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# ACUTE EFFECTS OF ALCOHOL ON SIMULATED DRIVING PERFORMANCE AND SELF-PERCEPTIONS OF IMPAIRMENT IN DUI OFFENDERS

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ACUTE EFFECTS OF ALCOHOL ON SIMULATED DRIVING PERFORMANCE  
AND SELF-PERCEPTIONS OF IMPAIRMENT IN DUI OFFENDERS

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THESIS

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A thesis submitted in partial fulfillment of the  
requirements for the degree of Master of Science in the  
College of Arts and Sciences  
at the University of Kentucky

By

Nicholas A. Van Dyke

Lexington, Kentucky

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2014

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## ABSTRACT OF THESIS

### ACUTE EFFECTS OF ALCOHOL ON SIMULATED DRIVING PERFORMANCE AND SELF-PERCEPTIONS OF IMPAIRMENT IN DUI OFFENDERS

Licensed drivers arrested for driving under the influence (DUI) of alcohol have increased rates of vehicle crashes, moving violations, and traffic tickets (Evans, 2004). To date, no research has examined specific self-regulatory mechanisms of the DUI driver under a dose of alcohol that might underlie risky driving behavior. The present study examined the degree to which DUI drivers display an increased sensitivity to the acute impairing effects of alcohol on driving performance and overestimate their driving fitness following alcohol consumption. Adult drivers with a history of DUI and a demographically-matched group of control drivers without a DUI were tested following a 0.65 g/kg dose of alcohol and a placebo. Results indicated that while alcohol impaired several measures of simulated driving performance, there were no differences between DUI offenders and controls on any of these measures. Compared with controls, intoxicated DUI drivers self-reported greater ability and willingness to drive as BAC declined despite no differences in levels of self-reported intoxication or BAC estimation. These findings provide evidence that DUI drivers might perceive themselves as more fit to drive after drinking despite clear evidence for their behavioral impairment. These findings could have important implications in the decisions to drink and drive.

KEYWORDS: Alcohol, Simulated Driving, DUI, Subjective Effects, Driving Ability

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## TABLE OF CONTENTS

List of Tables .....	v
List of Figures .....	vi
Chapter One: Introduction .....	1
Prevention and Treatment Efforts .....	2
Characteristics of DUI Offenders .....	3
Laboratory Assessment of Behavioral Control .....	4
Perceived Intoxication and Decisions to Drive .....	8
Gaps in Our Knowledge .....	9
Current Research .....	10
Design Summary .....	11
Chapter Two: Methods .....	12
Subject Recruitment and Screening .....	12
Apparatus and Materials .....	14
Simulated Driving Task (STISIM) .....	14
Precision Drive .....	14
Conflict Drive .....	15
Cued Go/No-go Task .....	15
Perceived Driver Fitness Scale .....	16
Measures of Drinking/Driving Experience and Alcohol-related Risk .....	17
Driving History and Experience Questionnaire .....	17
Drinking and Driving Questionnaire .....	17
Measures Used to Screen for Alcohol Abuse .....	17
Drug Abuse Screening Test .....	17
Short Michigan Alcohol Screening Test .....	18
Alcohol Use Disorders Identification Test .....	18
Measures of Self-reported Drinking Habits .....	18
Cognitive Measures Associated with Alcohol-related Problems .....	19
Drinking Motives Questionnaire .....	19
Temptation and Restraint Inventory .....	20
Barratt Impulsiveness Scale BIS-11 .....	20
Procedure .....	21
Pre-checks .....	21
Familiarization Session .....	21
Dose Sessions .....	22
Criterion Measures .....	23
Simulated Drive Task .....	23
Deviation of Lane Position .....	23
Steering Rate .....	23
Centerline and Road Edge Crossings .....	24
Drive Speed .....	24

Cued Go/No-go Task .....	24
Data Analyses .....	24
Chapter Three: Results .....	26
Demographics, Driving History, and Drug Use.....	26
Blood Alcohol Concentrations.....	31
Simulated Driving Performance .....	32
Precision Drive Test.....	32
Conflict Drive Test .....	35
Cued Go/No-go Task .....	37
Perceived Driver Fitness and Intoxication .....	38
Willingness and Ability .....	40
Subjective Intoxication and BAC Estimation.....	41
Chapter Five: Discussion .....	43
References.....	51
Vita.....	55

## LIST OF TABLES

Table 1. Demographics and driving history.....	26
Table 2. Drinking history and other drug use..	28
Table 3. Combined drinking and driving experience.....	29
Table 4. Drinking motives questionnaire.....	29
Table 5. Temptation and restraint... ..	30
Table 6. Hydraulic conditions for experimental tests....	30
Table 7. Impulsivity....	32
Table 8. Placebo ratings of driving fitness and intoxication.....	39



## LIST OF FIGURES

Figure 1. Blood alcohol concentrations under 0.65 g/kg alcohol .....	31
Figure 2. Simulated driving performance on the precision drive test.....	34
Figure 3. Simulated driving performance on the conflict drive test .....	36
Figure 4. Cued go/no-go task.....	37
Figure 5. Perceived driving fitness... ..	41
Figure 6. Self-appraisals of intoxication.....	42

## Chapter One: Introduction

Traffic safety continues to be a major public health concern. Traffic-related accidents lead to more than one million fatalities around the world each year and despite efforts to improve traffic safety, this number is expected to exceed two million in the next decade (Evans, 2004). In the United States alone, more than 40,000 people are killed and over five million are injured on the roads each year; totaling over \$230 billion in damages annually (Cavaiola & Wuth, 2002).

The combination of alcohol consumption and the operation of a motor vehicle produce an estimated 120 million occurrences of impaired driving per year (Evans, 2004). In 2010, it was reported that alcohol was a factor in over 250,000 traffic injuries and one-third of all traffic fatalities (NHTSA, 2012). While numbers have steadily declined in the past decade, in 2012 it was reported 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). This figure represents an increase from 2011 data where it was reported that 9,865 motor vehicle fatalities were alcohol-related (NHTSA, 2013).

A major focus of many public awareness and prevention programs has been to reduce the occurrence of drinking and driving. In the United States, a “per se” law determines the legal blood alcohol concentration (BAC) for which a driver can legally 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 Institute for Highway Safety, IIHS, 2013). Research has shown that one in every 127 licensed drivers is arrested for DUI and over one-third of DUI offenders will re-offend within three years (Nochajski & Stasiewicz,

2006). The punishment for receiving a DUI varies by state and can include, but is not limited to, any combination of the following: fines, license suspension, mandatory alcohol education classes, mandatory drug and alcohol treatment programs, jail time, and the less frequently used installation of an ignition interlock in the offender's vehicle (Cavaiola & Wuth, 2002).

### *Prevention and Treatment Efforts*

Widespread prevention efforts have led to only modest reductions in the incidence of DUI. Driving under the influence of alcohol remains one of the most frequently committed crimes (Federal Bureau of Investigation, 2006). Well-known advocacy groups such as Mothers Against Drunk Driving (MADD) and Students Against Destructive Decisions (SADD) have been contributed to reductions in alcohol-impaired driving (Cavaiola & Wuth, 2002). Other methods, such as sobriety checkpoints, have been used for over three decades and while initial data on their effectiveness was mixed, more recent reports have shown they have been effective in reducing the number of alcohol-related crashes (e.g., Fell et al., 2003). While prevention efforts have produced modest success in reducing DUI, treatment programs designed to reduce recidivism rates have shown limited efficacy. One issue is that education-based and treatment programs mandated to both first-time and recidivist offenders often lack well-defined goals and desired outcomes (Fitzpatrick, 1992; Frawley, 1988). Moreover, many programs, such as Alcoholics Anonymous, centrally focus on problems with alcohol as a treatment outcome (Alcoholics Anonymous, 1984) though research has shown that many DUI offenders do not necessarily have problems with alcohol (Wuth, 1987). Fillmore and Kelso (1987) suggest a mere 20% of DUI offenders show alcohol-related problems similar to

alcoholics. To date, researchers have sought to identify characteristics of the DUI offender in efforts to improve existing prevention and treatment programs.

### *Characteristics of DUI Offenders*

The overwhelming majority of research on DUI offenders has been conducted using surveys and personality inventories. In 2010, the NHTSA reported the DUI driver to be predominantly male and between the ages of 21 and 45 (NHTSA, 2012). Males offend at an approximate 4:1 ratio compared to females, although rates among women are rising (McCutcheon et al., 2011). DUI offenders above the age of 35 show increased rates of alcohol abuse (Cavaiola et al., 2003) while younger offenders do not typically meet diagnostic criteria for alcohol abuse or dependence (Lapham et al., 2004). The recidivist DUI offender may show antisocial personality traits, depressiveness, and anxiety that are often comorbid with alcohol abuse and/or dependence (Ball et al., 2000; Cavaiola et al., 2007).

Personality inventories of DUI offenders have identified traits implicated in risky driving behavior. Broadly speaking, the use of the five-factor model (Costa and McCrae, 1992) has correlated the neuroticism and extraversion personality dimensions with moving traffic offenses, road accidents, and aggressive driving behaviors (Dahlen & White, 2006; Lajunen & Parker, 2001; Matthews et al., 1991). Within these broad factors, decades of research links DUI offenders to impulsivity and other related personality attributes within the impulsivity domain (Chalmers et al., 1993; Ryb et al., 2006). Impulsivity can be defined as having a lack of control over the thoughts and behaviors within oneself (Barratt, 1994) and includes dimensions such as acting without thinking, sensation seeking, susceptibility to boredom, and inhibitory control (Buss & Plomin,

1975). Multiple studies have linked self-reported 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; Stanford et al., 1996). Studies have also shown sensation seeking contributes to multiple facets of risky driving behavior such as drunk driving and speeding (Arnett et al., 1997; Burns & Wilde, 1995). In addition to higher levels of impulsivity and sensation-seeking, DUI offenders also possess a lowered risk perception (Chalmers et al., 1993), all of which may make them more likely to engage in risky driving behaviors.

While research has established the DUI offender as having high levels of self-reported impulsivity, a major problem lies in the fact that impulsivity is a broad construct. The specific components underlying impulsivity in DUI offenders have not been systematically studied in the laboratory. Increased impulsivity in the DUI offender is suggestive of poor behavioral regulation and an increased sensitivity to rewards. In order to fully understand the DUI offender, research needs to examine the specific deficits of behavioral control to determine how increased disinhibition and risk-taking might contribute to decisions to drive and risky driving behaviors following a drinking episode.

#### *Laboratory Assessment of Behavioral Control*

The past decade has led to advancements in tasks used to measure specific behavioral components of impulsivity. A specific aspect of behavioral control, inhibitory control, can be defined as the ability to suppress dominant or prepotent actions (Fillmore et al., 2008; Fillmore & Vogel-Sprott, 2000) or the ability to inhibit inappropriate responses (Fillmore, 2003). This is especially relevant to DUI offenders as impairment of inhibitory control may contribute to the disinhibited behaviors in this population that are

often characterized by impulsive action and risk-taking. Inhibitory control has been measured in a laboratory setting for many years using cued go/no-go models (Fillmore, 2003). Cued go/no-go models are tasks in which subjects are told to respond as quickly as possible to go targets, while inhibiting responses to no-go targets. Cues preceding the target provide information about the likelihood of a go or no-go target that will follow and have a high probability of signaling the correct target (Fillmore, 2003). The task measures reaction time to go targets and the proportion of inhibitory failures to no-go targets. Poor inhibitory control is signified by a greater percentage of inhibitory failures (Fillmore, 2003).

Laboratory work using cued go/no-go models has well-documented the ability of alcohol to increase impulsive action by impairing basic inhibitory mechanisms necessary to inhibit behavior (Fillmore et al., 2008; Fillmore & Vogel-Sprott, 2000; Marczinski & Fillmore, 2003; Fillmore, 2003). A recent study by Weafer and Fillmore (2012) found that alcohol impaired inhibitory control indicated by an increase in failures to inhibit responses to go cues preceding no-go targets. Moreover, the magnitude of impairment followed in a dose-dependent fashion following placebo, 0.45 g/kg, and 0.65 g/kg alcohol. Testing in this study, under each dose, occurred 35 minutes post beverage consumption as BAC was rising rapidly (Weafer & Fillmore, 2012). Other studies have led to similar conclusions in finding that alcohol increased inhibitory failures on cued go/no-tasks following 0.65 g/kg alcohol compared to placebo on the ascending limb of the BAC curve (Fillmore et al., 2005; Fillmore & Weafer, 2004). Fillmore et al. (2005) also found increased impairment of inhibitory control from the ascending to the

descending limbs which provides evidence that alcohol-induced disinhibition is present after drinking has ceased.

In the DUI offender, a population characterized by impulsive action, an impairment of inhibitory mechanisms following alcohol could lead to risky driving behaviors while behind the wheel, such as speed fluctuations and failure to maintain their lane. Indeed, it is also important to consider inhibitory control in driving behavior. A study by Fillmore et al., (2008) tested healthy adult drinkers between the ages of 21 and 30 in a cued go/no-go task following 0.65 g/kg alcohol and a placebo. Results of the study indicated that compared with placebo, alcohol impaired simulated driving performance and performance on the cued go/no-go task. Moreover, the study indicated that driving behavior was closely related to inhibitory control, in that under alcohol poor inhibitory control was associated with increased impairment indicated by multiple measures of driving performance such as increased deviation of lane position, line crossings, increased steering rate, and a faster average driving speed.

Inhibitory control might be especially relevant to drinking and driving in situations of response conflict. Response conflict can be defined as a situation in which the driver receives incentives or rewards for both displaying and suppressing behaviors. A common response conflict scenario in everyday life could be encountered on a driver's daily commute to work. In this scenario, a driver is conflicted between the urge to speed to avoid being late for an important engagement but also to obey traffic laws (i.e., traffic lights). Failure to stop at red lights could lead the driver to incur traffic fines and a loss of the initial reward of not being late. Fillmore et al., (2008) examined the effect of alcohol in situations of response conflict in which drivers earned monetary rewards by quickly

finishing a driving scenario, but were penalized for failing to stop at red lights. Drivers were tested following 0.65 g/kg alcohol and a placebo in both the reward-punishment conflict described above and a non-conflict condition where there was no reward or punishment. Results indicated that alcohol impairment of driving performance was greater during the response conflict compared with non-conflict situation. Moreover, those with the greatest deficits of inhibitory control in a cued go/no-go task displayed the greatest impairment in response to alcohol. This indicates that poor inhibitory control could increase risky driving behaviors and these effects might be exacerbated under alcohol and in conflict situations that require increased restraint or self-control. Consequently, these findings could be especially relevant to the DUI offender, an at-risk population whose driving behaviors are characterized by impulsive action and risk-taking.

This research has also been extended to other populations considered to be at-risk drivers such as adults with attention deficit-hyperactivity disorder (ADHD). Individuals with ADHD are also characterized by heightened impulsivity (Weafer et al., 2008). Laboratory studies using cued go/no-go models have examined inhibitory control in adults with ADHD (Weafer et al., 2011; Roberts et al., 2011). Results have shown an increase in sensitivity to the disrupting effects of alcohol on inhibitory control evidenced by an increase in proportion of failures to inhibit responses to go cues that preceded no-go targets. Results also indicated that, compared to control drivers with no history of ADHD, drivers with ADHD displayed poorer overall driving performance under alcohol but, at the same time self-reported a greater perceived ability to drive on Likert-type rating scales. Thus, the results of the study suggest that an increased self-appraisal of



one's driving ability under alcohol is important because it could contribute to the decision to drive after drinking. Such appraisals of ability while intoxicated appear to be poor indicators of observed ability to drive and are also important because an overestimation of driving skill could factor into the decision to drive after drinking. The next section reviews studies on perceived impairment and how it can influence decisions to drive.

### *Perceived Intoxication and Decisions to Drive*

Another important variable to consider when examining the drinking and driving scenario are the factors that contribute to decisions to drive after drinking. Decisions to drive after drinking are based on both environmental factors and interoceptive cues within the individual. One important cue that has been examined in research studies throughout the years is perceived intoxication (Beirness, 1987). Self-evaluations of intoxication are made based on subjective and behavioral changes after drinking such as sedation and slurred speech and these evaluations are what the drinker may base important decisions on such as their willingness and ability to drive a vehicle (Marczinski & Fillmore, 2009). In the laboratory, self-reported levels of subjective intoxication are often measured using rating scales (e.g., 100 mm visual analogue). In completing these scales, participants place a tick mark along the continuum that includes anchors of "none at all" to "very much". The overarching design of existing studies requires participants to evaluate their intoxication following acute doses of alcohol using Likert-type rating scales. Overall, research has shown that people are often inaccurate at estimating levels of intoxication. Early studies required participants to estimate BACs at different time points and found that participants often underestimated their BAC (Oguzsoff & Vogel-Sprott, 1976). A study conducted by Beirness (1987) assessed intoxication by asking

participants to evaluate their perceived ability to drive a vehicle following alcohol. Results indicated that perceived ability to drive legally (i.e., below 80 mg/100 ml) became less accurate as BAC increased in response to a dose of alcohol. Other laboratory studies have shown that participants often underestimate their BAC and amounts of alcohol consumed (Marczinski et al., 2007). Importantly, these findings lend support to the idea that drivers may inaccurately assess their level of intoxication and driving fitness and therefore decide to drive after drinking despite being legally impaired.

### *Gaps in our Knowledge*

To date, none of these techniques have been applied to the DUI offender to determine how impaired inhibitory mechanisms or inaccurate self-appraisals of intoxication could affect decisions to drive and driving performance behind the wheel. In fact, rarely have DUI offenders been studied in a laboratory setting. Research continuously links the DUI offender to self-reported characteristics of impulsivity, but the extent to which DUI drivers display deficits in inhibitory control is unknown. We also do not know if the DUI driver might be more sensitive to the disinhibiting effects of alcohol in that they might display increased disinhibition and poorer driving performance in response to acute doses of the drug. Thus, no information exists on how DUI offenders might display reckless driving behavior and how this behavior may be exacerbated in conflict or other high-risk situations.

Similarly, no research has examined self-reported intoxication levels in DUI offenders. It will be important to understand how DUI drivers appraise their driving fitness (e.g., willingness and ability) and perceived levels of intoxication. Studies of ADHD drivers (e.g., Weafer et al., 2011) suggest that those characterized by heightened

impulsivity might over-estimate their driving performance, particularly in the intoxicated state. It may be likely that DUI offenders also self-report less subjective intoxication and perceived impairment leading them to more readily drive under the influence of alcohol compared to individuals without a DUI offense. Understanding these subjective evaluations could help us understand what factors lead to decisions to drive following a drinking episode in this high-risk population.

### *Current Research*

The current study sought to understand how DUI offenders respond under alcohol to determine what, if any, deficits might place them in a situation of increased risk characterized by disinhibition and risky driving behaviors. DUI offenders were compared to nonoffending controls and each group was tested in two different driving scenarios in response to a 0.65 g/kg dose of alcohol and a placebo. The first scenario emphasized driving precision and vigilance where drivers navigated winding, rural roads while maintaining a speed limit and proper lane control. The second scenario emphasized driver response conflict where drivers earned monetary rewards for finishing the drive in the shortest time and incurred monetary losses for failing to adhere to traffic laws (i.e., failing to stop at red lights). Participants also completed the cued go/no-go task to evaluate the effect of alcohol on inhibitory control.

Previous research has shown that DUI offenders self-report high levels of impulsivity (e.g., Chalmers et al., 1993). Therefore, it was hypothesized that DUI offenders would display poorer levels of inhibitory control while sober. In addition to high levels of self-reported impulsivity, research has also shown that DUI offenders commit more moving traffic violations and receive more traffic citations (e.g., Lajunen,

2001). Thus, it was hypothesized that DUI offenders would display poorer driving skills on multiple measures of driving performance (e.g., lane position, steering rate, line crossings) that require basic inhibitory mechanisms.

Under alcohol, it was hypothesized that the DUI offender would show an increased sensitivity to the disrupting effects of alcohol on inhibitory control. It was hypothesized that this increased sensitivity to the impairing effects of alcohol would also be evident in their driving performance. With regard to self-perceptions of impairment and decisions to drive under alcohol, DUI offenders might also differ from control drivers. Previous research using other at-risk populations (i.e., adults with ADHD) found increased levels self-reported driving ability and less perceived intoxication (Weafer et al., 2011). Therefore, it was hypothesized that DUI offenders would self-report an increased driving fitness (i.e., ability and willingness) and less subjective intoxication on the declining limb of the BAC curve, when decisions to drive are often made. Lastly, it was hypothesized that the impairing effects of alcohol on inhibitory control and simulated driving performance would be the most pronounced in the response conflict driving scenario where impulsive actions may be exacerbated by the presence of monetary incentives. Thus, it was predicted that the largest group differences between DUI offenders and controls would be evident in the response conflict drive scenario.

#### *Design Summary*

The study compared DUI offenders to controls on three sessions, one familiarization and two dose sessions (i.e., 0.65 g/kg and placebo) on separate days counterbalanced across subjects. During the familiarization session, drivers were familiarized with laboratory procedures and completed practice versions of the driving

scenarios and the cued go/no-go task. During the test sessions each participant received alcohol or a placebo and completed the task battery consisting of both driving scenarios and the cued go/no-go task. Measures of self-reported driving ability and subjective intoxication were administered at regular intervals across the declining limb of the BAC curve during each test session.

## Chapter Two: Methods

### *Subject 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). The gender makeup within each group was chosen to provide a sample that was representative of current DUI rates (i.e., approximately 4:1, male to female). Groups were matched on age and typical drinking habits. Online postings and fliers placed around the University of Kentucky's campus and 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<sup>®</sup>). Interested individuals called into the lab and underwent a preliminary telephone screening during which information on demographics, drinking habits, drug use, and physical and mental health was gathered. Participants self-reporting any psychiatric disorder, substance use disorder, CNS injury, or head trauma were excluded from participation. All subjects were current consumers of alcohol. However, volunteers 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 subjects must have held a valid driver's license for the past three years

and drove on a regular (i.e., weekly) basis. 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 on a number of criterion variables across two driving scenarios. 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 lane position standard deviation, steering rate, line crossings, and average speed across the drive.

*Precision drive.* This 15-minute simulated driving course consisted of 80,000 feet (24,384 m) or approximately 15.15 miles (~24.38 km) 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 (~88.51 km/hr) 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 participant in order to

maintain the center of the lane and the required speed throughout. The drive 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 (9479.28 m) or 5.9 miles (~9.50 km) 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. 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; Harrison et al., 2008).

*Cued go/no-go task.* Inhibitory control was measured by using a computerized cued go/no-go model used in previous research (e.g., Fillmore & Weafer, 2004) and was operated by E-Prime experiment generation software (Schneider, Eschman, & Zuccolotto, 2002). A trial began with a fixation point (+) for 800 ms, followed by a blank screen for 500 ms. A rectangular-shaped cue was then displayed for one of four randomly occurring stimulus onset asynchronies (SOAs = 100, 200, 400, and 800ms) before a go or no-go signal appeared for 1000ms. If the rectangle turned green (the go signal) subjects



were to make a computer key press as quickly as possible and if the rectangle turned blue (the no-go signal) they were to inhibit any response. A test consisted of 250 trials with 700 ms inter-trial intervals and required 15 min to complete. The orientation of the rectangular cue signaled the probability that a go or no-go signal would appear. A vertically-oriented rectangle (height = 7.5 cm, width = 2.5 cm) turned green on 80% of the trials and turned blue on 20% of the trials. A horizontally-oriented rectangle (height = 2.5 cm, width = 7.5 cm) turned green on 20% of the trials and turned blue on 80% of the trials. Therefore, vertical and horizontal-oriented rectangles operated as go and no-go cues, respectively. The measures of interest were the proportion (p) of inhibition failures to no-go targets in the go cue condition and the reaction time (RT) to go targets that were preceded by go cues. Greater p-inhibition failures indicate poorer inhibitory control (i.e., disinhibition) and RT in the go cue condition was measured by participants' average reaction time across trials in which a go target was presented. Presentation of the go cue increases response preparation (i.e., produces a response prepotency), making it more difficult to inhibit a response when the no-go signal unexpectedly appears. The disinhibiting effects of alcohol are most evident in this cue condition (Fillmore, 2003).

*Perceived driver fitness scale.* Participants self-evaluated their driving fitness (i.e., willingness and ability to drive a motor vehicle) and perceived level of intoxication on 100 mm visual-analog scales that ranged from 0 "not at all" to 100 "very much." 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). Participants were also tasked with estimating their current BAC on a scale ranging from 0

to 160 mg/100 ml and they were provided information on the current the legal driving limit (i.e., 80 mg/100 ml).

*Measures of drinking/driving experience and alcohol-related risk*

*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 (McCarthy, Niculete, Treloar, Morris, & Bartholow, 2012).* This self-report questionnaire gathered information on drinking and driving history. The first part of the questionnaire asked participants to respond to questions about drinking and driving on 4 or 5 point Likert scales. Included in the questionnaire are measures of frequency of drinking and driving, quantity of alcohol consumed before driving, and the most alcohol ever consumed before driving. The questionnaire also asked participants how many times in the past year they have driven following 1, 3, and 5 drinks in a 2 hour period.

*Measures used to screen for alcohol abuse*

*Drug Abuse Screening Test – DAST (Skinner, 1982).* This 28-item self-report questionnaire screened for drug abuse problems. Participants are asked to respond yes/no to each statement (e.g., “Do you try to limit your drug use to certain situations?”).

Totaled scores provide a measure of problems related to drug use. A score of six or more has been suggested as indicative of a drug use disorder (Skinner, 1982).

*Short Michigan Alcohol Screening Test – S-MAST (Selzer et al., 1975).* This 13-item self-report questionnaire was used as a screen for alcohol dependence. The questionnaire includes items such as “Have you ever gotten into trouble at work because of drinking?” and participants are instructed to respond yes/no to each item.

*Alcohol Use Disorder Identification Test – AUDIT (Babor et al., 1989).* This 10-item self-report questionnaire was used as a further screen for alcohol dependence and consequences of harmful drinking. For the majority of the questions (e.g., “How often during the last year have you had a feeling of guilt or remorse after drinking?”) participants respond on a 5-point Likert scale ranging from never to daily or almost daily. The questionnaire also measures quantity and frequency of drinking with anchors of 1 or 2 drinks to 10 or more drinks and never to 4 or more times a week, respectively. Lastly, participants respond to questions regarding injury while drinking and concern from family members on a 3-point Likert scale ranging from no to yes, and during the last year (Babor et al., 1992). Higher total scores indicate greater problems with alcohol. Use of the AUDIT has been well-validated for use in a variety of populations such as college students and drug users (Fleming et al., 1991; Skipsey et al., 1997).

*Measures of self-reported drinking habits.* The Timeline Follow-back (TLFB, Sobell & Sobell, 1992) 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 and total number of drinks consumed.

*Cognitive measures associated with alcohol-related problems.*

It is well-known that DUI offenders self-report increased levels of impulsivity (e.g. Chalmers et al., 1993). More recent research has indicated that DUI offenders might endorse different motives for drinking than nonoffenders (Miller & Fillmore, in press). That study also indicated that DUI offenders reported greater temptations with alcohol as measured by the CEP scale of the TRI.

*Drinking Motives Questionnaire – DMQ-R (Cooper, 1994).* This 20-item self-report questionnaire assessed an individual's motives to drink alcohol. Participants are asked to evaluate, of all their previous drinking episodes, how often they drank for each of the 20 statements (e.g., "To forget your worries") on a 5-point Likert scale ranging from almost never/never to almost always/always. Responses are categorized into one of four factors (i.e., social, coping, enhancement, and conformity) with higher scores indicating greater motives for each subscale. Drinking to experience positive social reward and drinking to relieve negative affect are characteristic of the social and coping subscales, respectively. Enhancement is defined as drinking to experience positive mood, while conformity can be defined as drinking to avoid social costs, such as teasing from a peer group (Cooper, 1994). The questionnaire has established predictive and discriminate validity in adult samples (Cooper et al., 1988; Cutter & O'Farrel, 1984). This questionnaire was included to determine if motivations to drink differed between DUI offenders and controls.

*Temptation and Restraint Inventory – TRI (Collins & Lapp, 1992).* This 15-item self-report questionnaire quantitatively measured drinking restraint by assessing an individual's temptations with alcohol and their ability to restrain from drinking (Collins & Lapp, 1992). Participants respond to each statement (e.g., “Do thoughts about drinking intrude into your daily activities?”) on a 9-point Likert scale ranging from none to a great deal. Responses are categorized into two factors related to restraint. The cognitive and behavioral control (CBC) factor represents restriction or successful/inhibitory regulation of drinking behavior. The cognitive and emotional preoccupation (CEP) factor represents temptation or unsuccessful/disinhibited regulation of drinking behavior (Collins & Lapp, 1992). The TRI has successfully predicted weekly alcohol consumption in moderate adult drinkers (Collins & Lapp, 1992; Collins et al., 2000) and may more effectively predict problems with alcohol than alcohol expectancies (Connor et al., 2000). The questionnaire determined if DUI offenders and controls differed in terms of thoughts and behaviors associated with alcohol use.

*Barratt Impulsiveness Scale – BIS-11 (Patton et al., 1995).* This 30-item self-report questionnaire is designed to measure the personality dimension of impulsivity. Impulsivity is thought to contribute to the risk of behavioral disinhibition under alcohol (Fillmore, 2007; Finn, Kessler, & Hussong, 1994). Participants rated 30 different statements (e.g., “I do things without thinking”) in terms of how typical each statement is for them 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).

### *Procedure*

Qualifying participants attended three sessions, a familiarization session and two dose sessions. The sessions were separated by a minimum of 24 hours and all of the sessions were completed within two weeks from the first day of participation.

### *Pre-checks*

Testing occurred in the Human Behavioral Pharmacology Laboratory in the University of Kentucky's Department of Psychology. All testing started between the hours of 10:00 a.m. and 6:00 p.m. and participants were instructed to fast for 4 hours and abstain from alcohol and other mind altering substances for at least 24 hours prior to each session. At the start of each session, a breath sample was collected to verify a zero BAC (Intoxilyzer, Model 400, CMI Inc., Owensboro, KY). Upon arrival to each dose session, urine samples were collected to test for the presence of drug metabolites (amphetamine, barbiturates, benzodiazepines, cocaine, opiates, and tetrahydrocannabinol) in all participants (On Trak TesTsticks, Roche Diagnostics Corporation, Indianapolis, IN). All females were also tested for pregnancy (Mainline Confirms HGL, Mainline Technology, Ann Arbor, MI).

### *Familiarization Session*

During the familiarization session, participants were familiarized with the laboratory procedures and completed the AUDIT, BIS, DAST, DMQ, S-MAST, and TRI questionnaires and provided background information on current alcohol use (TLFB), driving history (DHEQ), and combined drinking and driving behaviors. During this session participants also completed practice versions of the cued go/no-go task and each driving scenario.

### *Dose Sessions*

Drivers were tested under 0.65 g/kg alcohol and a placebo on separate days and the dose order was counterbalanced across subjects. The 0.65 g/kg alcohol dose is expected to produce a peak BAC of 80 mg/100 ml approximately 70 minutes after administration. Alcohol doses were calculated based on body weight and consisted of one part absolute alcohol to three parts carbonated mixer divided equally between two drinks in a single blind design. Placebo doses consisted of four parts carbonated mix in order to match the volume of the 0.65 g/kg dose. A small amount (i.e., 3 ml) of alcohol was floated on the surface of the placebo beverages and each glass was sprayed with an alcohol mist that provided a strong alcohol scent. Research has shown that participants report this type of beverage administration contains alcohol (Fillmore & Vogel-Sprott, 1998). During each dose session, volunteers had six minutes to consume both beverages.

Testing began 20 minutes post-beverage consumption and each task was separated by a 5 minute inter-trial rest interval. Timing and test order were identical across each dose session. The order of testing was chosen to be fixed for each subject and across each session in order minimize driver fatigue and ensure active participation in tasks that were not monetarily rewarded. At 20 minutes post-beverage, participants first completed the precision drive which required approximately 15 minutes to complete. The cued go/no-go task was administered 40 minutes post-beverage and required 15 minutes to complete. At 60 minutes post beverage participants completed the conflict drive scenario which required 5-10 minutes to complete, depending on the speed of the driver. 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 were given a hot

meal and allowed to watch a movie or television for the remainder of the session. The Perceived Driver Fitness Scale was first administered at 70 minutes post-beverage and again every 45 minutes thereafter. 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 lab until their BAC fell below 20 mg/100 ml upon which they were paid and debriefed. Transportation home was provided after the sessions.

### *Criterion Measures*

*Simulated drive task.* Four measures of driving performance were chosen for analysis across each driving scenario. 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 degree change in the steering wheel per second. A single steering rate score for a test was obtained based on the average degree change over 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.

*Cued go/no-go task: Failures of response inhibition and RT.* Drivers' inhibitory control was measured by the proportion of no-go targets in which the driver failed to inhibit a response during the test on the cued go/no-go task. Because go cues generate response prepotency and make inhibition difficult, the measure of interest was the proportion (p) of inhibition failure score in the go cue condition. Greater p-inhibition failures indicated poorer inhibitory control (i.e., disinhibition). Speed of responding to targets in the go cue condition was measured by participants' average RT for a test.

#### *Data analyses*

The performance measures on the driving and cued go/no-go tasks were each analyzed individually by a 2 Group (DUI vs. control) X 2 Dose (0.0 g/kg vs. 0.65 g/kg) mixed-design analysis of variance (ANOVA). Results of the perceived driver fitness scales were analyzed individually by 2 Group (DUI vs. control) X 5 Time (70, 115, 160,

205, and 250 minutes) mixed ANOVAs. BACs were analyzed by a 2 Group (DUI vs. control) x 8 Time (20 minutes – 250 minutes) mixed ANOVA.

### Chapter Three:

#### Results *Demographics, driving history, and 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. 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 ( $ps > .21$ ). The means for each group in terms of driving experience are reported in Table 1.

Table 1. Demographics and driving history

	Controls		DUI Offenders		<i>t</i>	<i>p</i>
	M	(SD)	M	(SD)		
Age	24.65	(3.41)	25.95	(4.11)	1.09	0.28
Time Since DUI	0	0	9.64	(16.10)	-	-
Drive years	9.01	(3.40)	9.92	(4.74)	0.77	0.44
Drive freq.	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
Traffic tickets	2.20	(4.90)	1.80	(2.22)	0.37	0.71
Accidents	1.04	(1.31)	1.52	(1.36)	1.27	0.21

Table 1. Comparison of DUI offenders to controls on background characteristics. Age = years; Time since DUI = months; Drive years = total years of licensed driving; Drive freq. = number of driving days per week; Drive distance = miles driven per week; Traffic

tickets = total number of traffic citations; Traffic accidents = total number of accidents in which the participant was the driver.

Table 2 lists the means for each group in terms of drinking history and other drug use-related questionnaires (i.e., S-MAST, AUDIT, and DAST). With regard to drinking habits, DUI offenders did not differ from controls on the total number of drinks consumed in the past 3 months,  $t(48) = 0.43, p = .67$ . Similarly, there was no difference between DUI offenders and controls on the total number of drinking days,  $t(48) = 0.41, p = .97$ . The groups did not differ on the total number of binge episodes,  $t(48) = 0.48, p = .64$ . A binge episode was defined as drinking to or in excess of the current legal driving limit of 0.08%. DUI offenders did not differ from controls on the number of self-reported drunk days in the past 3 months,  $t(48) = 1.01, p = .32$ . A drunk day was defined by a day in which the participants consumed alcohol to a level that they felt drunk. 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. No other drug use was reported in the past month. In terms of problems associated with the use of alcohol and other drugs, DUI offenders reported higher S-MAST scores compared to control drivers,  $t(48) = 3.97, p < .001$ . DUI offenders also scored higher on the AUDIT,  $t(48) = 2.22, p = .03$ . The groups did not differ on DAST scores ( $p = .50$ ).

Table 2. Drinking history and other drug use

	Controls		DUI Offenders		<i>t</i>	<i>p</i>
	M	(SD)	M	(SD)		
Total drinks	129.96	(100.55)	142.86	(109.68)	0.43	0.67
Total days	29.96	(14.53)	29.76	(19.82)	0.04	0.97
Binge days	9.60	(10.06)	8.28	(9.47)	0.48	0.64
Drunk days	9.12	(9.12)	11.72	(9.03)	1.01	0.32
S-MAST	1.16	(2.67)	4.72	(3.60)	3.97	<.001
AUDIT	7.80	(5.07)	11.40	(6.34)	2.22	0.03
DAST	2.20	(2.24)	2.72	(3.08)	0.68	0.50

Table 2. Total drinks = TLFB total drinks consumed in the past 3 months; Total days = TLFB total drinking days in the past 3 months; Binge days = days in which BAC exceeded 80 mg/100 ml on TLFB; Drunk days = self-reported drunk days on TLFB; S-MAST = total score; AUDIT = total score; DAST = total score.

With regard to the occurrence of drinking and driving, the groups differed on the frequency of drinking and driving episodes,  $t(48) = 2.17, p = .04$ , with DUI offenders reporting a greater frequency of drinking and driving episodes over their lifetime. The groups also differed on the greatest number of alcoholic drinks ever consumed before driving a motor vehicle,  $t(48) = 3.31, p = .002$ , with DUI offenders reporting a greater amount of drinks. However, there were no group differences in terms of the typical amount of alcohol consumed before driving a motor vehicle or self-reported driving in the past year following one, three, or five drinks in a two hour period ( $p > 0.73$ ). The means for each group are reported in Table 3.

Table 3. Combined drinking and driving experience

	Controls		DUI Offenders		<i>t</i>	<i>p</i>
	M	(SD)	M	(SD)		
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
Drink/drive most	2.56	(0.92)	3.32	(0.69)	3.31	0.002
Past Year						
1 drink	16.76	(25.59)	18.76	(27.44)	0.27	0.79
3 drinks	7.68	(14.64)	9.48	(21.51)	0.35	0.73
5 drinks	2.88	(8.33)	2.88	(5.49)	0.0	1.00

Table 3. Drink/drive frequency, quantity, and most = mean scores from drinking and driving questionnaire; Past year = how many times in the past year have you driven after having 1, 3, or 5 drinks in the past 2 hours.

Table 4 lists the group means on participants' motivation to drink as measured by the DMQ. There were no differences between DUI offenders and controls on any DMQ subscale ( $ps > .13$ ).

Table 4. Drinking motives questionnaire

	Controls		DUI Offenders		<i>t</i>	<i>p</i>
	M	(SD)	M	(SD)		
Social	17.32	(4.82)	19.40	(4.84)	1.52	0.13
Coping	10.32	(4.22)	11.04	(5.10)	0.54	0.59
Enhancement	13.64	(4.78)	14.64	(4.72)	0.75	0.46
Conformity	8.64	(4.36)	8.88	(3.48)	0.22	0.83

Table 4. Mean scores on the DMQ subscales.

With regard to the cognitive preoccupations with alcohol and attempts to control drinking from the TRI, there was a significant difference between DUI offenders and

controls on the TRI CBC scale,  $t(48) = 2.50, p = .016$ . More specifically, DUI offenders reported higher CBC scores indicating greater attempts to control drinking behavior. The groups did not differ on the CEP scale ( $p = .15$ ). The means for each group are shown in Table 5.

Table 5. Temptation and restraint

	Controls		DUI Offenders		<i>t</i>	<i>p</i>
	M	(SD)	M	(SD)		
CBC	11.72	(6.55)	18.04	(10.81)	2.50	0.016
CEP	19.96	(10.27)	25.80	(17.17)	1.46	0.15

Table 5. Mean scores from the TRI subscales. CBC = cognitive and behavioral control; CEP = cognitive and emotional preoccupation.

In terms of self-reported impulsivity, DUI offenders and controls did not differ on total impulsivity scores or any subscale, as measured by the BIS. Table 6 lists the means for each group.

Table 6. Impulsivity

	Controls		DUI Offenders		<i>t</i>	<i>p</i>
	M	(SD)	M	(SD)		
BIS total	61.40	(10.98)	63.28	(9.67)	0.64	0.52
Attention	9.84	(2.84)	9.40	(2.77)	0.56	0.58
Motor	14.72	(3.12)	16.20	(2.87)	1.75	0.09
Self-control	11.60	(3.72)	11.36	(3.40)	0.24	0.82
Cognitive	10.52	(2.58)	11.16	(2.59)	0.87	0.39
Perseverance	8.80	(1.53)	8.68	(1.73)	0.26	0.80
Cognitive instability	5.92	(2.24)	6.48	(2.29)	0.87	0.39

Table 6. BIS total = Barratt Impulsiveness Scale (BIS-11) total score and mean scores from the BIS subscales.

*Blood alcohol concentrations*

BACs under alcohol were examined by a 2 (Group) X 8 (Time) ANOVA. A main effect of time owing to the rise of BACs during the course of testing was found,  $F(7, 330) = 147.71, p < .001, \eta_p^2 = 0.76$ . Figure 1 plots the effect. Because BACs did not differ between DUI offenders and controls, readings at each time point were averaged across the entire sample. The figure reveals that BACs increased through the ascending limb toward the peak and decreased steadily across the declining limb. No main effects or interactions involving group or time were found ( $ps < .23$ ). The means averaged across the sample are reported in Table 7. No detectable BACs were observed in the placebo condition.

Figure 1. Blood alcohol concentrations under 0.65 g/kg alcohol

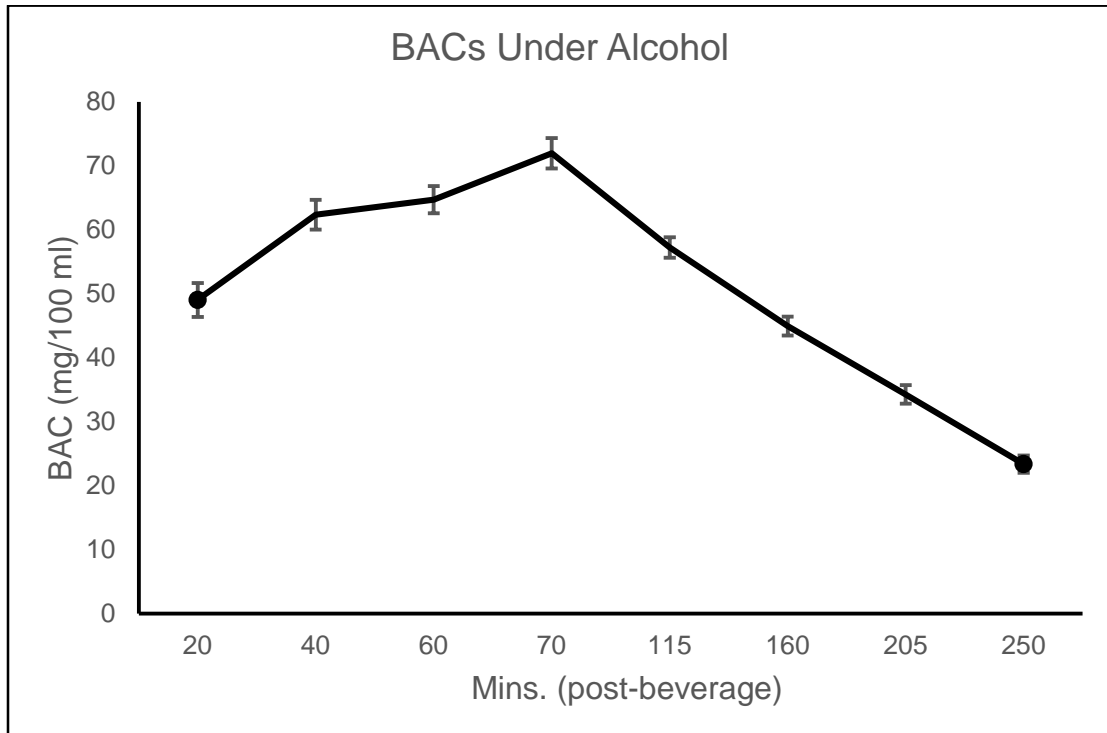


Figure 1. BACs under 0.65 g/kg alcohol averaged across the entire sample.



Table 7. Mean blood alcohol concentrations

	Entire Sample ( $n=50$ )	
	M	(SD)
BACs under alcohol		
20 min.	49.02	(18.63)
40 min.	62.35	(16.35)
60 min.	64.71	(15.40)
70 min. (peak)	71.96	(16.53)
115 min.	57.22	(11.14)
160 min.	44.92	(10.37)
205 min.	34.25	(10.19)
250 min.	23.35	(9.60)

Table 7. Mean BACs under 0.65 g/kg alcohol averaged across the entire sample.

*Simulated driving performance*

Driving performance for each drive scenario was examined independently due to the fact they occurred at different portions of the BAC curve.

*Precision Drive Test.* Figure 1 plots each criterion measures of driving performance on the precision drive scenario for each group following placebo and alcohol. A 2 (Group) X 2 (Dose) ANOVA of lane position standard deviation scores revealed a significant main effect of dose,  $F(1, 48) = 8.32, p = .006, \eta_p^2 = .15$ . The mean LPSD scores for each group following placebo and alcohol are shown in Figure 1b. The figure shows that LPSD increased following alcohol compared with placebo indicating less driving precision under the drug. No significant main effect of group or interaction was found ( $ps > .41$ ). Figure 1c plots the mean steering rate scores for each group following placebo and alcohol. A 2 (Group) X 2 (Dose) ANOVA indicated a significant main effect of dose,  $F(1, 48) = 11.74, p = .001, \eta_p^2 = .20$ . The figure shows an increase in steering rate under alcohol compared to placebo. No main effect of group or interaction

was found ( $ps > .33$ ). Figure 1d plots the mean number of line crossings. A 2 (Group) X 2 (Dose) ANOVA revealed a significant main effect of dose,  $F(1, 48) = 4.52, p = .039, \eta_p^2 = .09$ . The total number of centerline and road edge crossings increased under alcohol compared to placebo. No significant main effect of group or interaction was found ( $ps > .43$ ). A 2 (Group) X 2 (Dose) ANOVA of drive speed found no significant main effects or interactions ( $ps > .10$ ; figure 1a.). In Sum, alcohol impaired multiple aspects of driving precision; however, DUI offenders and controls did not differ in overall driving performance or in the degree to which alcohol impaired their performance.

Figure 2. Simulated driving performance on the precision drive test

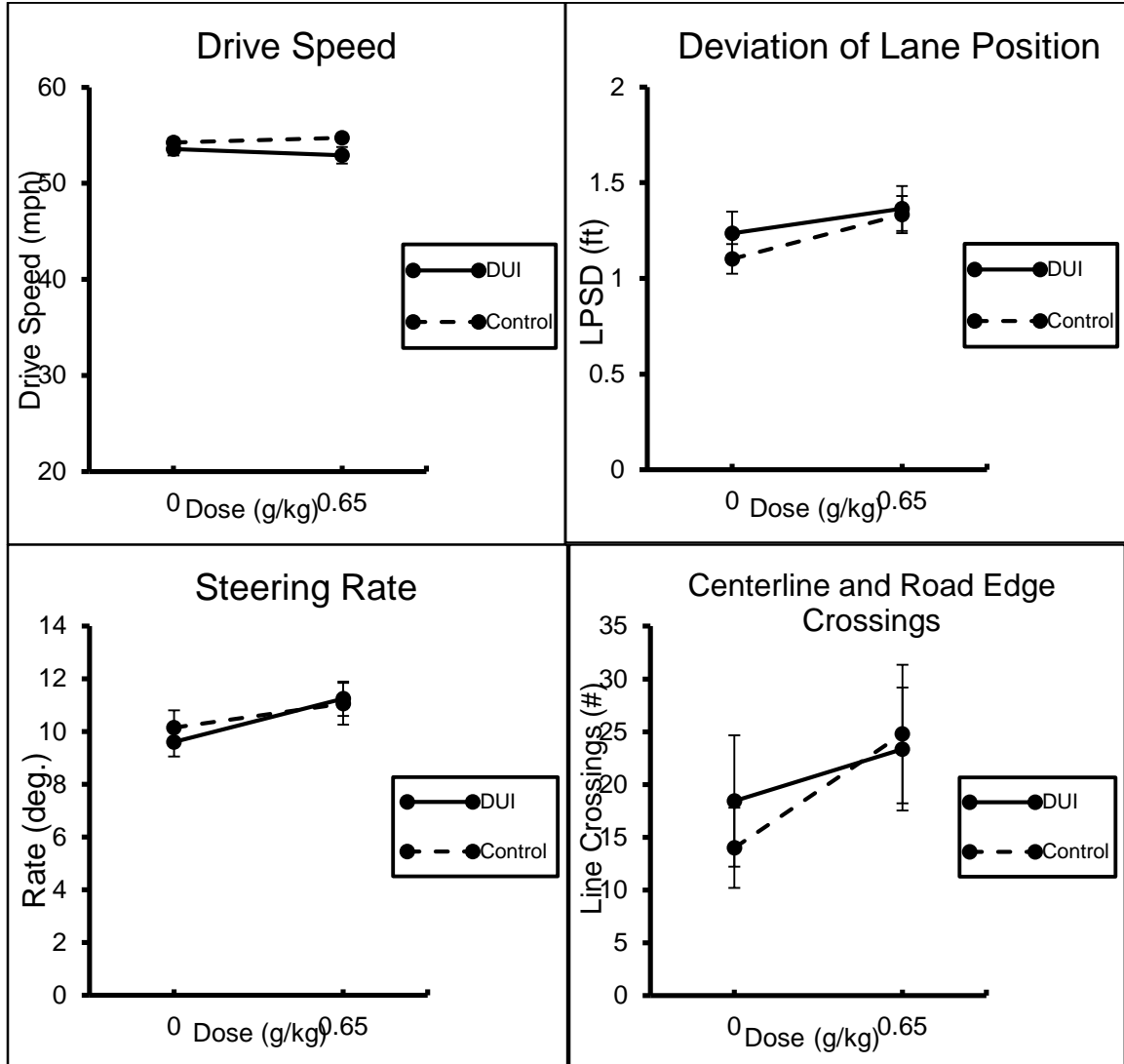


Figure 2. Mean drive speed (miles per hour) following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Figure 1b. Mean deviation of lane position (feet) following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Figure 1c. Mean steering rate in degrees following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Figure 1d. Mean number of centerline and road edge crossings following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. In each instance, error bars indicate standard error of the mean.

*Conflict Drive Test.* Figure 2 plots each criterion measure of driving performance on the conflict drive scenario for each group following placebo and alcohol. A 2 (Group) X 2 (Dose) ANOVA of LPSD scores revealed a significant main effect of dose,  $F(1, 48) = 29.78, p < .001, \eta_p^2 = .39$ . The mean LPSD scores for each group are shown in Figure 2b. The figure indicates that LPSD scores increased under alcohol compared to placebo indicating less driving precision under the drug. No significant main effect of group or interaction was found ( $ps > .46$ ). A 2 (Group) X 2 (Dose) ANOVA of steering rate found no significant main effects or interaction ( $ps > .069$ ). A 2 (Group) X 2 (Dose) ANOVA on the number of line crossings indicated a significant main effect of dose,  $F(1, 48) = 14.834, p < .001, \eta_p^2 = .24$ . Figure 2d shows that the total number of centerline and road edge crossings increased from placebo to alcohol. No significant main effect of group or interaction was found ( $ps < .73$ ). A 2 (Group) X 2 (Dose) ANOVA of drive speed found no significant main effects or interaction ( $ps < .17$ ; figure 2a). Results indicate that DUI offenders and controls did not differ on overall driving performance or in the degree to which alcohol impaired their performance.

Figure 3. Simulated driving performance on the conflict drive test

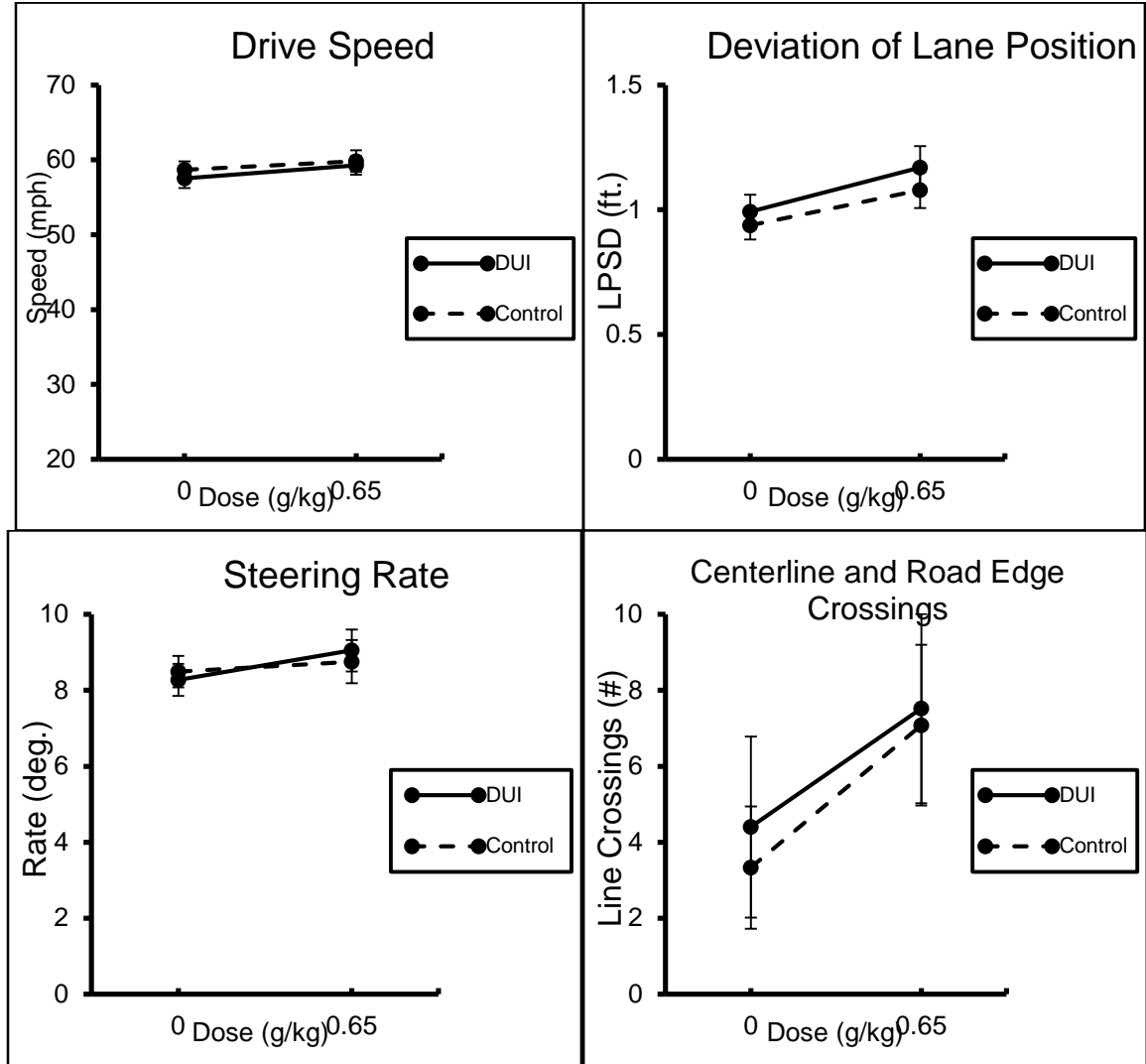


Figure 3. Mean drive speed (miles per hour) following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Figure 2b. Mean deviation of lane position (feet) following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Figure 2c. Mean steering rate in degrees following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Figure 2d. Mean number of centerline and road edge crossings following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Error bars indicate standard error of the mean.

### Cued go/no-go task

A 2 (Group) X 2 (Dose) ANOVA of drivers' proportion of inhibitory failures revealed a significant main effect of dose,  $F(1, 48) = 12.33, p = .001, \eta_p^2 = .21$ . Figure 3a plots the average p-inhibition failures for each group following placebo and alcohol. The figure shows that inhibition failures increased under alcohol compared with placebo, and this increase was similar for DUI offenders and controls. The figure also shows that DUI offenders tended to make more inhibition failures overall compared with controls. However, this difference was not significant as no main effect of group or interaction was found ( $ps > .40$ ). A 2 (Group) X 2 (Dose) ANOVA of reaction time to go cues found no significant main effects or interaction ( $ps > .056$ ). Figure 3b plots the average reaction time to go cues for each group following placebo and alcohol.

Figure 4. Cued go/no-go task

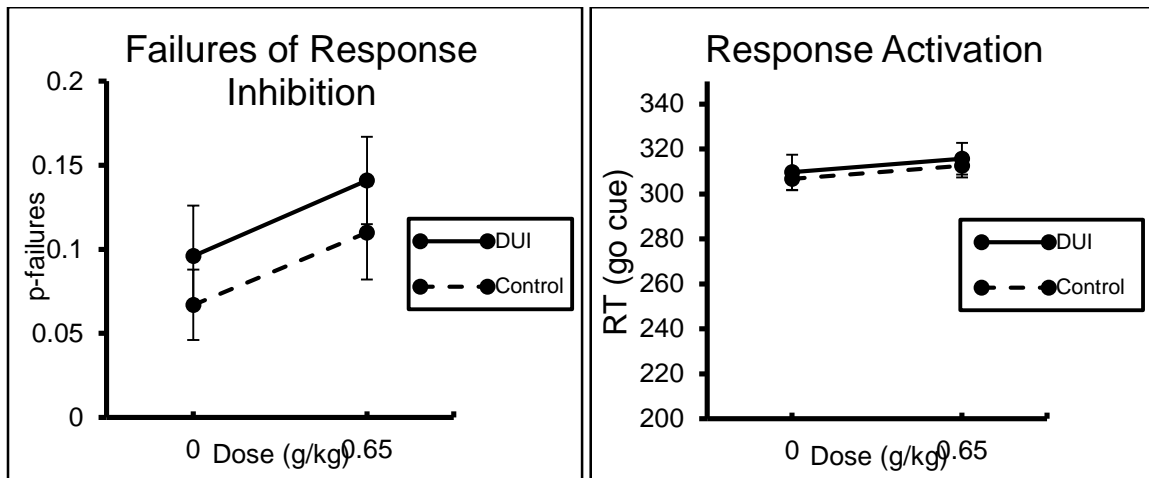


Figure 4. Mean number of inhibitory failures (p-inhibition failures) on the cued go/no-go task following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Figure 3b. Mean reaction time to go cues on the cued go/no-go task following 0.0 g/kg and 0.65 g/kg alcohol for DUI and control drivers. Error bars indicate standard error of the mean.

*Perceived driver fitness and intoxication*

Initial 2 (Group) X 5 (Time) ANOVAs of willingness, ability, intoxication, and BAC estimation under placebo revealed no group differences. The means for each group are reported in Table 8. The table indicates that self-reports of willingness and ability to drive started and remained high throughout the declining limb while reports of subjective intoxication and BAC estimation were relatively low at each time point. Therefore, subsequent analyses on perceived driver fitness and subjective intoxication are reported under alcohol only.

Table 8. Placebo ratings of driving fitness and intoxication.

	Controls		DUI Offenders	
	M	(SD)	M	(SD)
<b>Willingness</b>				
70 min	71.37	(23.34)	68.70	(28.79)
115 min	77.90	(20.70)	83.26	(22.77)
160 min	85.67	(15.89)	88.52	(21.72)
205 min	88.71	(15.04)	93.40	(15.53)
250 min	88.81	(16.04)	93.30	(17.38)
<b>Ability</b>				
70 min	80.27	(20.58)	70.04	(28.64)
115 min	85.04	(14.10)	85.60	(16.00)
160 min	88.96	(13.16)	95.10	(5.49)
205 min	89.88	(11.74)	96.18	(6.94)
250 min	91.83	(13.34)	94.78	(11.97)
<b>Intoxication</b>				
70 min	10.19	(13.74)	11.02	(11.38)
115 min	5.63	(7.29)	4.38	(4.84)
160 min	3.56	(5.07)	2.14	(3.13)
205 min	4.06	(7.28)	1.08	(1.37)
250 min	2.25	(4.86)	1.02	(1.43)
<b>BAC estimation</b>				
70 min	27.08	(25.45)	35.20	(31.11)
115 min	16.67	(21.96)	22.80	(28.51)
160 min	9.38	(15.76)	13.40	(21.54)
205 min	6.25	(9.81)	10.80	(19.29)
250 min	6.02	(6.02)	10.83	(10.83)

Table 8. Willingness = willingness to drive on 100mm visual-analogue scale; Ability = ability to drive on 100mm visual-analogue scale; Intoxication = subjective intoxication on 100mm visual-analogue scale; BAC estimation = estimated BAC on a scale ranging from 0 to 160 mg/100 ml. All times are post-beverage consumption.



*Willingness and ability.* A 2 (Group) X 5 (Time) ANOVA of self-reported willingness to drive a motor vehicle 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 X group interaction,  $F(4, 189) = 3.05, p = .027, \eta_p^2 = .06$ . No main effect of group was found ( $p = .068$ ). These effects are plotted in Figure 4a. The figure indicates that willingness to drive generally increased as BAC declined. Moreover, the groups reported similar levels of willingness to drive at the first time point, but DUI offenders reported greater willingness to drive compared to controls at all subsequent time points on the declining limb. Post-hoc two-sample t tests examined group differences at each time point across the declining limb. Results indicated that DUI offenders reported a greater willingness to drive 205 minutes ( $t[48] = 2.70, p = .010$ ) and 250 minutes ( $t[48] = 2.76, p = .008$ ) post-beverage. The difference at 160 minutes was marginally significant ( $t[48] = 1.81, p = .07$ ).

A 2 (Group) X 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 4b plots the effect. The figure indicates that ability to drive generally increased as BAC declined, and DUI offenders and control drivers reported similar levels of ability to drive a motor vehicle at the peak of the BAC curve. However, DUI offenders reported a greater ability to drive a motor vehicle across the declining limb of the BAC curve. Post-hoc t tests examined group differences at each time point across the declining limb. Results indicated that DUI offenders reported a greater ability to drive 205 minutes ( $t[48] = 2.18, p = .034$ ) and 250 minutes ( $t[48] = 2.48, p = .017$ ) post-beverage.

Figure 5. Perceived driving fitness

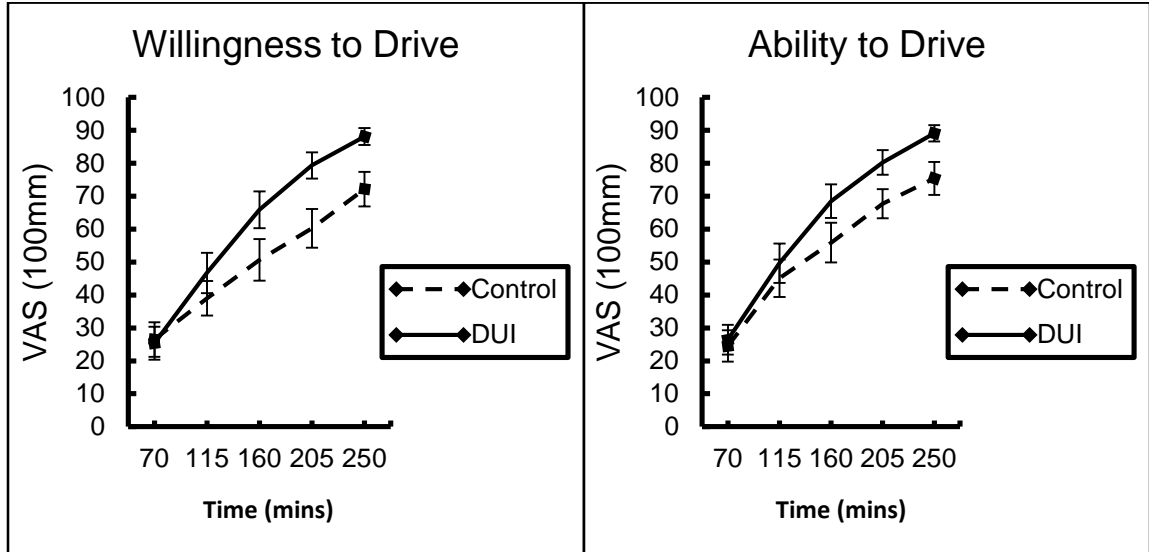


Figure 5. Mean willingness to drive ratings on 100-point visual analogue scales following 0.65 g/kg alcohol for DUI and control drivers. Figure 4b. Mean subjective rating of driving ability on 100-point visual analogue scales following 0.65 g/kg alcohol for DUI and control drivers. Error bars indicate standard error of the mean.

*Subjective intoxication and BAC estimation.* A 2 (Group) X 5 (Time) ANOVA of subjective intoxication revealed significant main effects of time  $F(4, 189) = 114.70, p < .001, \eta_p^2 = .71$ . There were no significant effects or interactions involving group on subjective intoxication ( $ps > .26$ ). Figure 5 plots the relationship between group and time under alcohol. The figure reveals that, in general, subjective intoxication declined as BACs declined. Moreover, there were no differences between DUI offenders and controls on levels of subjective intoxication across the declining limb of the BAC curve.

A 2 (Group) X 5 (Time) ANOVA of estimated BAC readings found significant main effects of time,  $F(4, 189) = 192.49, p < .001, \eta_p^2 = .80$ . There were no significant effects or interactions involving group on estimated BACs ( $ps > .45$ ). Figure 5b plots the

relationship between group and time under alcohol. The figure indicates that BAC estimation declined over time, as actual BACs fell. Moreover, there were no differences between DUI offenders and controls on BAC estimation across declining limb of the BAC curve.

Figure 6. Self-appraisals of intoxication

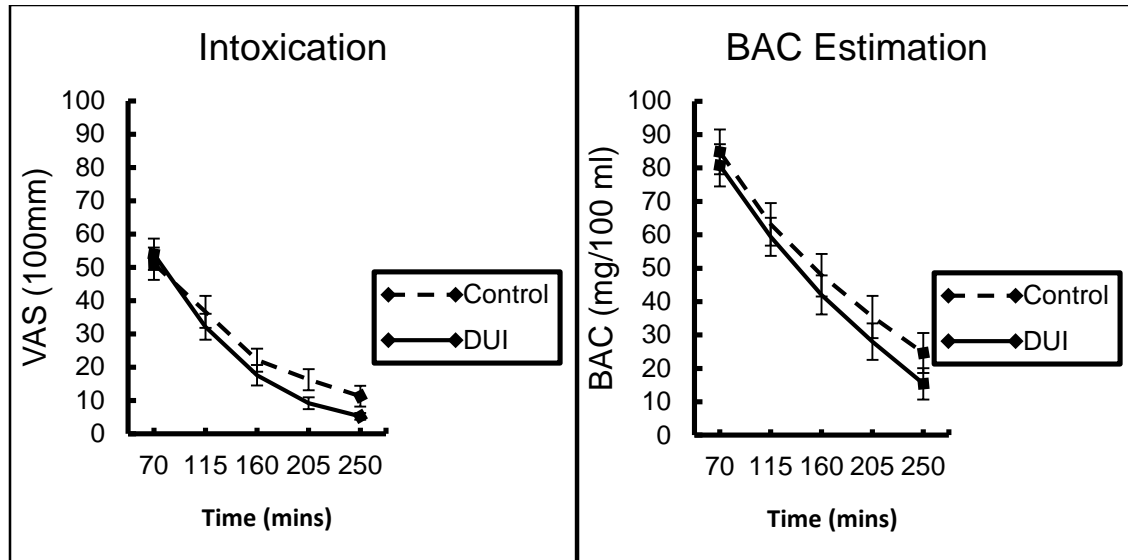


Figure 6. Mean subjective intoxication ratings on 100-point visual analogue scales following 0.65 g/kg alcohol for DUI and control drivers. Figure 5b. Mean BAC estimation ratings on a scale ranging from 0.0 g/% to 0.16 g/% following 0.65 g/kg alcohol for DUI and control drivers. Error bars indicate standard error of the mean.

## Chapter Four: 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 DUI history. 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 in the laboratory. Compared with placebo, drivers' performance under alcohol was characterized by more abrupt steering maneuvers, increased deviation of the vehicle within the lane, and a greater number of crossings outside the driver's lane. However, the degree to which alcohol impaired driving performance on each drive scenario did not differ between the two groups. With regard to self-evaluations of driving fitness and perceived intoxication, there were group differences across the declining limb. More specifically, compared with controls, DUI offenders reported greater willingness and ability to drive a motor vehicle as BACs declined (i.e., 205 and 250 minutes post-beverage). There were no differences between DUI offenders and control drivers on subjective intoxication or BAC estimation at any time point. Alcohol impaired performance on the cued go/no-go task, evidenced by increases in the number of inhibitory failures and slowed RTs. However, DUI offenders did not differ from controls on these measures.

The findings that DUI offenders did not differ from control drivers on any measure of simulated driving performance on either drive test provides some of the first pieces of evidence that DUI offenders may not necessarily display an increased sensitivity to the disrupting effects of alcohol on driving performance compared to drivers without a DUI history. That is, DUI offenders are just as impaired following a

dose of alcohol as control drivers. As mentioned in the introduction, the majority of behavioral research on DUI offenders has involved survey studies, and there have been limited laboratory assessments of specific cognitive and neuropsychological functioning in this population. Moreover, despite speculation and assumptions about the intoxicated driving behavior of DUI offenders, no previous research had examined how DUI offenders actually respond to alcohol in terms of their driving performance. A common assumption among researchers is that DUI offenders are heavy drinkers and consequently they might display tolerance to the impairing effects of alcohol, such that their driving ability is only mildly disrupted by alcohol (for a review see Martin et al., 2013). However, the present study showed that there were no differences in the drinking habits or drunk driving habits between DUI offenders and controls. Thus, in our sample, it is not likely that the groups differed in tolerance to the disrupting effects of alcohol on driving performance.

The current study included two drive scenarios, one that emphasized precision, and other response conflict. An important factor to consider from the current study is that the drive scenarios used in the current study emphasized skills that are relatively non-demanding, or reflect automated skill to execute. Driving researchers recognize that aspects of driving can be classified on the basis of representing either automatic or controlled modes of cognitive processing (e.g., Michon, 1985; Salvucci, 2006). Behaviors governed by automatic processes tend to be well-learned actions that require little conscious effort and can be conducted in parallel with other activities. By contrast, controlled actions are effortful, demanding greater cognitive resources, and are often disrupted by secondary activities (Shiffrin & Dumais, 1981). The driving tests in the

present study emphasized the ability to maintain proper lane position by executing minor steering adjustments that are reflective of automatic processes driving-related processes.

The study also provides some of the first pieces of evidence that in the intoxicated state, DUI offenders overestimate their willingness and ability to drive a vehicle making them more likely to drive following a drinking episode. It may be assumed that DUI offenders might simply engage in more frequent drinking and driving episodes than individuals who have not been arrested for DUI. It is well-known that the chances of being caught drinking and driving are extremely low and drivers often drive drunk many times before being caught (Evans, 2004). Thus, by the time DUI offenders are arrested for driving under the influence, they may have significantly greater experiences with drunk driving than the driver without a DUI history. One explanation could be that repeated occurrences of drinking and driving that did not result in a DUI arrest may explain why DUI offenders are more willing and report an increased ability to drive while intoxicated. However, results of the current study did not support this idea. DUI offenders reported a slightly higher frequency of lifetime drinking and driving, however the differences between groups were only a few times per year. Moreover, when examining current (past year) drinking and driving habits, there were no differences between DUI offenders and control drivers. In fact, of the several measures of current drinking and driving habits, DUI offenders only differed in the greatest number of alcoholic drinks they had ever consumed before driving a motor vehicle. It was not clear if this specific heavy drinking episode directly led to their arrest for DUI or not. Several of the drinking and driving history questionnaires in the current study asked about drinking and driving habits up to a maximum of one year from the date of participation in the study. The

current sample of DUI offenders reported an average time since DUI arrest of 10 months. Thus, while results indicate that it is evident that DUI offenders are still readily engaging in drinking and driving episodes despite their previous arrest(s), it seems entirely possible that the self-reported drinking and driving habits of our DUI sample were reduced as a direct result of receiving a DUI within the timeframe covered in the questionnaires, whether this was due to underreporting or reductions in actual consumption.

There are several other factors that an individual may use to make judgments of their willingness and ability to drive after drinking. Objects external to an individual may serve as clues by which an individual makes these important self-evaluations. In the current study, simulated driving performance and performance on the cued go/no-go task likely served as clues to the individual on their levels of alcohol-induced impairment. Given that DUI offenders and controls were equally impaired on all measures of driving performance and performance on the cued go/no-go task, it does not seem plausible that behavioral performance on the laboratory tasks can explain the increases in willingness and ability to drive in DUI offenders. Moreover, the tasks were completed on the ascending limb when the groups did not differ on self-reported willingness or ability to drive. Interoceptive cues, such as perceived levels of intoxication, may also serve as clues by which participants evaluate their willingness and ability to drive a motor vehicle after drinking. At the end of a drinking episode, an individual may evaluate their level of intoxication when deciding whether they will drive home, to another bar, or elsewhere. Given that DUI offenders self-reported similar levels of subjective intoxication and estimated similar BACs as controls in the current study, it does not seem as though perceived levels of intoxication can be used to explain the increased self-reported

willingness and ability to drive seen in DUI offenders. That is, the DUI offenders in the current study did not simply feel less impaired or intoxicated than the control drivers.

Another possible explanation is that there are inherent differences in the personalities of DUI offenders that might make them more likely to display risky behaviors at any given time. If this were true, the intoxicated DUI driver might report always being more willing and able to drive despite previous punishments and harmful consequences of their actions. However, the group differences in self-reported willingness and ability to drive only appeared toward the end of the descending limb. At the peak BAC and beginning of the descending limb, DUI offenders were just as cautious as control drivers in terms of their ability and willingness to drive. Moreover, these findings cannot be attributed to any potential group differences in the pharmacological effects of the dose of alcohol, because not only did DUI offenders and controls report similar levels of driving fitness at the peak BAC, but they also reported similar levels of intoxication and estimated similar BACs as controls at each time point.

Given that DUI offenders typically self-report greater levels of impulsivity compared with controls, it was expected that DUI offenders would display poorer inhibitory control as well. Although it is unclear why significant group differences were not found on the questionnaire measure of impulsivity, it is possible that the failure to detect differences on the cued go/no-go task was due to the multifaceted nature of impulsivity. The cued go/no-go task was employed to measure of inhibitory control as the ability to suppress a prepotent response. However, impulsivity also involves heightened approach tendencies toward appetitive or rewarding stimuli which often leads to a failure to delay gratification (Christiansen, Cole, Goudie, & Field, 2012). Thus, it could be likely



that the impulsivity seen in DUI offenders might be due to the inability to delay immediate rewards, despite negative long-term consequences. Recent research examined the effects of alcohol on impulsive behavior of drivers who reported drinking and driving in the past year (McCarthy et al., 2012). They found that, under alcohol, these drivers readily discounted rewards that were delayed, showing a preference for immediate rewards. Thus, it might be that those who drink and drive are more sensitive to the impairing effects of alcohol on the ability to delay reward, but not on the ability to inhibit pre-potent action. The current finding that differences between DUI offenders and controls in their willingness and ability to drive only become evident as BAC declines suggests that DUI offenders might start to discount the delayed reward (e.g., having to wait for a ride or a taxi-cab) on the descending limb in favor of the more immediate reward (e.g., driving to their desired destination).

The current sample of DUI offenders was comprised primarily of first-time offenders, with only three DUI offenders having multiple offenses (i.e., recidivists). As a group, first-time offenders are likely to be fairly heterogeneous with respect to any underlying behavioral dysfunction that might contribute to risky driving behavior and DUI. For many drivers, a single DUI conviction might not indicate any underlying behavioral dysfunction, but rather reflect an isolated, unlucky event for that individual. In fact, the self-report and personality measures included in the current study indicated that the DUI sample closely resembled the control drivers. DUI offenders scored significantly higher than controls on two measures of problems related to alcohol use (i.e., AUDIT and S-MAST) indicating that DUI offenders might engage in more risky drinking behaviors. However, the differences on the S-MAST are likely due at least partially to the fact that

the questionnaire contains a question asking about previous DUI arrests. The current DUI sample also reported a higher CBC score indicating greater efforts to control their drinking compared to control drivers, possibly as a result of the punishments associated with their DUI arrest. By contrast the recidivist offender demonstrates a pattern of poor decision-making and risky driving behavior that is more likely to reflect some underlying and enduring behavioral or cognitive dysfunction. Indeed, among the few laboratory studies that examine neurocognitive functioning in DUI offenders, cognitive dysfunction is most often observed in DUI groups who are comprised solely of recidivist offenders (e.g., Glass et al., 2000; Ouimet et al., 2007). To the extent that recidivism reflects some behavioral dysregulation, it is possible that recidivist offenders could also display increased sensitivity to the disruptive effects of alcohol on impulse control and measures of driving performance.

In summary, the findings point to the need for future laboratory research to examine other types of driving situations commonly encountered outside the lab, such as drive scenarios that are more demanding and those that emphasize risky driving behaviors compared to the drive scenarios in the current study that focused more on skill and precision. Moreover, future studies should focus on identifying the underlying mechanisms that lead DUI offenders to report being more able and willing to drive after drinking and the potential implications of the overestimations. The findings also point to the need to identify the specific aspects of behavioral dysfunction underlying the self-reported impulsivity in DUI offenders. Thus, a systematic breakdown of specific behavioral components of impulsivity in DUI offenders should be examined in further laboratory studies. In designing future studies to directly target these unanswered

questions, it will be important to consider the likely differences among the DUI population (i.e., first-time versus recidivists). Thus, future studies should include separate groups of first-time and recidivist DUI offenders. The integration of such approaches allows long-standing but rarely tested hypotheses to be examined, such as the possibility that DUI drivers display aberrant reactions to alcohol that could compromise self-regulatory processes and contribute to their decisions to drive after drinking.

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### PUBLICATIONS

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### PRESENTATIONS

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Van Dyke, N., & Fillmore, M. T. (2013). One for the road: DUI offenders underestimate the effects of alcohol on driving ability. Poster presented at the 2013 Research Society on Alcoholism conference, Orlando, Florida.

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