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Combined effects of alcohol and distraction on driving performance

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ABSTRACT

Although alcohol and distraction are often cited as significant risk factors for traffic crashes, most research has considered them in isolation. It is therefore necessary to consider the interactions between alcohol and distraction impairment sources, especially when examining the relationship between behavior and crash risk. In a driving simulator, the primary goal was to maintain a safe headway to a lead vehicle and the secondary goal was to maintain stable lane position. All participants engaged in distractions that represented different levels of resource competition and half of the participants consumed alcohol (target BAC 0.08 g/dl). Specific comparisons were made between sober driving while distracted and driving intoxicated without distraction. Distraction tasks produced more changes in driving behavior than did alcohol for both longitudinal (primary) and lateral (secondary) driving goals. Alcohol impairment was evident only in relation to lateral driving performance, however there was an amplification of impairment when alcohol and distraction conditions were combined. Distraction resulted in a general level of impairment across all driving goals, whereas participants with alcohol appeared to shed secondary driving goals to "protect" primary driving goals. Drivers' strategies to cope with alcohol (and distraction) may not be sufficient to offset the increased crash risk.

1. Introduction

Efforts to reduce traffic fatalities should be based on a scientific understanding of the causes of traffic crashes. Research has demonstrated a consistent relationship between driver blood alcohol content (BAC) and the risk of a fatal traffic crash, especially for younger drivers (e.g., Zador et al., 2000). In the US, 39% of the 43,443 traffic fatalities in 2005 were related to alcohol (NHTSA, 2006) and economic model analyses have estimated the annual comprehensive cost associated with alcohol-related crashes to be $120 billion (Miller et al., 1998). Given alcohol's prevalence as a crash factor and the cost associated with related crashes, NHTSA has identified the reduction of alcohol-related traffic fatalities as a priority for improving traffic safety (NHTSA, 2001).

Younger drivers represent a large portion of this problem, as evidenced by Minnesota data between 1997 and 2006 which shows that drivers under the age of 35 accounted for 60% of all DUI violations; 9.2% of which represent drivers under 21 years of age (Office of Traffic Safety, 2007). When not impaired by alcohol, younger drivers have been found to have an increased crash risk from distractions such as conversing on mobile phones or from glancing away for longer periods at the center console (Ferguson, 2003). This is supported by the post-crash narrative data from Stutts et al. (2001) which found that drivers under the age of 20 were most likely to have a distraction-related crash that involved adjusting radio controls. That said, drivers of every age double their crash risk when they frequently converse on a phone (Laberge-Nadeau et al., 2003). Traditionally, research to support this traffic safety agenda has tended to either *isolate* the impairment effects of alcohol (Holloway, 1995) or *compare* the effects of alcohol to other risk factors such as distraction (Burns et al., 2002; Strayer et al., 2006) or fatigue (Fairclough and Graham, 1999; Falleti et al., 2003).

Wang et al. (1996) found that 7.8% of non-fatal crashes reported in the 1995 CDS database could be attributed to a complex driver state defined by a combination of distraction and alcohol. Minnesota crash data between 1996 and 2004 also shows that 21% of fatal crash-involved drivers that were presumed to be distracted also tested positive for alcohol. In a study using a desktop driving

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simulator, Iudice et al. (2005) demonstrated that alcohol may be linked to faster speeds when drivers completed "divided attention tasks" over a hands-free phone, but slower speeds when fatigued. This suggests that the impairment effect of a risk factor may depend on the presence or absence of other risk factors. It would be beneficial to replicate this trend and examine the combined effects of alcohol with other driver state risk factors using a more ecologically representative driving environment.

Compelling evidence from the psychomotor effects of alcohol impairment and distraction suggests that alcohol may exacerbate the impairment effect of distraction. Mechanisms of distraction in terms of peripheral task engagement while driving can be postulated in terms of (1) the disruption of the visual field—eyes not on road (Zwahlen and DeBald, 1986; Wierwille, 1993); (2) the diversion of attention—looked but did not see (Strayer et al., 2003); or (3) the depletion of available processing resources—resource competition (Boer, 2001). In comparison, alcohol has been shown to have similar psychomotor impairment in terms of reduced normal visual search patterns (Green, 2003) or reduced contrast sensitivity and processing speed of sensory information (Jones et al., 1998; Pearson and Timney, 1998).

Moreover, alcohol has been shown to restrict attention focus (Bartholow et al., 2003) and impair attention-switching ability between and within multi-task environments that require controlled skills (Holloway, 1995; Moskowitz and Fiorentino, 2000). Impaired attention-switching may result in intoxicated persons focusing attention on the primary task goal and ignoring secondary goals, suggesting that alcohol may leave primary task performance relatively unaffected (Bartholow et al., 2003) while jeopardizing performance on secondary goals (Erblich and Earlywine, 1995). Finally, whereas there is no direct evidence that alcohol depletes processing resources through increased resource competition, alcohol has been shown to inhibit the suppression of inappropriate or risky behaviors during dual-task conditions (Fillmore and Vogel-Sprott, 2000). This evidence suggests increased crash risk during conditions in which intoxication and distraction are combined.

To investigate this supposition, this study was designed to examine the individual and combined effects of alcohol and distraction resource conflicts on coping strategies. According to Hockey (1986, 1993), a person may react to a stressor by adopting one or several coping strategies: (1) try harder and invest resources to focus on predictive control in achieving target state; (2) lower performance goal by relaxing target goal or increasing tolerance margin such that effort can be diverted to dealing with the stressor; (3) manage or ignore the stressor; and (4) endure the stress state. Resource conflicts manifest themselves in the control activity, target state, and overall driving performances. Based on multiple resource theory (Wickens and Hollands, 2000), resource allocation for driving is primarily directed to visual information processing and manual control. Accordingly, this study included a *high resource conflict* condition ("in-vehicle" tasks) which was expected to result in high resource competition with driving for visual information processing and manual control (Boer, 2001). A *low resource conflict* condition ("cell phone" tasks) was expected to result in low resource competition with driving for central processing resources (Boer, 2001). Finally, there was a *no resource conflict* condition in which subjects drove the scenario without any distraction tasks ("baseline").

In addition to these resource allocation "distraction" conditions, half of the participants were administered alcohol to a target BAC of 0.08. Consistent with previous research (Burns et al., 2002; Strayer et al., 2006), it was hypothesized that both distraction and alcohol would evoke performance impairments depending on the adopted coping method. It was further hypothesized that more impairment would be evident in the high resource conflict condition, consistent with naturalistic findings showing glances away from the road to be riskier than holding a conversation (Klauer et al., 2006). Finally, based on the evidence that alcohol interferes with attention switching (Fisk and Scerbo, 1987; Moskowitz and Fiorentino, 2000) and the expectation that alcohol would reduce the saliency of performance discrepancies, alcohol and distraction were expected to interact and produce an amplified impairment effect. Based on evidence suggesting that alcohol may restrict attention to the primary task goal in a multi-task environment (Bartholow et al., 2003), an amplified impairment effect within the car following scenario was hypothesized to be weaker for headway maintenance and stronger for lane position maintenance.

2. Methods

2.1. Participants

Male participants over the age of 21 were recruited because males exemplify a higher-risk population for drunk driving. Males have been shown to be more likely to drink and drive than females (NHTSA, 2006), including during 2006 when males were at the wheel during 83% of alcohol-related crashes in the US (NHTSA, 2008) and represented 85% of Minnesotans who died while driving with a BAC level greater than the per se 0.08 limit (Office of Traffic Safety, 2007). The final sample consisted of 45 male drivers (M = 22.3 years) randomly sorted into alcohol and placebo BAC dosing groups.

There were no differences between the alcohol (n = 24) and placebo (n = 21) groups in terms of age, years driving, weekly alcohol consumption, annual mileage, and traffic convictions (all p > 0.30). All participants were compensated USD $50 for their participation.

2.2. Driving simulator and scenario

The study used the HumanFIRST Program driving simulator at the University of Minnesota, which is an immersive, motion-base simulator operating SCANeR II simulation software. It uses a full-sized Saturn vehicle and a dynamics model operating at 100 Hz with a data-sampling rate of 20 Hz. The visual images were projected using Epson 7600 projectors (1024 × 768, 2200 lumens, 400:1 contrast, 24 bit color) at a frame rate greater than 30 Hz. The forward scene was comprised of a five-channel 210° field of view on white-painted flat panels with 2.5′ per pixel resolution. The rear scene was comprised of a single channel 50° field of view on a projection screen and the mirror housings contained color LCD panels. Auditory and haptic feedback were provided using a 3D audio system, subwoofer, car body vibration, force feedback steering, and a three-axis electric motion system (roll, pitch, z-axis).

Participants drove on a rural four-lane median-divided highway while following a lead car that varied its speed in a sinusoidal pattern. Unbeknownst to the participant, the car following task consisted of 30 s of practice and then two 2-min experimental segments: *low demand*, randomly cycling every 25–50 s between 55 and 75 mph; and *high demand*, randomly cycling every 8–16 s between 55 and 75 mph. The lead vehicle's taillights did not illuminate while slowing since this maneuver is comparable to a mild deceleration experienced by releasing the accelerator under real world highway conditions.

During the scenario, participants were instructed that their main task was to maintain a safe headway. This is representative of a continuous driving task requiring sustained vigilance to maintain a constant safe headway with a lead vehicle as it dynam-