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Drinking and driving behavior at stop signs and red lights

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ABSTRACT

Alcohol is one of the principal risk factors for motor vehicle crashes. One factor that contributes to vehicle crashes is noncompliance with stop signs and red lights. The present experiment investigated the effects of alcohol and drinking patterns on driving behavior at stop signs and red lights. 28 participants participated in drinking and simulated driving sessions during which they received a moderate dose of alcohol (0.08% BAC) or a placebo. Simulated driving tasks measured participants' driving performance at stop signs and red lights in response to each dose. Results suggested that alcohol impaired the driver control of speed and direction and prolonged their simple and complex reaction time, which were exhibited by impaired speed and lateral control, longer reaction time when the lights turned yellow, and lower deceleration towards stop signs and red lights. Visual degradation may also occur under alcohol intake. It was also suggested that alcohol impaired non-binge drinkers more severely. To be specific, higher acceleration was observed in impaired non-binge drinkers.

1. Introduction

Alcohol is one of the principal risk factors for motor vehicle crashes. Over 10,000 motor vehicle fatalities in the United States involved alcohol, representing an average of one alcohol impaired driving fatality occurring every 52 min, in the year 2013 (NHTSA, 2014). There is a large body of evidence demonstrating that moderate doses of alcohol impair a broad range of the skills important to driving performance (Carpenter, 1962; Donovan et al., 1983; Holloway, 1994; Levine et al., 1975; Mitchell, 2016; Moskowitz and Robinson, 1987). Alcohol produces visual degradation (Harrison and Fillmore, 2005a), alters decision-making (Burian et al., 2002; Modell and Mountz, 1990), slows simple and complex reaction time (Holloway, 1994), and decreases hand steadiness (Laberg and Löberg, 1989). Laboratory studies have also shown that moderate doses of alcohol impairs driving performance in driving simulations (Moskowitz and Burns, 1990). Alcohol impairs driving precision (as evident by the impaired perception of speed, increased within-lane and speed deviation and stopping accuracy) (Allen et al., 2016; Perrine and Huntley, 1971; Harrison and Fillmore, 2005b; Marczinski and Fillmore, 2009; Mets et al., 2011; Stein and Allen, 1987), and the behaviors critical to the safe operation of vehicles, such as braking reaction time (Laurell, 1977; Liguori et al., 1999).

One factor that contributes to multiple-vehicle crashes at intersections, as well as those involving pedestrians, is noncompliance with traffic control devices such as stop signs and red lights. In 2012, 683,000 vehicles were involved in crashes at stop signs. Approximately one-third of these crashes resulted in injury and more than 7000 were fatal (NHTSA, 2013). Retting et al. examined the prevalence of stop sign and traffic signal running crashes in urban areas using police-reported crash data obtained from three cities (Akron, Ohio; New Orleans, Louisiana; and Yonkers, New York) and identified that, among running traffic control (e.g., stop signs, red lights, yield signs) crashes, stop sign running accounted for the largest proportion (41%), followed by red light running, which accounted for 24% of crashes (Retting et al., 1995). Alcohol involvement was reported in 62.3% of all single vehicle crashes in which the driver failed to obey the stop sign, compared to 31.9% in the failure to obey the traffic signal (Campbell et al., 2004). O'Donnel reviewed eleven studies which described the driver's drinking location prior to a specific alcohol-impaired driving incident. Most of these studies showed that more than 40% of those alcohol-impaired drivers have consumed their last drink on licensed premises (O'Donnell, 1985). Most on-premise establishments are located along urban roads, which drivers use directly after leaving a licensed premises before reaching another destination on an urban road or before merging onto a highway (State Liquor Authority, 2016). If these alcohol-impaired drivers could be identified at stop signs or red lights, it would be easier for the police to stop them on urban roads. As a result, much higher

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severity of alcohol-impaired driving accident on highways would be prevented.

Despite the large numbers of crashes at stop signs and traffic signals involving alcohol and their relatively severe nature, drinking and driving behavior at stop signs and traffic signals has not been the subject of much detailed research. Romano et al. reviewed stop sign violation data from police reports and indicated that the incidence of stop sign violation increases when the driver consumed alcohol (Romano et al., 2006). Retting et al. examined the prevalence of red light running crashes on a national basis and identified the characteristics of such crashes and the drivers involved (Retting et al., 1999). They found that red light runners were more likely to have consumed alcohol. There were only a few experimental studies on the drinking and driving behavior at stop signs and traffic signals. Quillian et al. have investigated the effects of alcohol on the percentage of complete stop and stopping duration at the stop sign using driving simulators and only obtained statistically significant results on the former measurement (Quillian et al., 1999). Rafaelsen et al. investigated driving behavior at red lights in a driving simulator study and found that alcohol increased response time when lights turned from green to red as well as when lights turned from red to green (Rafaelsen et al., 1973). In Fillmore et al. (2008)'s study, worse compliance to the red light and greater acceleration when the light turned from red to green under alcohol was observed, compared with a placebo (Fillmore et al., 2008). Worse compliance at traffic signals was also observed in Stein and Allen (1987)'s study (Stein and Allen, 1987). In contrast, Harrison & Fillmore and Veldstra et al. did not find any difference in the compliance to the red light between participants under alcohol and those who took a placebo (Veldstra et al., 2012; Harrison and Fillmore, 2011).

Another important variable that may be contributing to alcohol-related driving skill impairment is the drinking pattern. Drinking pattern is associated with the development of tolerance, which refers to diminution in effects of a drug occurring with the same dose of drug that is due to previous administration of the drug (Mitchell, 2016). Current studies have shown that experienced drinkers often demonstrate behavioral tolerance or less impairment from acute alcohol than lighter drinkers (Hollingworth, 1923; Goldberg, 2017; Fillmore and Vogel-Sprott, 1995; Fillmore and Vogel-Sprott, 1996; Evans and Levin, 2004; Zhao et al., 2010). These findings are consistent across many studies on measures of sensory perception, memory tasks, psychomotor tasks, and steadiness of gait or body sway. However, some studies reported that individuals with chronic and excessive alcohol consumption exhibit a number of cognitive deficits and problems in inhibitory control. These cognitive deficits were associated with impulsivity (Moselhy et al., 2001), impaired cognitive function in working memory tasks, pattern recognition tasks (Weissenborn and Duka, 2003), and vehicle control (Zhao et al., 2010), even in a sober driving situation. Currently, only a few studies have suggested an effect of drinking pattern on impairment in driving performance (Coldwell, 1958), and driving behavior at stop signs and red lights has not been addressed.

The overall objective of this research was to investigate the effects of alcohol intake on driving behavior at stop signs, as well as the combined effects of drinking pattern with a laboratory driving experiment. It was hypothesized that driver behavior including speed and lateral position control, stop sign and red light compliance, stopping accuracy and braking/acceleration control at both stop sign and red light were worse under alcohol condition compared with placebo. Binge driver may exhibit better control of speed, lateral position, stopping accuracy and braking/acceleration at stop sign and red light.

2. Methods

2.1. Participants

A total of 28 healthy participants (14 males, 14 females) between the ages of 21 and 36 years (Mean = 23.43, SD = 3.12) were included in the study. Participants were included if they had a valid driver's license for at least two years. Exclusion criteria were current or past drug use, positive alcohol breath test, being pregnant, physical or mental illness, currently taking medication for which alcohol is contra-indicated, or having been involved in other substance abuse treatment services within the past year (or currently). All participants had normal or corrected-to-normal vision. State University of New York at Buffalo Institutional Review Board approved the study and volunteers received $10/h for their participation.

2.2. Self-reported measures

All participants were asked to complete a set of questionnaires before engaging in the driving task. The first questionnaire was designed to capture participant demographics (e.g., gender, age) and driving history (e.g., driving experience, annual mileage). Participants were also required to complete the Timeline follow-back (Sobell and Sobell, 1992), which assesses daily patterns of alcohol consumption over the past 3 months and includes measures of the number of drinks consumed each day. The measure provided an accurate retrospective account of alcohol use during that time period. Participants were classified as binge or non-binge drinkers on the basis of the widely used Wechsler definition of a binge-drinking episode, which is five or more drinks on one occasion for men and four or more drinks on one occasion for women (Substance Abuse and Mental Health Services Administration, 2007).

2.3. Apparatus

A STISIM® driving simulator (STISIMDRIVE M100K, Systems Technology Inc, Hawthorne, CA) was used in the study. This desktop driving simulator includes a Logitech Momo® steering wheel with force feedback (Logitech Inc, Fremont, CA), a throttle pedal, and a brake pedal. The driving scenarios were presented on a 27-inch LCD with 1920 × 1200 pixel resolution. Auditory feedback was provided by speakers and included the sound of the engine and braking. Whenever a collision occurred, a broken windshield was projected, and the sound of breaking glass could be heard.

2.4. Driving scenarios

Two 14-mile driving scenarios were developed for each session, which included vehicles, pedestrians, traffic lights, traffic signs (e.g., stop sign, speed limit), and buildings. Traffic signs were displayed 500 feet in front of the driver and traffic lights were displayed 1000 feet in front of the driver. Traffic signs were displayed 500 feet in front of the driver. The driving scenario consisted of various numbers of lanes (from 1 lane to 3 lanes) in each direction. Participants were instructed to drive safely, obey traffic rules, remain in the center of the rightmost lane and adjust their speed as if they were driving a real vehicle on the road.

Each driving scenario included two stop signs and three red lights. The speed limit was either 30 mph or 35 mph when the driver was within 2000 feet of a stop sign intersection, with only one lane in each direction. The speed limit was 45 mph when the driver was within 2000 feet of a red light intersection, with two lanes in each direction. There were crossing vehicles or crossing pedestrians at each type of intersection.

2.5. Experimental design and procedures

Applicants who responded to local advertisements were interviewed first by telephone. They were screened in terms of driving history, drinking history, health history, current health status, and use of alcohol and other drugs. Qualified applicants were told to refrain from alcohol for at least 24 h, from other drugs (except tobacco) for 72 h, and