THE IMPACT OF INTERNAL DISTRACTION ON DRIVER VISUAL BEHAVIOR

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ABSTRACT

Driver distraction can arise from sources internal as well as external to the driver. In this paper we describe a study (in progress) designed to examine the influence of internal distraction, created by cognitive tasks, on drivers' visual behavior and vehicle control. Sixteen drivers will drive a city route while carrying out tasks of varying cognitive complexity. The tasks and their responses will be communicated via a handsfree cell phone so that drivers will not have to look away from the road or manually operate the phone. Driver performance will be examined under conditions of close vehicle following and more open driving conditions. Visual scanning patterns will be recorded using eyetracking equipment, measures of vehicle control will be obtained using the MicroDAS system, and drivers' subjective evaluation of workload and safety will be assessed through questionnaires. Based on previous research, it is expected that increased cognitive load will result in a reduced area of visual inspection. In addition, detailed analyses will be made of the fixation distributions as a function of cognitive task. The results of this study will contribute to the understanding of driver internal distraction that may be associated with voice interactive technologies.

INTRODUCTION

Distraction has been implicated as a contributing factor to motor vehicle crashes in reviews of accident causation (e.g., Treat et al., 1979; Zaidel et al., 1978). Concerns about driver distraction and inattention are not new, nor are concerns that new technologies may contribute to driver distraction. Indeed, when windshield wipers were first introduced, concerns were raised over their potential hypnotic effects on drivers. What is new is the proliferation of information-based technologies available to drivers and the range of in-vehicle activities on-board devices offer. Currently, drivers may converse by cell phone, read e-mail, access the Internet, and receive faxes - all while driving. New applications for information technology are constantly being developed and many of these are being adapted for in-vehicle use. Some systems, which provide automatic accident notification or road condition warnings, may provide a safety benefit to the driver and other road users. Other systems, however, are available in the vehicle primarily for driver convenience or to improve the productivity of the driver while driving.

When an in-vehicle system requires manual input and/or visual attention to a display, the driver is obligated to redirect attention from the road during its use. In response to the safety concerns raised about these types of interfaces, speech recognition technology has been introduced for many in-vehicle devices. Voice commands are appealing in that they allow drivers to keep their eyes on the road and their hands on the wheel. Voice interaction, however, is not necessarily accomplished without "cognitive cost" and changes in driving behavior. Some voice commands may be simple "on/off" instructions. In other instances, the cognitive effort associated with controlling the device may be much greater. For example, a driver might have to navigate through several levels of a directory or a complex menu using voice commands. The mental model of the system that the driver would have to maintain could significantly increase the cognitive workload associated with performing the task. Of course, the nature and content of the voice interactions (whether with human or machine) while using the device are additional factors affecting the degree of distraction. In a survey of cell phone users, McKnight & McKnight (1991) reported that 72% of cell phone conversations are for business purposes. To the degree that the content of these calls is important or complex, and their nature urgent, they may increase driver distraction.

The focus of the present study is the impact of internal distractions, the sort that could arise as a consequence of voice interactions, on driver performance. Due to the current interest in the use of in-vehicle technology, participants will use a cell phone to receive and transmit information, rather than interact with a passenger in the vehicle. The intensity of the interaction is manipulated by varying the cognitive load associated with performing the secondary task.

What are the important changes in driver behavior which could result from using voice interactions while driving? Given that much of the information relevant to driving is taken in visually, measures of drivers' visual behavior as well as measures of vehicle control will be obtained.

It is known from past research (e.g., Miura, 1990) that patterns of visual search may be influenced by environmental complexity, such as that available in the road scene. There is also evidence that visual search behavior may be influenced, not only by the external environment, but also by factors internal to the person, such as the cognitive complexity of an ongoing task. Recently, Recarte & Nunes (2000) measured eye fixations while driving. They reported that drivers' visual functional-field size was reduced (vertically and horizontally) when drivers performed a demanding cognitive task while driving. These findings are consistent with a preliminary report and additional pilot work we have carried out (Eizenman, Jares, & Smiley, 1999; Harbluk, 2000).

The present study will attempt to go beyond previous work to explore possible mechanisms underlying the narrowing of visual attention which seems to accompany high cognitive load. In particular, analyses of saccadic movements should help explain whether this effect is due to a reduced rate of visual sampling, a focus on specific areas of the visual field, reduced size of saccades, or visual lockup. The implications of these alternative mechanisms for safety may be quite different. Driving will take place in a complex city environment. Conditions of car following and more open sections of driving will be separately evaluated since these conditions have been shown to influence visual behavior while driving (Mourant, Rockwell, & Rackoff, 1969). Finally, there is concern that drivers may not realize when these voice-based interactions are distracting and as a result, they may not compensate by modifying the voice task or their driving behavior (Boase, Hannigan, & Porter, 1988). This issue will be explored by evaluating the relationship between subjective evaluations of task workload and safety provided by the drivers and their driving performance.

METHOD

Participants: Sixteen participants will take part. They will be experienced drivers (minimum 5 years experience, approximately 10K driven annually), with good vision (correction with contacts acceptable) who are between the ages of 21-35. They will receive $50.00 for their participation.

Design: A one-way repeated measures design will be used. The order of presentation of task conditions (two levels of complexity of mental arithmetic and the control condition) will be counterbalanced across subjects.

Equipment: Participants will drive a 1999 Toyota Camry, that has been equipped with a Micro-DAS data collection system (Barickman & Goodman, 1999). The system is capable of recording a number of driving performance parameters including lateral and longitudinal acceleration, steering wheel angle, brake activation, and lane position. Video (forward view, driver's face, hands and feet) and audio recordings will also be made. The vehicle is owned and maintained by Transport Canada. It is equipped with an additional safety brake on the front passenger side where an experimenter will be seated.

While driving, participants will wear a portable eyetracking apparatus (El-Mar Vision 2000; Eizenman et al., 1999). This unit is lightweight (300 gms) and can be compared to wearing a bicycle helmet. It is fitted with a visor (70 gms) to filter IR, the visual effect of which is comparable to wearing sunglasses. The unit does not interfere with head movement nor vision to the front or periphery.

The cell phone is a Nokia 5160, a currently popular model. It will remain in the cradle (Nokia car kit) for the duration of the study and is mounted in the typical location to the right of the console.

Procedure: After a brief description of the overall procedure, driver information will be collected and the consent form completed. The participant will also complete a pencil and paper test of dual task ability (Baddeley et al.,1997), the results of which will be used to ascertain any individual differences in dual task performance. The participant and the experimenters will drive to the start of the route. Prior to the actual drive, the participant will receive full instructions concerning the experiment, the tasks, and the eyetracker. The eyetracker will be calibrated and the participant will drive a practice route to become acquainted with the vehicle, eyetracker, and the tasks required.

The test route is a 4 km stretch of a busy 4-lane city road with on which the driver will drive north and south for a total of 8 km per condition. The participant will complete three runs, each under one of following task conditions: difficult addition (47+38), easy addition (6+9), or no additional task. The arithmetic questions will be presented to the participant over the cell phone by an assistant at a remote location. After each run, there will be a brief break (5-10 minutes) during which the eyetracking unit will be removed and the participant will complete a modified version of the NASA-TLX to assess workload and to answer questions about driving safety

At the conclusion of the test trials, each participant will be interviewed to solicit their opinions about perceived safety, whether they feel their driving behavior may have changed and what behaviors, if any, did they consciously alter as a result of the task conditions.

RESULTS

Driving segments will be categorized as close following or open driving, and analyzed separately. This should reduce variance in the data due to different strategies that drivers might employ when closely following a lead vehicle compared with driving under more loosely coupled conditions.

The impact of the three levels of cognitive task on drivers' behavior will be assessed. The dependent measures fall into the following categories:

Visual behavior using eyetracker:
- Glance duration, glance frequency
- Fixation location
- Specific objects (e.g., mirrors, instruments)
- Range of visual sampling

Video and Audio Data:
- Digital video of forward road scene, driver's face, hands, and feet.
- Audio data of the full session

Vehicle control measures:
- Lane position
- Speed
- Steering angle
- Longitudinal acceleration

Questionnaires:
- Workload assessed by modified NASA-TLX
- Dual task performance

DISCUSSION

Driver distraction due to on-board interactive technologies represents a potentially serious threat to road safety. When a driver's attention is drawn away from the road and the surrounding environment, the result could be a delayed reaction to a hazard, or worse, a failure to detect it at all.

In this study, we will investigate the impact of internal distraction on drivers' visual behavior and vehicle control. This is the type of distraction that might be created by the processing of information in the course of interacting with or conversing over a handsfree in-vehicle device.

The contribution made by this study lies in the examination of visual search behavior, measures of vehicle control and the drivers' subjective evaluations concerning workload and safety.

The results of this study are expected to improve our understanding of the effect of cognitive load on driver visual behavior. Such knowledge should contribute toward the improved design of on-board information and communication systems and support the development of government policy in the area.

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KEYWORDS

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