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Effects of distraction and experience on situation awareness and simulated driving

Steven J. Kass [a,*], Kerstan S. Cole [b], Claudia J. Stanny [a]

[a] University of West Florida, Department of Psychology, 11000 University Parkway, Pensacola, FL 32514, United States
[b] Texas Tech University, Department of Psychology, Lubbock, TX 79409-2051, United States

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Abstract

This study examined the impact of cell phone conversation on situation awareness and performance of novice and experienced drivers. Driving performance and situation awareness among novice drivers ages 14–16 ($n = 25$) and experienced drivers ages 21–52 ($n = 26$) were assessed using a driving simulator. Performance was measured by the number of driving infractions committed: speeding, collisions, pedestrians struck, stop signs missed, and centerline and road edge crossings. Situation awareness was assessed through a query method and through participants' performance on a direction-following task. Cognitive distractions were induced through simulated hands-free cell phone conversations. The results indicated that novice drivers committed more driving infractions and were less situationally aware than their experienced counterparts. However, the two groups suffered similar decrements in performance during the cell phone condition. This study provides evidence of the detrimental effects of cell phone use for both novice and experienced drivers. These findings have implications for supporting driving legislation that limits the use of cell phones (including hands-free) in motor vehicles, regardless of the driver's experience level.

Keywords: Distracted driving; Situation awareness; Attention; Experience level

1. Introduction

Many studies have shown that talking on a cell phone while driving significantly influences driver performance. Furthermore, consumers are purchasing cell phones at increasing rates. As the number of cell phone users increases, the potential health risks also increase not only for those who choose to converse while driving, but also for passengers, pedestrians, and other drivers (Ferguson, 2003; Lam, 2002; Peters & Peters, 2002). In an analysis of nearly 700 cell phone-related accidents, Redelmeier and Tibshirani (1997) concluded that

* Corresponding author. Tel.: +1 850 474 2107; fax: +1 850 857 6060.
E-mail address: skass@uwf.edu (S.J. Kass).

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talking on a cell phone increased the probability of a collision between 3 and 6.5 times. They also suggested that these distraction effects are comparable to a blood–alcohol-content above the legal limit. In fact, Strayer, Drews, and Crouch (2006) found that in a driving simulation task, cell phone users showed greater impairments as measured by increased number of rear-end collisions and time required to regain speed following braking than drivers who were legally drunk (i.e., blood–alcohol-content of 0.08). Additionally, Strayer and Johnston (2001) reported that drivers engaged in cell phone conversations missed twice as many traffic signals and had slower reaction times. Consiglio, Driscoll, Witte, and Berg (2003) also found that cell phone use (hand-held or hands-free) slowed drivers' braking reactions compared to when they drove without distraction or when listening to music on the radio.

1.1. Role of situation awareness in driving

Research on situation awareness (SA) is often traced back to military aviation studies, but SA is crucial to the performance of any dynamic complex task, including driving in heavy traffic (Endsley, 1995). SA involves identifying relevant environmental stimuli or cues, integrating that information into the operator's knowledge base to form a mental model or representation of the situation, and using that representation to project the occurrence of events in the near future (see Dominguez, 1994; Endsley, 1990; Kass, Herschler, & Companion, 1991). As drivers move through the environment, they must identify the relevant information in rapidly changing traffic patterns (e.g., distance to other vehicles, closing speed) and be prepared to react to events that may occur (e.g., car backing out of driveway, stop sign) to avoid accidents. To achieve SA, individuals must rely on perception and pattern recognition abilities (Durso & Gronlund, 1999; Kass et al., 1991), attention and working memory (Gugerty, 1997; Wickens & Hollands, 2000), as well as long-term memory (e.g., Endsley, 1995). Therefore, cognitive distractions that tax a driver's attention or memory load may adversely impact SA.

Recently, researchers (e.g., Beede & Kass, 2006; Garcia-Larrea, Perchet, Perrin, & Amendo, 2001; McKnight & McKnight, 1993; Recarte & Nunes, 2003) have provided empirical evidence that driving performance suffers as a result of such cognitive distractions as cell phone use. These distractions may become particularly important safety issues when motorists are navigating through changing traffic patterns while attempting to maintain SA. Attention and hazard detection, aspects of SA, are known to be adversely affected by the cognitive distractions of cell phone conversation (Strayer & Johnston, 2001).

1.2. Experience level and situation awareness

Research on risk exposure of younger drivers indicates that they are more likely to speed, pull into smaller gaps in traffic, and glance away from the road for longer intervals than experienced drivers (see Ferguson, 2003; Strayer & Drews, 2004; Underwood, Crundall, & Chapman, 2002). Crundall and Underwood (1998) investigated the differences in spatial strategy between novice and experienced drivers under different road conditions by examining participants' visual attention. Experienced drivers employed a more flexible form of spatial strategy, such as searching for alternative routes, while novice drivers had rigid spatial strategies and usually focused on the one possible strategy that their visual search allowed. Lacking experience, novice drivers may not have learned to cope with the cognitive load imposed by complex road conditions while simultaneously attending to the overall demands of the driving task. This may result in a loss of SA and an inability to avoid collisions resulting in injury or death.

The current experiment was designed to test the hypothesis that cell phone conversations disrupt SA and impair driving performance by preventing drivers from attending to situation-relevant stimuli such as speed limit postings, stop signs, pedestrians, and other traffic. These failings should manifest themselves in terms of increased driving infractions and an inability to take on an additional task (direction following). Prior research suggests that practice effects (e.g., Ferguson, 2003; Strayer & Drews, 2004), mental models (e.g., Langham, Hole, & Edwards, 2002), and flexible spatial strategies (e.g., Crundall & Underwood, 1998) developed through experience enhance operators' performance. Thus, experience level was expected to mitigate some of the decrements in driving performance and SA associated with cell phone conversations.