Accident Analysis and Prevention 50 (2013) 787–792

Contents lists available at SciVerse ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

A simulator study of the effects of singing on driving performance

Genevieve M. Hughes[a], Christina M. Rudin-Brown[b,*], Kristie L. Young[b]

[a] Department of Psychology, Monash University, Australia
[b] Human Factors Team, Monash University Accident Research Centre (MUARC), Monash Injury Research Institute (MIRI), Building 70, Wellington Road, Clayton, VIC 3800, Australia

ARTICLE INFO

Article history:
Received 13 December 2011
Received in revised form 28 June 2012
Accepted 1 July 2012

Keywords:
Driver distraction
Driving simulation
Mental workload
Music

ABSTRACT

This study aimed to investigate how singing while driving affects driver performance. Twenty-one participants completed three trials of a simulated drive concurrently while performing a peripheral detection task (PDT); each trial was conducted either without music, with participants listening to music, or with participants singing along to music. It was hypothesised that driving performance and PDT response times would be impaired, and that driver subjective workload ratings would be higher, when participants were singing to music compared to when there was no music or when participants were listening to music. As expected, singing while driving was rated as more mentally demanding, and resulted in slower and more variable speeds, than driving without music. Listening to music was associated with the slowest speeds overall, and fewer lane excursions than the no music condition. Interestingly, both music conditions were associated with slower speed-adjusted PDT response times and significantly less deviation within the lane than was driving without music. Collectively, results suggest that singing while driving alters driving performance and impairs hazard perception while at the same time increasing subjective mental workload. However, singing while driving does not appear to affect driving performance more than simply listening to music. Further, drivers' efforts to compensate for the increased mental workload associated with singing and listening to music by slowing down appear to be insufficient, as evidenced by relative increases in PDT response times in these two conditions compared to baseline.

1. Introduction

Driving is a complex task, involving the coordination and execution of various cognitive, physical, sensory, and psychomotor skills (Young and Regan, 2007). Despite this complexity, it is common to see drivers engaging in other 'secondary' activities ranging from the seemingly benign (e.g., talking to a passenger) to the potentially hazardous (e.g., eating a bowl of cereal) (Regan et al., 2008). Drivers may choose to engage in secondary activities while driving as a result of being overly familiar with the task of driving; they may use spare cognitive capacity to perform another task at the same time, for the most part, without problems (Beirness et al., 2002). Although secondary tasks vary in the degree to which they distract the driver, any activity that competes for the attention of the driver has the potential to degrade driving performance and may have serious consequences for road safety (Ranney et al., 2000).

The automobile is the most frequently reported location for listening to music (Brodsky, 2002) and listening to music is reportedly one of the most common activities engaged in by drivers. Radios have been available as factory equipment in passenger automobiles since the early 1930s (Motorola, 2012). How listening and singing along to music may affect driving performance is, therefore, an important research question. In a survey of 1780 British drivers, Dibben and Williamson (2007) found that 68% of drivers reported listening to recorded music or the radio while driving. This finding supports earlier data collected by Stutts et al. (2003), who found that, over 3 h of video-recorded driving, music was playing in the 70 participant vehicles 71.5% of the time. Despite being such a common activity, listening to music may also be detrimental to driving performance. In two investigations of police crash report statistics, in-vehicle entertainment systems were found to be the most prevalent (Stutts et al., 2001) and second-most prevalent (Stevens and Minton, 2001) sources of in-vehicle distraction.

Clearly, it is important to define what aspects of music may be distracting in order to understand the level of impairment that a subset of music usage, such as singing along to music, might impose on driving performance. Music within the vehicle, whether simply being listened to or being sung along with, has the potential to affect driving performance by virtue of the sound it produces, in the same manner as it affects cognitive performance (Furnham and Allass, 1999). Music may also mask auditory feedback from the vehicle, such as engine noise, which would otherwise be used for self-monitoring one's driving performance (Dibben and Williamson,

* Corresponding author. Tel.: +61 3 998 1947.
E-mail addresses: christina.rudin-brown@tc.gc.ca, missy.rudin-brown@monash.edu (C.M. Rudin-Brown).

0001-4575/$ – see front matter
http://dx.doi.org/10.1016/j.aap.2012.07.001

2007). Music may also mask the sound of auditory warning signals from outside of the vehicle, such as sirens and horns, potentially increasing crash risk (Slawinski and MacNeil, 2002).

Devoting one's attention to music being played within the vehicle may represent a cognitive distraction. This possibility has been termed the 'Distraction hypothesis' (Furnham and Strbac, 2002). Strayer and Johnston (2001) found that attending to a radio programme while completing a simulated driving task did not result in longer reaction times or an increase in the number of misses in a pursuit tracking task compared to silence, but that conversation with a confederate was more detrimental to driving performance, implying that it is likely something other than simple passive receipt of auditory information that distracts drivers. Pêcher et al. (2009) found that listening to 'happy' music distracted drivers, resulting in reduced speeds and poorer lane-keeping compared to a 'no music' condition. The authors suggest that particular technical characteristics of the happy music may have distracted the participants by creating a kind of 'dual-task' condition, where the technical characteristics acted as external sources of distraction. Drivers were often observed to, for example, whistle, tap, and sing along to the happy music while driving, causing them to be less able to adequately control the vehicle. On the other hand, 'sad' music, which was also associated with slightly reduced speeds, was associated with improved lane-keeping ability – a finding that suggests drivers in this condition were attempting to maintain a 'no risk' speed and trajectory control. Ayres and Hughes (1986) argue that the sensory processing of music must be inherently different than the processing of sounds in general, as participants' performance in a visual acuity task was significantly impaired by loud music (at 107 dB) but not by noise at the same volume. Finally, in a recent driving simulator study, van der Zwaag et al. (2012) found that, compared to a 'no music' driving condition, music that participants rated as 'positive' in terms of energy and valence was associated with slightly lower speeds while having no effect on lateral lane deviation. Interestingly, the authors interpret these findings as demonstrating that participants were likely *not* distracted by the music, but rather may have been experiencing increased engagement in the driving task when they listened to music, which resulted in improved speed maintenance (more appropriate speed choice) and no change in lane-keeping ability. What all of these studies suggest is that it may not simply be the sound of music itself that can distract the driver, but the cognitive effort required to process *and respond to* the music. Singing along with music being played represents such a response.

It is possible that more complex music distracts drivers more than less complex music. In a seminal study investigating the effect of music tempo on driving performance in a simulated driving task, Brodsky (2002) found that, compared with a baseline no music condition, the frequency of collisions, lane crossings and missed red lights consistently increased as tempo of the music increased. North and Hargreaves (1999) found that the effect of music on speed choice in a simulated driving task was dependent on the nature of both the music and the demands of the driving task. They found that mean lap times on a computerised motor-racing game were longer when the music was more arousing and the driving task more demanding, indicating that the cognitive demands of the arousing music and demanding driving task competed for cognitive resources, causing participants to drive more slowly. In another study of driving-related tasks, Beh and Hirst (1999) found that louder music increased reaction times to peripheral signals in a high-demand driving condition. Listening to music seems to alleviate stress and mild aggression in drivers (Dalton and Behm, 2007; Wiesenthal et al., 2003); however, while in some circumstances listening to music facilitates driving performance, in other conditions (e.g., depending on its volume, type, and tempo), it impairs it (Dalton and Behm, 2007). If more complex or arousing music does have a detrimental effect on driving performance (even if only in high demand conditions), then on the same basis, singing along to music being played, particularly complex or arousing music, may also worsen driving performance.

The present study investigated the effects of singing on simulated driving performance, both in terms of its impact on drivers' subjective perception of their own mental workload, as well as objective measures of driving performance. It was hypothesised that subjective workload would be rated higher in the simulated driving task when participants sang to music compared to conditions with no music or where participants only listened to music. It was also hypothesised that driving performance as measured by the driving simulator – maintenance of speed, maintenance of lane position, lane excursions, and response time to a concurrent peripheral detection task (PDT) – would be impaired in the singing condition compared to the listening condition, which would in turn be more affected than the no music condition.

2. Method

2.1. Study design

A one-way repeated-measures design with three levels of music condition ('Baseline'; 'Listening'; and 'Singing') was used. The order of presentation of the music conditions was counterbalanced across participants.

2.2. Participants

The study was approved by the Monash University human research ethics committee, and used a convenience sample of 21 participants (20 female, one male), aged between 18 and 55 years ($M = 35.05$, $SD = 13.75$). Participants were recruited via on-campus flyers posted on Monash University's Clayton campus, an online advertisement in the Monash Memo newsletter, and through announcements made at two of the authors' amateur singing groups. All participants were current and licensed drivers, and reported driving between 2 and 10 h ($M = 7.21$, $SD = 3.17$) on average per week. Participants reported singing while driving on $45.9 \pm 29.0\%$ of all trips. All participants had normal or corrected-to-normal vision and hearing, and did not suffer from epilepsy or severe motion-sickness.

2.3. Equipment

The experiment used the MUARC Portable Driving Simulator, an EF-X by Eca-Faros (Lannion, France) with modified software for research purposes (Fig. 1). The simulator consists of a driver's seat with dashboard, steering wheel, accelerator and brake pedals, handbrake and gear shift. The simulated environment was displayed on three screens providing the driver with a 120° field of view including a rear view mirror. Volume of ambient simulator noise from the driver's seat was ≅52 dB, which increased to ≅60 dB when music was playing. Music was played through a laptop computer positioned approximately 1.5 m from the participant.

2.4. Driving scenarios

Driving scenarios were those of the MUARC Driver Distraction Test (DDT) (Young et al., 2010), a PC-based driving task that measures simulated driving performance while a driver performs a secondary task, and which includes a series of expected (e.g., traffic light changes) and unexpected (e.g., pedestrian stepping onto roadway) events. The test drive consisted of a 6.6 km urban driving environment, divided into six 1.1 km segments. Three different orders of presentation of these segments were used to avoid any