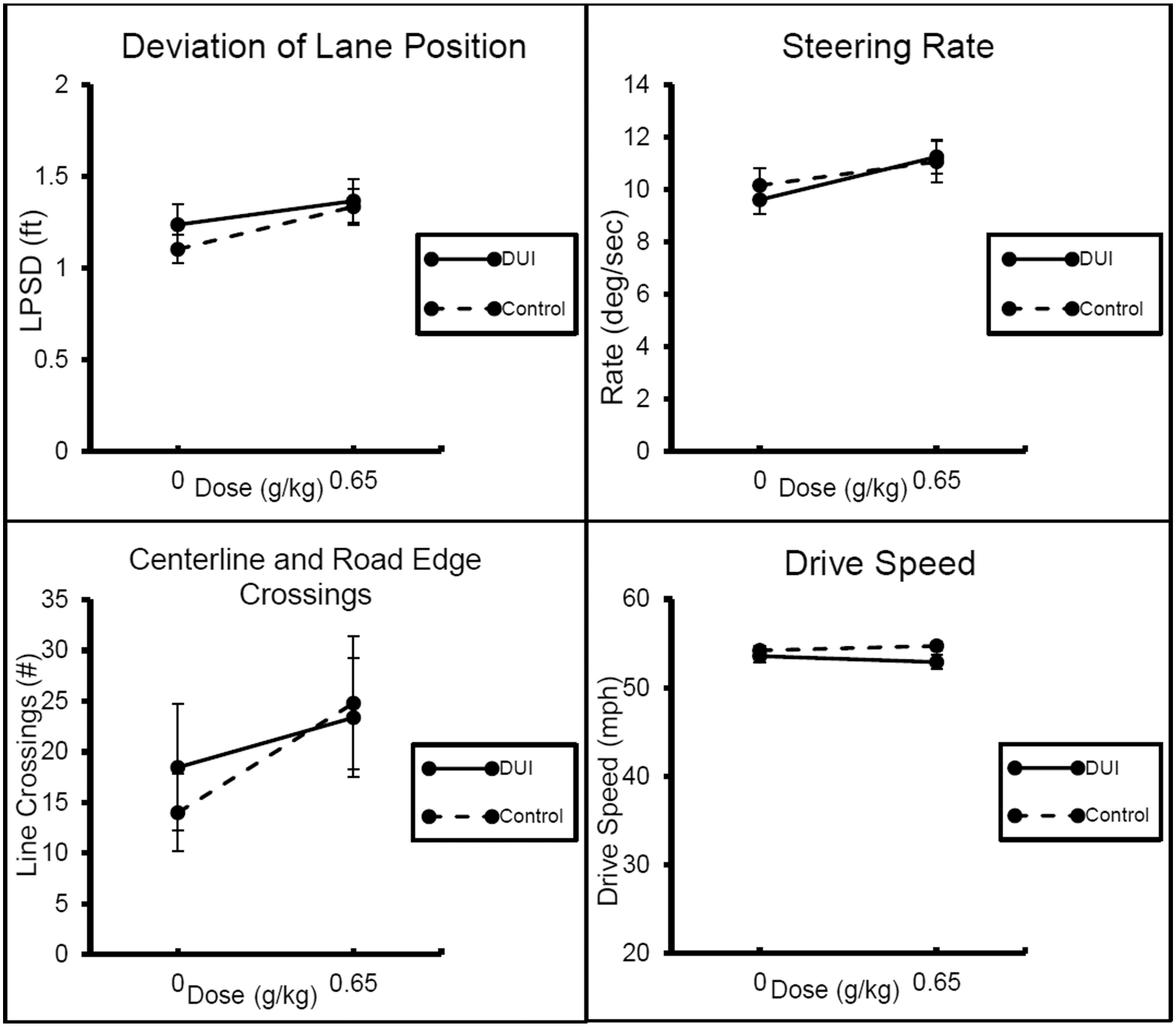

Figure 1. Simulated driving performance on the precision drive test

Top left = mean deviation of lane position (feet) following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Top right = mean steering rate in degrees/sec following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Bottom left = mean number of centerline and road edge crossings following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Bottom right = mean drive speed (miles per hour) following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Error bars indicate standard error of the mean.

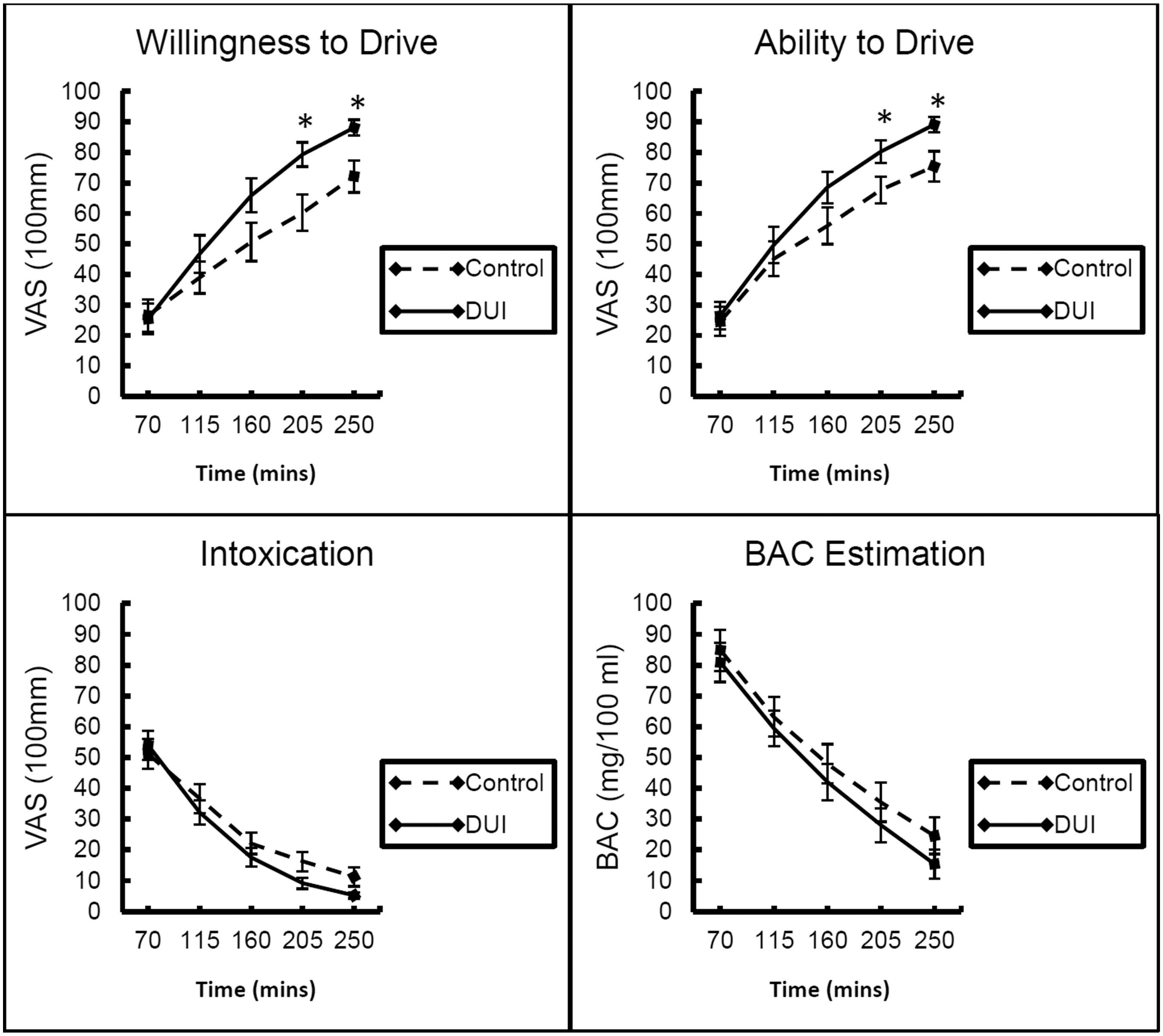

Figure 2. Perceived driving fitness

Top left = mean willingness to drive ratings on 100-point visual analogue scales following 0.65 g/kg alcohol for DUI and control drivers. Top right = mean subjective rating of driving ability on 100-point visual analogue scales following 0.65 g/kg alcohol for DUI and control drivers. Bottom left = mean subjective intoxication ratings on 100-point visual analogue scales following 0.65 g/kg alcohol for DUI and control drivers. Bottom right = mean BAC estimation ratings on a scale ranging from 0.0 g/% to 0.16 g/% following 0.65 g/kg alcohol for DUI and control drivers. Error bars indicate standard error of the mean. * denotes significant group difference.

Table 1

Demographics and drinking and driving history

Ratio (*n*): Men/Women	Controls 18/7		DUI Offenders 18/7			
	M	**(SD)**	**M**	**(SD)**	***t***	***p***
Age	24.65	(3.41)	25.95	(4.11)	1.09	0.28
Months since DUI	0	0	9.64	(16.10)	-	-
Years driving	9.01	(3.40)	9.92	(4.74)	0.77	0.44
Drive frequency	5.72	(1.97)	6.18	(1.49)	0.93	0.36
Drive distance	131.90	(115.32)	90.15	(60.25)	0.44	0.67
Total traffic tickets	2.20	(4.90)	1.80	(2.22)	0.37	0.71
Total accidents	1.04	(1.31)	1.52	(1.36)	1.27	0.21
TLFB total drinks	129.96	(100.55)	142.86	(109.68)	0.43	0.67
TLFB drinking days	29.96	(14.53)	29.76	(19.82)	0.04	0.97
TLFB binge episode	9.60	(10.06)	8.28	(9.47)	0.48	0.64
TLFB drunk days	9.12	(9.12)	11.72	(9.03)	1.01	0.32
Drink/drive freq.	1.68	(0.90)	2.24	(0.93)	2.17	0.04
Drink/drive quant.	1.44	(0.58)	1.76	(0.88)	1.52	0.14
AUDIT total	7.80	(5.07)	11.40	(6.34)	2.22	0.03
DAST total	2.20	(2.24)	2.72	(3.08)	0.68	0.50
BIS total	61.40	(10.98)	63.28	(9.67)	0.87	0.39

Comparison of DUI offenders to controls on background characteristics. Age = years of age; Years driving = total years of licensed driving; Drive frequency = total number of driving days per week; Drive distance = miles driven per week; Total traffic tickets = total number of traffic citations; Total accidents = total number of accidents in which the participant was the driver; TLFB total drinks = TLFB total drinks consumed in the past 3 months; TLFB drinking days = TLFB total drinking days in the past 3 months; TLFB binge episodes = number of binge drinking episodes defined as drinking to or in excess of 80 mg/100 ml; TLFB drunk days = total number of days in which the participant drank to a level that they felt drunk; Drink/drive freq. = mean score of how often participants' drive after drinking alcohol; Drink/drive quant. = mean score of how much alcohol participants typically drink before driving; AUDIT total = total score; DAST total = total score; BIS total = Barratt Impulsiveness Scale (BIS-11) total score.