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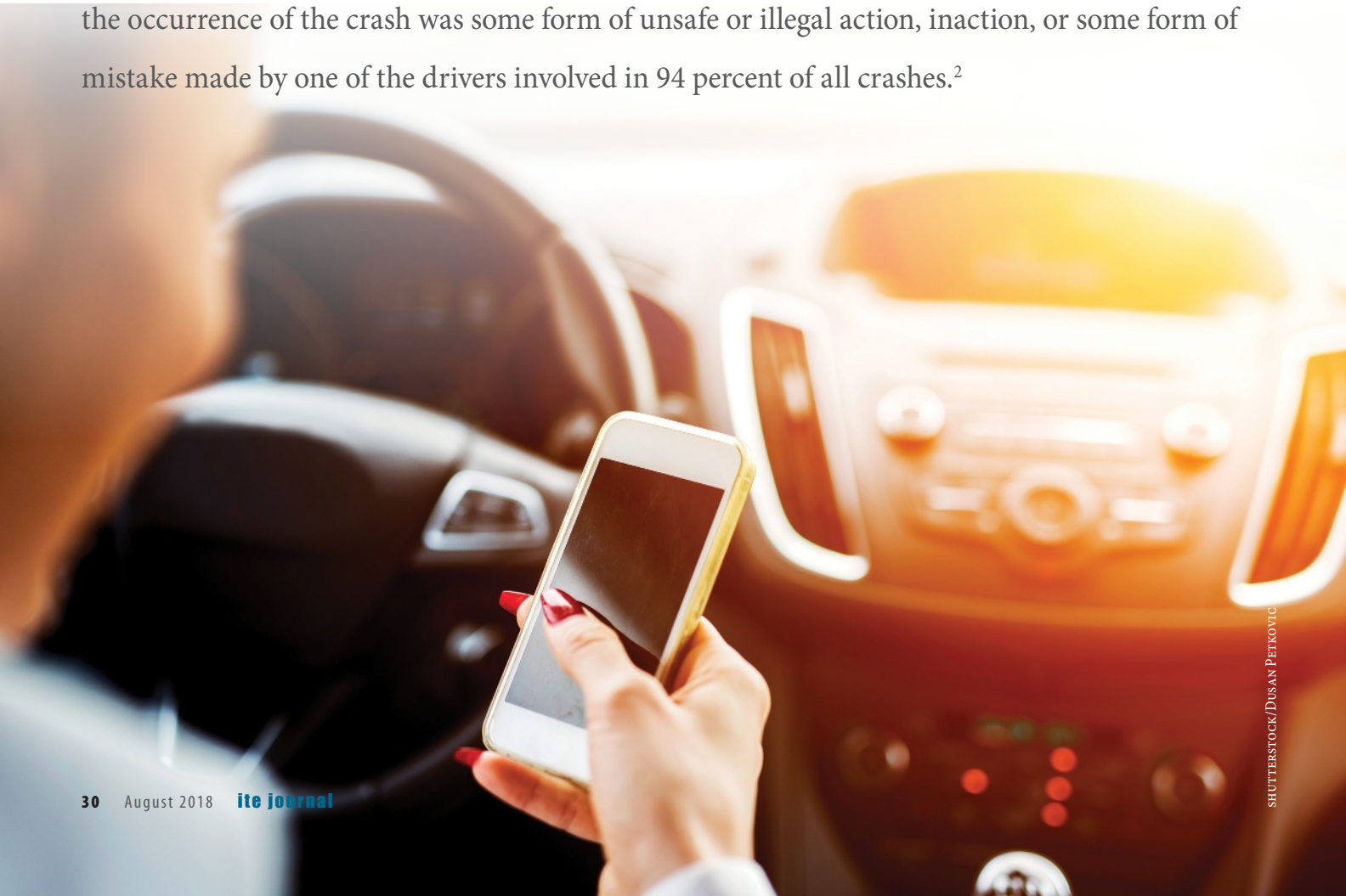
Reducing Crash Risk and Improving Traffic Safety:

Research on Driver Behavior and Performance

By Brian C. Tefft, William J. Horrey, Ph.D., and C. Y. David Yang, Ph.D.

According to the National Highway Traffic Safety Administration (NHTSA), 7,277,000 motor vehicle crashes were reported to the police in the United States in 2016, injuring 3,144,000 people and killing 37,461.[1] In-depth crash investigations have revealed that the immediate reason for the critical event that led to the occurrence of the crash was some form of unsafe or illegal action, inaction, or some form of mistake made by one of the drivers involved in 94 percent of all crashes.[2]



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The mission of the AAA Foundation for Traffic Safety (AAAFTS) is to save lives through research and education. In recognition of the fact that the vast majority of all motor vehicle crashes can be traced back to something that a driver did or failed to do, one of the AAA Foundation's four focus areas is *Driver Behavior and Performance*. Through research on driver behavior and performance, AAAFTS seeks to guide drivers toward safer decisions. This article details recent research into two aspects of driver behavior and performance that have profound implications for traffic safety: distracted driving and drowsy driving.

Distracted Driving

Safe driving requires that drivers pay attention to the road and traffic. However, research has revealed that all too often, drivers choose to allocate their attention elsewhere. For example, in the AAAFTS annual survey of the U.S. driving population, the *Traffic Safety Culture Index*, distracted driving continues to be among drivers' greatest safety concerns. Nearly four out of every five drivers rated texting while driving as a very serious threat to their own personal safety—making this Americans' number 1 concern and placing it well ahead of drunk drivers or drivers using drugs. Nonetheless, fully 45 percent of all drivers indicated that they had read a text message or e-mail while driving at least once in the past 30 days, and 35 percent admitted having typed and sent one themselves. Ten percent of respondents—representing 23 million drivers nationwide—were even willing to admit that they type or send text messages or emails while driving fairly often or regularly.[3]

NHTSA's Crash Report Sampling System, which comprises data from police reports of crashes that occurred in a sample of cities and counties around the United States every year, indicates that more than 1 million crashes—approximately one of every seven—involved a driver who the police officers investigating the crash believed was distracted.[4,5] These crashes resulted in 3,450 deaths and an estimated 483,000 injuries. As shocking as these numbers are, they almost certainly underestimate the true scope of the problem. A 2005 report by the Transportation Research Board (TRB) likened crashes in which driver distraction is actually reported by the police to the tip of an iceberg.[6]

Modern research methods make it possible to gain a new window into the roles of driver behavior and performance in motor vehicle crashes. For example, in the Second Strategic Highway Research Program (SHRP 2) Naturalistic Driving Study (NDS) sponsored by TRB, a team of researchers led by the Virginia Tech Transportation Institute (VTTI) recruited a sample of more than 3,500 ordinary drivers in and around six major U.S. cities, placed cameras and other sophisticated data collection equipment in their vehicles, and recorded detailed data continuously as these drivers went about their usual driving for periods ranging from several months to over a year. The study ultimately compiled more than 2 petabytes of data from more than 35 million miles of driving.[7] Over the course of the study, participants were involved in a total of 905 crashes that resulted in property damage or injury. When researchers examined the final 6 seconds of video preceding these crashes, they found some form of observable distraction present in 68 percent, a stark contrast to the 14 percent of crashes nationwide in which police reports indicate that a driver was distracted.[7]

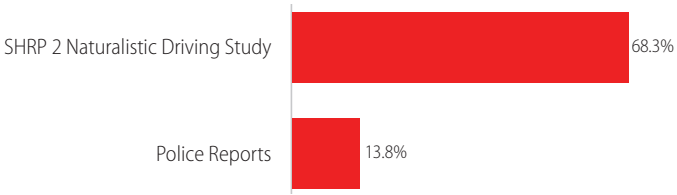

Figure 1. Percent of All Crashes that Involve Driver Distraction, as Estimated from Police Reports and the SHRP 2 Naturalistic Driving Study.[4,7]

A recent study performed by the VTTI for the AAAFTS analyzed data collected in the SHRP 2 NDS to quantify the crash risk associated with using a cell phone while driving. Researchers examined how and whether a driver was using a cell phone in the 6 seconds immediately before crashing and in up to four 6-second segments of video in which the same driver was driving under similar conditions in the 3 months before the crash occurred. Segments of ordinary driving ("baseline epochs") were matched to the crashes with respect to time of day, day of week, traffic conditions, environmental conditions, and speed. A total of 566 crashes were matched to 1,749 segments of ordinary driving. Some form of cell phone use was observed in the seconds leading up to 83 of the 566 crashes examined, with texting being the most common, followed by talking, locating/reaching for/answering the phone, and browsing. Results indicated that visual-manual cell phone use overall, and texting in particular, approximately doubled a driver's risk of crash involvement. Risks were further elevated in types of crashes in which the driver played a clear active role such as rear-end and road-departure crashes. Results with respect to simply talking on a cell phone in the absence of any visual-manual interaction with it were inconclusive.[8]

The AAAFTS has also sponsored research looking into the visual and cognitive demands of interacting with embedded in-vehicle information systems (IVIS) or "infotainment" systems. In a recent study, researchers at the University of Utah developed and refined measures to assess visual, cognitive, and overall demands as well as task completion time.[9] In the on-road study, researchers tested 30 vehicles from a variety of manufacturers (model year 2017). Participants included 120 licensed drivers aged 21 to 36. Depending on the available features, each vehicle offered up to three modes of interaction, including voice-commands, center stack display (e.g., touch screen) and controls in the center console (e.g., writing pads, control dial). Four types of tasks were evaluated

using the different modes of interaction, including: (a) calling or dialing; (b) text messaging; (c) programming audio entertainment; or (d) programming navigation.

Overall, navigation was the most demanding task, and text messaging was associated with a significantly higher level of overall demand than tuning the radio and calling/dialing. Using controls in the center console led to higher overall demands than interactions using the center stack and voice commands. The use of voice-commands led to lower levels of visual demands compared to the other modes of interaction; however, in many cases these benefits were offset by longer interaction times. There was significant variability in the demands generated by the different vehicle systems. Of the 30 vehicles tested, 23 vehicles generated high or very high levels of overall demand on drivers.

In a recent expansion of this work, the research team at the University of Utah examined how native OEM infotainment systems compared with third party systems: Apple's CarPlay and Google's Android Auto.[10] Both of these third party systems incurred lower overall demands on drivers than the OEM systems.

Drowsy Driving

Driver drowsiness represents another significant issue for traffic safety. Although it is a known risk factor, the AAAFTS surveys and crash statistics reveal that all too often, Americans find themselves driving while impaired by drowsiness. The medical community recommends that a typical healthy adult should sleep for 7–9 hours per night on a regular basis for optimal health,[11] however, surveys by the Centers for Disease Control and Prevention reveal that one in three drivers usually do not.[12] While 95 percent of drivers in the AAAFTS annual *Traffic Safety Culture Index* say that it is unacceptable for a driver to drive in a state in which they are "so tired that they have a hard time keeping their eyes open," 31 percent admitted having done so at least once in the month before the survey, including 4 percent who reported doing so "fairly often" or "regularly."[3]

Statistics from NHTSA indicate that drowsiness was reported by the police as a factor in nearly 120,000 crashes in the United States in 2016, resulting in 63,000 injuries and 803 deaths.[4,13] However, as with distraction, experts widely regard these statistics as substantial underestimates of the scope of the problem.[6]

A previous AAAFTS study examined a sample of in-depth crash investigations and estimated that as many as 7 percent of all crashes nationwide—and approximately 16 percent of fatal crashes—involve a drowsy driver.[14] Extrapolating those percentages to the most recent data available on crashes would suggest that as many as 500,000 crashes and 6,000 deaths nationwide likely involve a drowsy driver, a stark contrast to the much lower numbers that appear in official government statistics.

Another recent AAAFTS study confirmed these results. Researchers at VTTI performed in-depth analysis of video data from the SHRP 2 NDS to calculate the percentage of time that the driver's eyes were more than 80 percent closed or covering the pupil. This measure, called PERCLOS (Percent Eye Closure) has been shown in numerous studies to be highly correlated with subjective drowsiness, lapses in attention, and elevated rates of lane departures in simulated driving. By this measure, the researchers estimated that 9 percent of all crashes in the SHRP 2 NDS and 11 percent of those severe enough to be reportable to the police involved moderate to severe driver drowsiness, an even higher percentage than in previous AAAFTS research and nearly an order of magnitude greater than statistics derived from police reports would suggest (See Figure 2).[15]

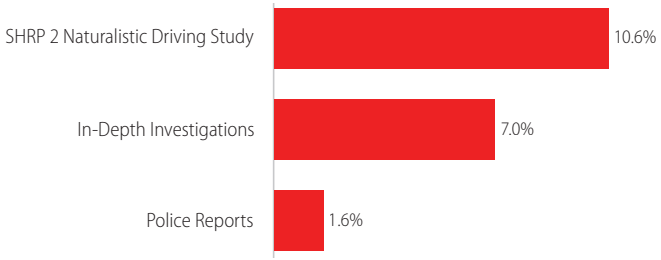

Figure 2. Percent of Crashes that Involve Driver Drowsiness, as Estimated from Police Reports, In-Depth Crash Investigations, and the SHRP 2 Naturalistic Driving Study.[4,14,15]

What can drivers do to avoid finding themselves driving under the influence of drowsiness? Another recent AAAFTS study points to an unsurprising answer: sleep. To quantify the relationship between the amount that a driver sleeps and his or her risk of causing a crash, AAAFTS researchers examined data from crash investigations to quantify the crash risk associated with sleep reported during the 24 hours before the crash. After controlling for other factors also correlated with crash risk, results showed that drivers who reported less than 7 hours of sleep had significantly increased risk of causing a crash. Among these drivers, as hours of sleep decreased, risk increased. Drivers who had slept for less than 4 of the past 24 hours had risks on par with those of drivers with blood alcohol concentrations well over the legal limit of 0.08.[16]

Implications & Future Directions

Virtually all crashes involve some form of driver behavior or performance error. Research into driver behavior and performance is paramount towards the understanding of these causal mechanisms. The current article focuses on two important aspects of driver behavior and performance: distracted driving and drowsy driving. While both are recognized as issues, their prevalence and impact have been widely underestimated. The research described in this article seeks to highlight the true magnitudes of distracted and drowsy driving, as well as straightforward approaches to reducing their risks.

The research described in this article reveals how distracted and drowsy driving can impair driving performance and increase

crash risk. Different modes of interaction with technology, whether integrated into the vehicle or carried in by the driver, can impact a driver's workload, attention to driving, response to critical events, and ultimately safety. Automobile manufacturers and system designers can leverage the results from these studies to isolate the most significant sources of driver demand and to enhance the design of the systems to help minimize the demands placed on drivers. Similarly, drowsiness and fatigue due to sleep deprivation can impair drivers' judgment and reaction time, and in the worst case scenario can even cause the driver to fall asleep at the wheel. While the only proven countermeasure to drowsiness is sleep, technologies that monitor driver state may also have a role to play in reducing the prevalence and impact of drowsy driving; more research is needed.

The research described in the current article contributes to our understanding of the magnitude and scope of these traffic safety issues. This information is useful in guiding research, funding decisions, and legislative priorities, to name a few. These efforts in turn implicate a variety of stakeholders who are essential in taking steps towards addressing the issues, including academics and other researchers, federal and state legislatures, and traffic safety advocates. Automobile manufacturers and other technology developers also have an important role to play; some of the research described herein offers insights into design elements, such that improvement can be achieved through iterative design.

The vision of continued reductions in traffic injuries and fatalities is admirable. This article contributes to such effort by examining the effect of distracted and drowsy driving on crash risk and traffic safety. It is hoped that this research, combined with the growing body of scientific knowledge, can have a significant and lasting impact in the progress towards the ultimate goal of zero deaths on our roadways. **itej**

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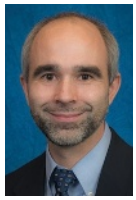

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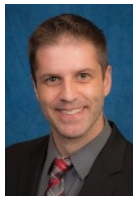

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