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Laboratory analysis of risky driving at 0.05% and 0.08% blood alcohol concentration

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ABSTRACT

Background: The public health costs associated with alcohol-related traffic crashes are a continuing problem for society. One harm reduction strategy has been to employ per se limits for blood alcohol concentrations (BACs) at which drivers can legally operate motor vehicles. This limit is currently 0.08% in all 50 US states. Recently, the National Transportation Safety Board proposed lowering the legal limit to 0.05% (NTSB, 2013). While research has well-validated the ability of alcohol to impair driving performance and heighten crash-risk at these BACs, relatively little is known about the degree to which alcohol might increase drivers' risk-taking.

Methods: Risk-taking was examined in 20 healthy adults who were each tested in a driving simulator following placebo and two doses of alcohol calculated to yield peak BACs of 0.08% and 0.05%, the respective current and proposed BAC limits. The drive test emphasized risk-taking by placing participants in a multiple-lane, high-traffic environment. The primary measure was how close drivers maneuvered relative to other vehicles on the road (i.e., time-to-collision, TTC).

Results: Alcohol increased risk-taking by decreasing drivers' TTC at the 0.08% target BAC relative to placebo. Moreover, risk-taking at the 0.05% target was less than risk-taking at 0.08% target BAC.

Conclusions: These findings provide evidence that reducing the legal BAC limit in the USA to 0.05% would decrease risk-taking among drivers. A clearer understanding of the dose-response relationship between various aspects of driving behaviors, such as drivers' accepted level of risk while driving, is an important step to improving traffic safety.

1. Introduction

In the United States, driving while intoxicated leads to an estimated 120 million occurrences of impaired driving per year (e.g., Blincoe et al., 2015; Jewett et al., 2015). In the US, drivers may be arrested for driving under the influence of alcohol (DUI) if their blood alcohol concentration (BAC) exceeds the "per se" legal limit of 0.08%. However, it is well-known that individuals differ in their responses to alcohol and individuals may be impaired well below this limit (for a review, see: Ogden and Moskowitz, 2004). Indeed, many countries have adopted lower BAC limits (i.e., between 0.02% and 0.05%) in an effort to reduce motor vehicle crashes (MVCs) and improve public safety. Recently the National Transportation Safety Board issued a recommendation that the United States lower its legal BAC limit from 0.08% to 0.05% (NTSB, 2013). As such, it is important to determine precisely how the adverse effects of alcohol on driving behavior are lessened when the BAC of the driver is reduced from 0.08% to 0.05%.

For many years laboratory studies of simulated driving have sought to determine factors that contribute to MVCs. Two aspects of driving performance shown to contribute to MVCs are drivers' skill and their propensity to engage in risk-taking behaviors. In terms of driver skill, it is suggested that MVCs are caused by deficits in basic skills, such as slowed reaction times and poor motor coordination. Such skill deficits may result in increased rates of swerving, exaggerated and delayed steering wheel manipulations to correct for lane position, and greater deviations of vehicle drive speed (for a review, see Ranney, 1994). However, it is also recognized that MVCs may be caused by the driver engaging in risk-taking behaviors. Indeed, reports indicate that risky driving accounts for a significant proportion of traffic fatalities in young adults (Department of Transport and Main Roads, 2011). Risk-based models of driving behavior suggest that drivers select a level of risk for traffic injury/collision they are willing to accept (i.e., a safety margin) and then drive in accordance with that risk level. Risk-taking is often measured by proxemics, indicated by instances where drivers maneuver close to other vehicles on the road. For example, drivers who adopt a high-risk acceptance are more likely to place their vehicle closer to

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other vehicles (e.g., tailgating) on the road compared with drivers with low-risk acceptance. This risk-taking behavior is quantified by determining drivers' time-to-collision (TTC). TTC is a time-related safety margin measure determined by the bumper-to-bumper distance between the driver's vehicle and other vehicles on the road, divided by the closing speed of the vehicles (Taieb-Maimon and Shinar, 2001; Zhang and Kaber, 2013). Thus, TTC provides a measure of the time (in seconds) it would take for a collision to occur between two or more vehicles on the roadway (Zhang et al., 2006). Risky driving is evidenced by lower TTC values compared with non-risky driving. Research indicates that greater risk-taking, as measured by TTC, is associated with increased risk for MVCs (e.g., Hayward, 1972; Ranney, 1994; Summala, 1985, 1988; Wilde, 1982).

It is also recognized that alcohol likely contributes to MVCs by its joint effects of impaired driver skill and increased risk-taking behavior. Laboratory studies of the acute impairing effects of alcohol using high-fidelity driving simulators have clearly established the ability of alcohol to impair several basic driving behaviors reflective of skill. Indeed, research indicates that alcohol-induced impairment of driving performance leads to increased standard deviation of the vehicle's lane position on the road (SDLP), increased and delayed steering corrections, and increased lane exceedances (for a review, see: Ogden and Moskowitz, 2004). As such, intoxicated drivers are less able to execute small, continuous steering wheel manipulations necessary to maintain the center position of their lane than sober drivers. Moreover, there is evidence that alcohol impairs these skill-based driving behaviors at and below the current legal limit BAC in the United States, 0.08% (e.g., Mitchell, 1985; Moskowitz and Fiorentino, 2000; Moskowitz and Robinson, 1988).

By contrast, less is known about alcohol effects on risk-taking at BACs below 0.08%. To our knowledge, only a few laboratory studies have examined risky driving in response to alcohol (see: Burian et al., 2002, 2003; Cohen et al., 1958; Laude and Fillmore, 2015; Leung and Starmer, 2005). In general, these studies have shown that alcohol increases risky decisions while driving. For example, studies have found that intoxicated drivers are more willing to choose risky traffic lanes over less-risky options (Burian et al., 2002, 2003), maneuver through narrower gaps (Cohen et al., 1958), and underestimate potential collision time with oncoming traffic (Leung and Starmer, 2005). A recent study conducted in our laboratory examined driver risk-taking as measured by TTC following placebo and an acute dose of alcohol designed to produce a peak BAC of 0.08% (Laude and Fillmore, 2015). Under alcohol, drivers decreased their TTC by driving closer to other vehicles on the roadway relative to placebo. Examination of individual differences in response to alcohol showed that the magnitude of alcohol effect on risk-taking was independent of the magnitude with which the drug impaired drivers' skill. As such, it is possible for alcohol to promote risk-taking in drivers even in cases where the drug has little effect on their skill. While this hypothesis has received little research attention, the assumption that driver skill could be distinguished from driver risk-taking has been held for some time (Barry, 1973).

Increased risk-taking while intoxicated is likely due in part to the disinhibiting effects of the drug on impulse control. Laboratory evidence implicates inhibitory control as an important contributor toward maladaptive, impulsive driving behaviors. Indeed, in a laboratory study of alcohol effects, we have shown that individuals whose inhibitory control was most impaired by alcohol on a cued go/no-go task also displayed the greatest level of risky driving behaviors under the drug (Fillmore et al., 2008). This relationship suggests that risky driving could be decreased in situations in which inhibitory control is improved. A number of studies have examined the effect of alcohol on inhibitory control using alcohol doses that produce peak BACs between 0.05% and 0.08% (for a review, see: Weafer and Fillmore, 2016). In general, these studies provide some evidence that the disinhibiting effect of alcohol is less pronounced at a BAC of 0.05%, compared with 0.08% (Marczinski and Fillmore, 2003). Given the importance of inhibitory control to risky driving behavior, there is reason to suspect that risky driving might also decrease in a similar manner at BACs below 0.08%.

The current study tested this hypothesis in a sample of healthy adult drivers who completed a risky driving scenario in a driving simulator following placebo and active doses of alcohol calculated to yield target BACs of 0.08% and 0.05%, the respective current and recently proposed BAC limits in the United States. The driving scenario placed drivers in a high-traffic, urban setting and encouraged risky driving by providing monetary incentive for completing the drive scenario quickly. It was predicted that alcohol would increase risky driving, relative to placebo. Moreover, it was predicted that risky driving under alcohol would be significantly diminished at a BAC of 0.05% compared with 0.08%.

2. Materials and methods

2.1. Participants

Twenty licensed adult drivers (10 men and 10 women) between 21 and 35 years of age participated in this study. 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. Interested individuals called the laboratory and completed a telephone screen that gathered information on demographics, drinking habits, other drug use, and physical and mental health status. Volunteers who self-reported head trauma, psychiatric disorder, or substance abuse disorder were excluded from participation. All volunteers had to drive a motor vehicle and consume alcohol at least one day per week. Individuals 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)*. 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 (ICUP Drug Screen, Instant Technologies). Any volunteer who tested positive for the presence of any of these drugs (with the exception of THC) was excluded from participation. Current marijuana users were instructed to abstain from use for at least 24 h prior to participation. No female volunteers who were pregnant or breast-feeding participated in the research as verified by self-report and urinalysis (Icon25 Hcg Urine Test, Beckman Coulter). Sessions were conducted in the Human Behavioral Pharmacology Laboratory of the Department of Psychology. Volunteers were required to abstain from alcohol for 24 h, food for 4 h, and water/fluids for 2 h prior to each test session. Test sessions were initiated between 10:00 a.m. and 6:00 p.m. At the beginning of each session, a zero blood alcohol concentration (BAC) was verified by Intoxilyzer, Model 400 (CMI Inc., Owensboro, KY). The University of Kentucky Medical Institutional Review Board approved the study. All participants provided informed consent, and received $130 compensation for their participation plus any bonus money based on their simulated driving performance (see Section 2.2.1 Risk-based drive scenario)

2.2. Apparatus and materials

A computerized driving simulator measured driving performance (STISIM Drive, Systems Technology Inc., Hawthorne, CA). In a small room, participants sat in front of a 19-inch computer display, which presented the driving simulation at a 60° horizontal field of view. 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 (lane width = 12 ft) surroundings and instrument panel, which included an analog speedometer. Crashes, either into another vehicle or off the road, resulted in the presentation and sound of a