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The effects of using a portable music player on simulated driving performance and task-sharing strategies

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ABSTRACT

This study examined the effects of performing scrollable music selection tasks using a portable music player (iPod Touch™) on simulated driving performance and task-sharing strategies, as evidenced through eye glance behaviour and secondary task performance. A total of 37 drivers (18–48 yrs) completed the PC-based MUARC Driver Distraction Test (DDT) while performing music selection tasks on an iPod Touch. Drivers' eye glance behaviour was examined using faceLAB eye tracking equipment. Results revealed that performing music search tasks while driving increased the amount of time that drivers spent with their eyes off the roadway and decreased their ability to maintain a constant lane position and time headway from a lead vehicle. There was also evidence, however, that drivers attempted to regulate their behaviour when distracted by decreasing their speed and taking a large number of short glances towards the device. Overall, results suggest that performing music search tasks while driving is problematic and steps to prohibit this activity should be taken.

1. Introduction

As the number and complexity of in-vehicle infotainment systems (IVIS), such as navigation systems and music players, increase, so too do concerns over the potential for these technologies to distract drivers. Driver distraction can be defined as a diversion of attention away from activities critical for safe driving towards a competing activity (Lee et al., 2008). The National Highway Traffic Safety Administration found that in 2009 in the US, driver distraction was a primary contributing factor in 16 percent of all fatal and 21 percent of injury crashes (Ascone et al., 2009). Estimates from the 100-Car Naturalistic Driving Study are similar, placing secondary task engagement as a contributing factor in over 22 percent of crashes and near-crashes (Klauer et al., 2006). As the number and complexity of in-vehicle and portable technologies grow, this figure is expected to increase.

An increasingly popular trend in the automotive environment is for drivers to use portable digital music or MP3 players, such as iPods. This was confirmed in a recent Australian survey which found that 41 percent of drivers who own a portable music player (e.g., iPod) reported using it while driving (Young and Lenné, 2010). Figures from the United Kingdom are similar, with just under 40 percent of drivers reporting using add-on media devices including iPods when driving (Lansdown, 2009). Music selection tasks using these devices typically involve scrollable lists, whereby drivers select one of potentially thousands of songs by scrolling through a long list of items using either a thumbwheel dial or kinetic, 'finger flick' scrolling on a touch screen. Operation of these devices can require a high level of visual demand, particularly those tasks that required drivers to navigate through complex menu structures and lists (Chisholm et al., 2008). The potential for driver distraction and degradation of driving performance is therefore significant.

Compared to some portable devices such as mobile phones, relatively few studies have investigated the effects of interacting with portable music players on driving performance (Chisholm et al., 2008; Crisler et al., 2008; Salvucci et al., 2007). Salvucci et al. (2007) found that listening to songs or podcasts was not associated with changes in either lane position standard deviation or vehicle speed in a driving simulator; however, selecting items (and watching videos) on a music player resulted in greater lateral deviation from the centre line. Crisler et al. (2008) also found that manipulating an iPod resulted in significant decrements in lane-keeping performance and increases in speed variability in a driving simulator. Furthermore, more complex music player interactions (those involving more than two steps) have been associated with increases in perception response time to critical events (i.e. pedestrian walking onto roadway) and frequency of collisions, as well as the number and duration of glances inside the vehicle (Chisholm et al., 2008).

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Since these seminal studies were conducted, there has been an explosion in the prevalence and popularity of touch screen interfaces for portable devices, including portable music players (Gartner, 2010). Given their recent emergence, no published studies, to the knowledge of the authors, have examined the effects on driving performance of interacting with music players that features 'touch technology' interfaces. While touch screens offer a range of advantages such as configurability and direct and intuitive (pointing) input, their use in vehicles has raised concern, primarily because they are likely to place significant visual demand on the driver due to the absence of tactile and kinaesthetic feedback (Pitts et al., 2010). In the absence of tactile cues, users are required to glance at the interface more often to confirm that a correct selection or action has been made (e.g., Harrison and Hudson, 2009), a perturbing finding given the predominantly visual nature of the driving task (Sivak, 1996). Adding to safety concerns is the trend towards the use of scrollable lists to present large lists of items (e.g. phone contacts, songs). A lack of tactile feedback may present a particular problem when scrolling long lists because, unlike discrete button presses, scrolling requires multiple steps and, thus, presumably multiple glances and the opportunity for errors, such as overshooting the target item, is high. Kinetic touch scrolling, where users use a finger flicking motion to move the list, introduces a level of scrolling speed variability dependent on the amount of kinetic force used. This variability may result in drivers losing track of where they are in the list, particularly if the list keeps scrolling after the driver has glanced back to the roadway. Taken together, the increasingly ubiquitous nature of portable touch screen devices and the potential safety issues associated with their use indicates that research into the distracting effects of this interface type is paramount.

One factor that can moderate the level of distraction associated with a device is the attention allocation, or task-sharing, strategies engaged in by drivers. In a series of studies conducted by the authors at MUARC (Mitsopoulos-Rubens et al., 2011; Williamson et al., in press; Young et al., 2009b), drivers were observed engaging in self-regulatory behaviour when allocating attention across driving and on-board music system tasks. Specifically, when performing the lane change test (LCT), many drivers delayed their interaction with the IVIS tasks until they were between lane change manoeuvres. However, in the absence of eye movement data, these strategies could not be fully investigated. The only conclusions that could be drawn in regard to drivers' task-sharing strategies made use of secondary task completion times to examine if drivers were taking longer to complete the IVIS tasks when driving compared to completing the IVIS tasks alone (and thus sacrificing performance on the secondary task to concentrate on driving). Determination of drivers' allocation of attention across multiple tasks can be assisted with the use of eye movement measures. The present study extends this earlier research by examining driver eye movement data, in addition to secondary task performance measures.

An important factor affecting how drivers allocate their attention in dual-task situations is the extent to which the secondary task can be interrupted and resumed. When a driver is performing an in-vehicle task while driving they shift their attention back and forth across tasks, essentially interrupting each task when they shift attention to the other. A secondary task that can be interrupted and easily resumed after an interruption is generally deemed acceptable to perform while driving as, depending on its complexity and the length of the interruption, drivers can usually shift their attention back and forth easily between the secondary and driving tasks without any serious degradations in the performance of either (Fagerstrom et al., 2001; Green and Tsimhoni, 2001). A task that cannot be postponed, or cannot be resumed after interruption, cannot be shared effectively with the driving task because drivers are less able to shift their attention away from that task without introducing delays or errors in task completion (Young et al., 2008a). While drivers will initiate their own interruptions with the secondary task to focus on the driving task, variations in individual drivers' strategies can make the examination of task interruptability difficult. Therefore, to examine the degree of interruptability of the music selection task and, thus, the potential for drivers to vary or adapt their task-sharing strategies, this study introduced a standard, system-initiated interruption to the IVIS tasks to examine systematically how easily drivers could resume the task of searching scrollable music lists after being interrupted.

The present study aimed to investigate the effects of performing scrollable music selection tasks on an iPod Touch™ on driving performance and task-sharing strategies, as evidenced through the analysis of both driving and secondary task measures alongside eye glance behaviour. The included an assessment of the nature of the music selection tasks in terms of how easily they could be resumed after an interruption. Data were collected using a PC-based driving simulator, which allowed for an examination of the music search tasks under safe and controlled conditions. Participants completed five runs of the simulated drive; while searching for songs in short and long lists without an interruption, while searching for songs in short and long lists with a system initiated interruption and once while performing no secondary task. On the basis of previous distraction research, it was expected that the scrollable music search tasks would degrade driving performance on a range of measures, particularly those measures related to lateral control given the highly visual nature of the tasks. It was also expected that the music search tasks would result in increased eyes off road time and more frequent and longer glances to the iPod, at that these effects would be more pronounced for the long compared to the short lists. Finally, given the greater potential for drivers to become 'lost' within the longer lists, it was predicted that the resumability of the music search task would be lower under the long compared to the short list condition.

2. Method

2.1. Participants

Participants were 37 drivers, aged 18–48 years (M = 27.68 years; SD = 9.81 years). A similar number of males (17) and females (19) took part in the study. Thirteen of the drivers held a probationary driver's licence (first 4 years of solo licensure), while the remainder held their full licence. The drivers had an average of 8.91 years solo driving experience (SD = 8.77, range < 1–29 yrs). All participants had normal or corrected-to-normal sight and hearing.

A total of 29 (78%) of participants had prior experience using a portable music player, and 13 (35%) reported having previous experience using a digital music player with a touch screen interface. Participants reported spending an average of 6.17 h per week (SD = 7.36) using a digital music player.

2.2. Equipment

2.2.1. Driving task

The PC-based MUARC Driver Distraction Test (DDT) measures simulated driving performance while the driver is performing a secondary task (Young et al., 2009a). The DDT consists of a 6.6 km urban driving environment containing a straight, undivided road with two lanes of travel in each direction, and contains four speed zones: 40 (school zone), 60, 70 and 80 km/h. The roadway contains low density traffic travelling in both directions. Drivers are required to maintain their speed and position on the road using standard