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Compensating for failed attention while driving

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ABSTRACT

While operating a motor vehicle, drivers must pay attention to other moving vehicles and the roadside environment in order to detect and process critical information related to the driving task. Using a driving simulator, this study investigated the effects of an unexpected event on driver performance in environments of more or less clutter and under situations of high attentional load. Attentional load was manipulated by varying the number of neighboring vehicles participants tracked for lane changes. After baseline-driving behavior was established, the unexpected event occurred: a pedestrian ran into the driver's path. Tracking-accuracy, brake initiation, swerving, and verbal report of the unexpected pedestrian were used to assess driver performance. All participants verbally reported noticing the pedestrian. However, analyses of driving behavior revealed differences in the reactions to the pedestrian: drivers braked faster and had significantly less deviation in their steering heading with a lower attentional load, and participants in low clutter environments had a larger overall change in velocity. This research advances the understanding of how drivers allocate attention between various stimuli and the trade-offs between a driver's focus on an assigned task and external objects within the roadway environment. Moreover, the results of this research lend insight into how to construct roadway environments that encourage driver attention toward the most immediate and relevant information to reduce both vehicle-to-vehicle and vehicle-to-pedestrian interactions.

1. Introduction

A key factor in the ability to safely and successfully navigate through a roadway environment is driver attention. Attention is critical for locating objects along the roadway and for tracking or following other moving vehicles. When attention is impaired or distracted by other activities or events, driving errors can occur and safety can be diminished. Attention is a limited cognitive resource. Individuals preforming more than one attention-demanding task must divide their attention between multiple tasks while allocating attention to information that is most important and away from other information. This can result in critical information being overlooked, despite the information being clear and directly within an observer's line-of-sight (Hyman, Boss, Wise, McKenzie, & Caggiano, 2009; Simons & Chabris, 1999).

Driving is an attention-demanding task because attention must be allocated to surrounding vehicles, objects near the roadway, and objects inside of the vehicle. "Target detection" is a general term used to describe the process of detecting, finding, or noticing a specific item amidst a variety of distractors, which demand attention (Treisman, 1986). Inattentional

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blindness occurs when individuals fail to detect unexpected events or targets while performing an attention-demanding task (Simons & Chabris, 1999). Inattentional blindness could have severe consequences while driving. For example, the failure to detect a pedestrian entering the roadway could lead to a fatal accident.

The research suggests that inattentional blindness while driving is more likely to occur when drivers are participating in attention demanding tasks (Most & Astur, 2007; Strayer, Drews, & Johnston, 2003). A failure to be attentive to critical targets while driving may account for hundreds of motor vehicle crashes every day. Thus, the need for research into primary driving tasks (e.g. following vehicles) and environmental elements (e.g. ambient roadside density) that engage a driver's attention outside the vehicle is essential for improving highway safety. To date, the focus of most previous driving research on attentional limits has been on distractions that occur inside of the vehicle rather than outside of it (Young & Regan, 2007). The current research investigated the effects of attentional distraction by elements outside of the cockpit to determine when failed attention is present while driving and what compensation driving strategies are utilized when lapses in attention occur.

1.1. Attention is limited

Focused attention is an essential factor in the ability to drive a motor vehicle, and failed attention is a significant contributor to driving errors and motor vehicle crashes (Young & Regan, 2007). Two of the most important attention-demanding tasks while driving are tracking moving objects and detecting items in the roadway environment (Pylyshyn & Storm, 1988; Simons, 2000; Treisman & Gelade, 1980). Errors on these tasks are more likely to occur when attention is diverted or overloaded (Hyman et al., 2009; Simons & Chabris, 1999). Furthermore, due to the relative monotony and repetitive nature of the driving task, drivers often adapt or become habituated to the task (Duncan, Williams, & Brown, 1991; Shinar, Meir, & Ben-Shoman, 1998; Wickens, 2002), making them more susceptible to errors caused by inattention. Therefore, attention failures can occur while driving because attention is not always appropriately allocated to critical information.

Typically, there is a goal associated with a primary task, which provides the parameters for what information will be attended and what information will be ignored. In traditional work on inattentional blindness participants are tasked with counting ball passes (Simons & Chabris, 1999), counting wall bounces (Most, 2010), or some other attentionally engaging task (Most & Astur, 2007; Neisser & Becklen, 1975; Strayer et al., 2003). While performing this attentional engagement task, an unexpected object or event occurs. These unexpected events or objects can be anything ranging from women carrying umbrellas (Becklen & Cervone, 1983), motorcycles veering into a car's path (Most & Astur, 2007), unicycling clowns (Hyman et al., 2009), or a gorilla beating its chest (Simons & Chabris, 1999). What's remarkable is that although participants are generally very good at performing the primary task, nearly half of participants fail to notice the unexpected object (Simons & Chabris, 1999). Therefore, to the extent that driving a car and monitoring the other cars on the roadway is treated as the primary task, a secondary and more incidental task of detecting pedestrians entering the roadway may receive less attentional resources than needed for optimal performance.

There are many tasks that can occur inside the motor vehicle while driving that can serve as a primary attentionally demanding task, leading to decreased performance on other tasks. Specifically, tasks inside the car can lead to attentional distractions, which limit the driver's ability to effectively distribute attention while driving (Wickens, 2002). One area that has been extensively researched is the inclusion of various electronic devices (e.g., cell phones, radio, GPS navigation systems) in vehicles (see Young & Regan, 2007 for a review). The consensus of such research is that the use of these devices by drivers consistently hinders driving performance. For example, talking on a cell phone has been shown to negatively impact driver ability (Nelson, Atchley, & Little, 2009; Strayer & Johnston, 2001; Strayer et al., 2003). These experiments have shown that drivers alter various aspects of their driving behavior to accommodate these secondary tasks, such as reducing speed/acceleration, increasing inter-vehicle distance, or altering the allocation of attention toward other variables (Alm, 1995; Brookhuis, De Vries, & De Waard, 1991; Horberry, Anderson, Regan, Triggs, & Brown, 2006; Strayer et al., 2003). It should be noted that most research has focused on attention distractions that occur inside of the vehicle rather than outside of it (Young & Regan, 2007). However, attention directed outside of vehicle could also result in drivers missing critical road- and driving-related events (Most & Astur, 2007). Therefore, understanding how and when tasks and environmental elements outside of the vehicle affect critical target detection is essential for improving driver safety.

Much of the relevant information and events that occur during driving are located outside of the vehicle (Charlton & Starkey, 2013; Pammer & Blink, 2013). Two of the most important attentionally demanding tasks required outside-of-the-vehicle are (1) target detection and (2) neighboring-car monitoring. A driver's ability to quickly detect important targets (e.g. traffic signs, pavement marking, pedestrians, etc.) while ignoring irrelevant distractors (e.g., advertisements) is a key component to maintaining a safe driving environment (Borowsky, Shinar, & Parmet, 2008). Therefore, the current study will examine the effects of target detection while monitoring the number of lane changes of neighboring cars. As an analog to the inattentional blindness research, we are treating the neighboring-car monitoring task as the primary task because participants are directly instructed to do this task, and the target detection task as secondary because although pedestrian detection is incidental to the driving task, it was not explicitly described as a task of interest to the participants.

Target detection performance is not only affected by other ongoing tasks that distract attention, but also by the amount of competing information in the visual environment. Specifically, as the number of distractors or the level of clutter increases, the amount of time needed to find the target also increases (Beck, Lohrenz, & Trafton, 2010; for reviews see Eckstein, 2011;