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Using event-triggered naturalistic data to examine the prevalence of teen driver distractions in rear-end crashes

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ABSTRACT

Introduction: While teen driver distraction is cited as a leading cause of crashes, especially rear-end crashes, little information is available regarding its true prevalence. The majority of distraction studies rely on data derived from police reports, which provide limited information regarding driver distraction. *Method:* This study examined over 400 teen driver rear-end crashes captured by in-vehicle event recorders. A secondary data analysis was conducted, paying specific attention to driver behaviors, eyes-off-road time, and response times to lead-vehicle braking. *Results:* Among teens in moderate to severe rear-end crashes, over 75% of drivers were observed engaging in a potentially distracting behavior. The most frequently seen driver behaviors were cell phone use, attending to a location outside the vehicle, and attending to passengers. Drivers using a cell phone had a significantly longer response time than drivers not engaged in any behaviors, while those attending to passengers did not. Additionally, in about 50% of the rear-end crashes where the driver was operating/looking at a phone (e.g., texting), the driver showed no driver response (i.e., braking or steering input) before impact, compared to 10% of crashes where the driver was attending to a passenger. *Conclusions:* The high frequency of attending to passengers and use of a cell phone leading up to a crash, compounded with the associated risks, underlines the importance of continued investigation in these areas. *Practical applications:* Parents and teens must be educated regarding the frequency of and the potential effects of distractions. Additional enforcement may be necessary if Graduated Driver Licensing (GDL) programs are to be effective. Systems that alert distracted teens could also be especially helpful in reducing rear-end collisions.

1. Introduction

Rear-end collisions are frequent among drivers of all ages, but especially with young drivers. In 2013, rear-end crashes accounted for 49.5% of *all* vehicle-to-vehicle crashes involving 16–19 year old drivers. Furthermore, rear-end crashes accounted for 51% of property damage, 47% of injury, and 11% of fatal crashes for teen drivers ages 16–19 (L. Cianflocco, NCSA Information Services, personal communication, 3/24/2015). Distraction is a frequent contributing cause of rear-end collisions (Engström, Werneke, Bärgman, Nguyen, & Cook, 2013; Lind & Dozza, 2012). According to the National Safety Council (2013), distraction doubles risk of a rear-end crash. Research shows that teen drivers are more willing (Johnson, 2012; Pöysti, Rajalin, & Summala, 2005; Simons-Morton et al., 2011; Williams, 2003) and less able (Klauer et al., 2014; McKnight & McKnight, 1993; Simons-Morton, Guo, Klauer, Ehsani, & Pradhan, 2014; Wikman, Nieminen, & Summala, 1998) than adults to drive distracted, thus increasing their risk.

Many crash studies to date have examined large administrative databases like the National Highway Traffic Safety Administration (NHTSA) Fatal Analysis Reporting System (FARS), and the National Automotive Sampling System (NASS) General Estimates System (GES), which get their data from police-reported crashes. However, these data sources provide limited information regarding distraction due to recall bias, social pressure to report safe driving, and the difficulty of assessing distraction in the case of a fatal crash. It is thus likely that many studies using these sources do not accurately reflect the size of the distraction problem (NHTSA, 2009; Stutts, Reinfurt, Staplin, & Rodgman, 2001).

Over the past 10 years, researchers have developed new and sophisticated methods to collect and analyze traffic safety data. Using in-vehicle event recorders (IVERs), researchers can gather data from both inside and outside the vehicle allowing researchers an accurate and unbiased view into the vehicle to record the behaviors that drivers engage in during particular driving situations. The 100-car study (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006) and more recently SHRP2 (Campbell, 2012) employed IVERS to collect continuous naturalistic data and in doing so have collected over 50 million miles of important data regarding driver behaviors. However, they have captured a surprisingly low number of crashes. The 100-car study captured only 15 police-

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reportable crashes (Neale, Dingus, Klauer, Sudweeks, & Goodman, 2005) and SHRP2, the largest naturalistic study to date, has identified only 904 property-damage crashes with less than 300 of those being police-reportable (Owens, Angell, Hankey, Foley, & Ebe, 2015; Insight Data Access Website, accessed 12/16/2015). In each of these studies, the number of crashes involving teen drivers is limited and the number of teens involved in *rear-end crashes*, specifically, even more so.

This study examines a large set of teen driver rear-end crashes using naturalistic data collected through event-triggered IVERs technology. This type of system is not continuously collecting data; it only provides information for a period of time before and after the trigger (e.g., the crash). While this type of system does not give researchers the exposure data necessary to calculate risk estimates, it does provide accurate, unbiased information regarding the prevalence of behaviors and actions of drivers in the seconds leading up to a crash, including details such as eye glances and response times. This study will examine the prevalence of particular pre-crash behaviors of teen drivers to identify driver behaviors to target for more effective interventions through education and technology.

2. Methods

2.1. Study design

The source of the data was crashes involving young drivers (16–19) enrolled in a teen-driving program. The program provided teens and parents with web-based feedback regarding the young drivers' performance. All crashes were released by the parent of the teen driver involved in the program. A database was started by Lytx in August 2007 and included all crashes that occurred from that time to July 2013, when they were requested by the University of Iowa (UI). All crashes occurred in Arizona, Colorado, Illinois, Iowa, Minnesota, Missouri, Nevada, and Wisconsin. The secondary analysis of these crash videos was approved by the UI's Internal Review Board (IRB).

Crashes were captured via DriveCam IVERs installed in participants' vehicles. This system collects video, audio, and accelerometer data when a driver triggers the device by hard braking, fast cornering, or an impact that exceeds a specified *g*-force. Videos are 12 s long (8 s before and 4 s after the trigger). However, we focused on the 6 s prior to the crash believing these to be most relevant and potentially contributory. Videos included views of the vehicle interior and exterior, an approximately 120° field of view out the front, a resolution of 256×200 pixels, and a frame rate of 4 Hz.

From an initial 6842 crash videos, 3785 were identified as minor (i.e., curb strikes or low speed, non-police reportable), 1205 were identified as single-vehicle crashes, and 315 were identified as vehicle-to-vehicle crashes other than rear-end. These were eliminated from this study. Other unusable videos (i.e., animal strikes, driver not being a teen) were also removed. This left 412 vehicle-to-vehicle *rear-end* crashes for coding and analysis. It should be noted that, other than the video, no additional information was available regarding the driver involved in a particular crash. Additionally, crashes were received from Lytx in batches according to the day and year in which they occurred and coded as they were received. Therefore, we could not positively determine whether a single driver was present in more than one crash, potentially months or years apart. Analysts reported that it may have been the case in only one or two instances and was therefore not a frequent enough occurrence to take into account during data analysis.

2.2. Study sample selection

All 412 rear-end crashes involved a teen driver impacting a lead vehicle. Pre-crash scenarios selected included those in which the lead vehicle was traveling at a slower speed, decelerating, or stopped in the lane of travel.

2.3. Development of coding methodology

The coding methodology was developed specifically for these videos (for further detail, see Carney, McGehee, Harland, Weiss, & Raby, 2015). Briefly, development began with a review of existing crash coding from government, academic, and industry sources. Twenty-four data elements were selected based on relevance and ability to code reliably. These elements were specific to environmental conditions, contributing circumstances, and driver and passenger behaviors.

2.4. Data collection and variable definitions

Four broad categories of data were coded: general background/environment (time of day, weather, light conditions); crash related (contributing circumstances); driver-related (gender, condition, behaviors); and passenger-related (estimated age, gender, behaviors). A detailed description of the variables is available in Carney et al. (2015). In the current study of rear-end crashes, we paid particular attention to driver behaviors, eyes-off-road time, inadequate surveillance, and response times to lead-vehicle braking (Table 1).

Coders made no judgments as to whether a driver was actually distracted, simply coding what was observed inside the vehicle. Behaviors could occur sequentially or simultaneously in the 6 s prior to the crash, so multiple behaviors might be observed in one crash. Two highly trained and experienced reviewers coded each crash. The data files were then merged, and discrepancies identified. Discrepancies due to data entry errors were corrected. Discrepancies due to reviewer disagreement were mediated by a third reviewer. Glance durations and response times differing even by 1 frame (0.25 s) were mediated to achieve the highest possible accuracy. Due to the high level of coder training and the mediation process employed, intra/inter-rater reliability was not calculated.

2.5. Data analysis

To examine the effect of teen driver gender and the prevalence of driver behaviors, frequencies and proportions were calculated and the Pearson's chi-square test (cell sizes ≥ 5) or a Fisher's exact text (cell size <5) was used to determine statistically significant differences ($p < 0.05$). To characterize how eyes-off-road time and response time (seconds) may be effected by driver behaviors, means and standard deviations are reported and the Student's *t*-test was used to test for statistically significant differences. All analyses were completed using SAS (version 9.4®; SAS Institute Inc., Cary, North Carolina).

3. Results

Overall, drivers were observed engaging in some type of potentially distracting behavior in 76% of rear-end crashes. The greatest proportion of crashes contained cell phone use (18.0%) with 95% (70 of 74) of those behaviors coded as operating/looking at phone (e.g., texting). Attending to a location outside the vehicle (17.2%) was the second most frequent behavior, and attending to passengers was third (16.0%). Of the 412 crashes analyzed, just over 50% had a female driver, and 36% had at least one passenger. The proportion of crashes involving potentially distracting driver behaviors was broken down by driver gender (Table 2). There were no significant differences in driver behaviors by gender.

Interestingly, for the 98 crashes with no driver behavior coded, 70% did not have passengers and occurred on dry roads. Additionally, for these same crashes, about one-third of the drivers (37.8%, $n = 37$) were coded as following a lead vehicle too closely (<2 s), and 72.5% ($n = 71$) were coded as inadequately surveying the roadway ahead.

In nearly 90% of crashes, driver surveillance of the roadway was inadequate. Total eyes-off-road times averaged 2.5 s during the 6 s prior to impact. On average, drivers with no observed behaviors had their