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Changes over 12 months in eye glances during secondary task engagement among novice drivers

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ABSTRACT

During their first year of driving, crash rates among novice drivers are very high but decline rapidly. However, it is not clear what skills or knowledge they are acquiring in this period. Secondary task engagement while driving is a contributing factor to many traffic collisions and some of the elevated crash risk among novices could be explained by greater prevalence or longer periods of eyes off the road while engaging in these non-driving tasks. The current study looked at the eye glances of novice teen drivers engaging in secondary tasks on a test track at 0 and 12 months of licensure and compared their performance with their parents. Novices improved from 0 to 12 months on their longest single glance off the forward roadway and total percentage of time for eyes off the forward roadway, but parents remained stable. Compared with their parents, the longest single glance off the forward roadway was longer for novices at 0 months, but by 12 months there was no difference between the groups. However, for total percentage of time for eyes off the forward roadway, novices performed the same as their parents at 0 months and actually had shorter times at 12 months. These findings could reflect the combined development of driving skills over 12 months and the relative experience that modern teenagers have with portable electronic devices. The results suggest that novice drivers are particularly poor at engaging with secondary tasks while driving.

1. Introduction

Motor vehicle deaths represent a critical public health issue in the United States. According to the Centers for Disease Control and Prevention (2015), these deaths lead to an estimated 1.5 million years of potential life lost in the US in 2013. Motor vehicle collisions are leading cause of death among 15–24 year-olds and compared with other age groups these drivers are disproportionately involved in fatal motor collisions (NHTSA, 2010). It is not clear whether the high number of fatal accidents among young drivers is due to lack of driving experience or to an age effect e.g. poorer inhibitory control (e.g. O'Brien and Gormley, 2013). While Groeger (2006) reports that younger novice drivers do have a higher crash risk compared with older novices, the rate of crash risk does decrease with each subsequent year of driving experience, regardless of age of licensure (Twisk and Stacey, 2007). For young drivers in particular, the sharpest drop in crash risk occurs during the first year (McCartt et al., 2009), in part because it is so high right after licensure. However, it is not clear why crash rates decline so rapidly or why they remain high relative to adult rates into the early or mid-twenties.

Secondary task engagement (e.g. cell phone use, eating, talking to passengers etc.) is an issue of particular concern for novice drivers. Young drivers are more likely to manipulate handheld devices while driving (NHTSA, 2011) and cell phone use increases the odds of a crash for all drivers (McEvoy et al., 2005). Additionally, Klauer et al. (2014) found that the crash risk of novice drivers was much more affected by engagement in secondary tasks (e.g. texting, eating) compared with expert drivers, although prevalence of engagement was similar. Engaging in secondary tasks can influence crash risk in two main ways: "mind-off-the-road" and "eyes-off-the-road" (see Liang and Lee, 2010). Mind-off-the-road refers to the general cognitive distraction introduced by secondary task engagement (e.g. Lee et al., 2001), while eyes-off-the-road refers to drivers looking away from the forward roadway (e.g. Simons-Morton et al., 2014).

A number of studies suggest that eyes-off-the-road is a contributing factor to many collisions. In the 100 car study, Klauer et al. (2010) found that the total time that a driver's eyes are off the for-

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ward roadway is predictive of crash/near crash likelihood. Among novice young drivers engaging in a secondary task, the longest single glance off the forward roadway has been associated with increased crash/near-crash likelihood (Simons-Morton et al., 2014). Additionally, looking away from the forward roadway impacts the ability to maintain lane position (Peng et al., 2013).

Visual attention while driving is important since drivers cannot react to hazards that materialize while they are looking away. Perhaps the high crash rate among young drivers is due in part to their failure to attend to the forward roadway. Such a suggestion is supported by a number of simulators and naturalistic driving studies that point to a general visual skills deficit among novice drivers. In test-track studies, Lee et al. (2008) found that experienced adult drivers demonstrated more recognition of hazards and Pradhan et al. (2011) found that after 12 months of driving, novice drivers showed an improvement in hazard detection during some, though not all, secondary tasks measured. Underwood (2007) described a number of studies which suggest that, compared with advanced drivers, novice drivers scan the forward roadway less frequently. Specifically, novice drivers have a decreased sampling rate, a longer processing time, and less broad scanning of the road (Konstantopoulos et al., 2010). Interestingly, Underwood presents evidence which suggests that a simple training exercise can reduce some of the visual skill deficits displayed by novice drivers.

The present study investigates changes in eye-glance behavior for novice drivers during the first year of independent driving. To our knowledge, this is the first study that investigates changes over time in the amount of time novice drivers to look away from the roadway during secondary task engagement. The hypothesis is that novice drivers look away from the forward roadway longer than adults do when engaging in secondary tasks and that this difference decreases with driving experience.

2. Materials and methods

2.1. Participants

The current data were collected as a part of the Naturalistic Teenage Driving Study; Lee et al. (2011) provide a full description of the recruitment of the 42 teens (mean age of 16.5 years (SD = 0.2) at 0 months, 48% female) and 42 parents (mean age of 46.8 years (SD = 5.3) at 0 months, 40% female). Participants were recruited in 2006/2007 through driving schools and newspaper advertisements. All participants were licensed to drive in the Commonwealth of Virginia and had 20/40 corrected vision. Participants received $20 per hour for their participation in this part of the study.

2.2. Design

Each of the 42 dyads was made up of one parent and their teenage child. There were 3 within-subjects independent variables: age group (Teen vs. Parent), time (0 vs. 12 months), and task-type (control vs. experimental); the classification of age group as a within-subjects variable reflects the potential covariation between a parent and their teen (e.g. Bingham et al., 2015). Participants completed three types of experimental task—the texting task, the directions task, and the iPod task. Based on video footage, trained coders recorded when participants were looking at the forward roadway (see Section 2.3 for more details). The dependent variables for each trial were the Longest single Glance Off the forward Roadway (LGOR) and the Total percentage of time for Eyes Off the forward Roadway (TEOR).

2.3. Procedure

The study took place at two time points: time of licensure (0 months) and 12 months post-licensure (12 months). Testing took place on the Smart Road at the Virginia Tech Transportation Institute; a 2.2 mile, controlled-access test track built to interstate standards which includes features such as traffic lights, a crossroads and a bridge. Participants were first familiarized with the test vehicle and the secondary task devices. The test vehicle was a 1997 Ford Taurus which recorded, among other things, simultaneous video footage from four cameras. These cameras were directed at the driver's face, out the windshield, at the pedals, and over the driver's shoulder. Participants drove on the smart road for roughly 90 min and were accompanied by two experimenters. Parents and teens were not present in the same car when teens and parents were driving, respectively. There were two types of trials: self-selected speed (SSS) and self-selected following distance (SSFD). In the former trial type, participants were told to drive at a speed that they found comfortable. For SSFD trials, a vehicle drove ahead of the participant's at a constant speed of 35 mph and the participant was told to maintain a following distance that they found comfortable. A control task and the three experimental tasks were completed within both SSS and SSFD trial types. For counter-balancing, half the participants completed the SSS trials first while the other half completed the SSFD trials first. The order of tasks was reversed at the 12 month data collection time point.

During the control tasks, participants were asked to maintain a constant speed or following distance, depending on whether the control trial was part of the SSS trials or SSFD, respectively. For each experimental task, participants were given instructions and asked to repeat what the instructions were before beginning. For the texting task, participants were asked to send a text message (e.g. "Meet me in the lobby at 7pm") to the number 357-1501. For the directions task, participants were asked to read a list of directions on a card and then turn the card over and answer a simple question on the back e.g. "was the last turn in the list of directions a right or left turn?" For the iPod task, participants were asked to use an iPod Nano (2nd generation) to answer a simple question (e.g. "Say out loud what song comes after *Forever* on the iPod"). Participants were given slightly different questions in the SSS and SSFD trials (e.g. "Say out loud the last song by Kid Rock" for the iPod task). The same questions were always asked in SSS and SSFD trials, but, as mentioned above, the order of those trials was counterbalanced across participants. Eye glances were coded from the beginning of each task for a 30 s period by a team of 3 trained coders. The 30 s of video footage were transformed into 300 images (10 Hz). Coders analyzed each of these images to determine eye glance direction at each 100th of a second. Any glance away from the forward roadway was classified as being a glance *off the forward roadway*. The possible off road eye glance locations were: iPod, Phone, Cue Card (for directions task), left side-mirror, right side-mirror, rear-view window, passenger, over shoulder, eyes closed, center stack, instrument cluster, interior object, left windshield, right windshield. The software for this coding was custom built for this purpose. On dual 23 in. screens, coders were presented with a full screen image combining the footage of the four cameras at a specific time point. Coders could skip back and forth between images to determine the point at which an eye glance was directed away from the forward roadway and the point at which it was directed back to the forward roadway. The coding results of the 3 coders on 14 separate tasks were compared with those of a supervising reduction manager's. Agreement between the coders and the manger on these three tasks ranged from 71% to 96% accuracy. If a participant completed the task within this time they were given a second, similar question and coders could clearly