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Good distractions: Testing the effects of listening to an audiobook on driving performance in simple and complex road environments

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ABSTRACT

Distracted driving (driving while performing a secondary task) causes many collisions. Most research on distracted driving has focused on operating a cell-phone, but distracted driving can include eating while driving, conversing with passengers or listening to music or audiobooks. Although the research has focused on the deleterious effects of distraction, there may be situations where distraction improves driving performance. Fatigue and boredom are also associated with collision risk and it is possible that secondary tasks can help alleviate the effects of fatigue and boredom. Furthermore, it has been found that individuals with high levels of executive functioning as measured by the OSPAN (Operation Span) task show better driving while multitasking. In this study, licensed drivers were tested in a driving simulator (a car body surrounded by screens) that simulated simple or complex roads. Road complexity was manipulated by increasing traffic, scenery, and the number of curves in the drive. Participants either drove, or drove while listening to an audiobook. Driving performance was measured in terms of braking response time to hazards (HRT): the time required to brake in response to pedestrians or vehicles that suddenly emerged from the periphery into the path of the vehicle, speed, standard deviation of speed, standard deviation of lateral position (SDLP). Overall, braking times to hazards were higher on the complex drive than the simple one, though the effects of secondary tasks such as audiobooks were especially deleterious on the complex drive. In contrast, on the simple drive, driving while listening to an audiobook lead to faster HRT. We found evidence that individuals with high OSPAN scores had faster HRTs when listening to an audiobook. These results suggest that there are environmental and individual factors behind difference in the allocation of attention while listening to audiobooks while driving.

1. Introduction

Forty percent of all collisions can be attributed to in-car distractions, most of which were the result of the driver carrying out other (secondary) tasks while driving (Lee et al., 2013). When drivers carry out several tasks at once, there is interference, which is to say performance on one or both tasks suffers. Recently a great deal of attention has been focused on the interference/distraction produced by cell phone use but any task that takes drivers' minds off the road can produce distraction. The effects of distraction are often understood in terms of the concept of mental workload. Mental workload is the relationship between the cognitive demands placed on an individual by a task or environment and an individual's available cognitive resources (Palinko et al., 2010). Humans have limited cognitive resources; the more attention is diverted to a secondary task, the more performance on the primary task suffers, particularly when tasks are deliberate and effortful (not automatic) and compete for the same (limited) cognitive resources (Courage et al., 2015; Heatherton and Wagner, 2011; Lavie, 2005). The dangers associated with distracted driving stem from mental overload, which occurs when task demands exceed an individual's capacity to effectively allocate attention between various tasks (Berka et al., 2007). Nonetheless, driving impairment can also occur when the demands of the environment are particularly low compared to the individual's capacity, a condition known as mental underload. Mental underload occurs when drives are particularly simple, uneventful and/or repetitive (Kahneman, 1973; Wickens, 2002).

Mental underload is most commonly associated with the negative effects of driver fatigue and boredom. Fatigue (mental or physical) is a well known risk factor when driving; it is associated with up to 30% of all motor collisions (Connor et al., 2002; Schwarz et al., 2012; Trick et al., 2004). When fatigued, drivers may be tempted to reduce the attentional resources devoted to the driving task, a tendency that is especially strong when the driving task is not very demanding, though fatigued drivers can sometimes "rise" to the occasion when the task becomes more challenging (Davenne et al., 2012; Trick et al., 2004). This finding has been interpreted as evidence that attentional resources

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are malleable and can change in response to environmental demands (Kaplan and Berman, 2010; Stanton and Young, 1998). Similarly, mental underload can cause boredom (Matthews and Desmond, 2002; Verwey and Zaidel, 2000). Boredom is an unpleasant feeling that occurs when people become aware that they are not sufficiently immersed in the current situation. It stems from an overall lack of cognitive stimulation, and much like fatigue, it is more common on uneventful drives such as rural roads and highways. The feeling of boredom is aversive, because of this, drivers sometimes seek to alleviate it by finding other tasks to become immersed in. This can result is mental overload if the task they choose is too demanding to carry out while driving.

The problem of mental underload is extremely pervasive, affecting anyone who spends long hours driving familiar routes. Professional drivers, including truck drivers and commercial delivery drivers, are certainly at risk at risk but so are many daily commuters, especially when those daily commutes are long and uneventful (Chen et al., 2016). Individual commute times in big metropolitan areas are increasing steadily. In 2011 the average commuter spent 66 min on their way to and from work in Toronto, with about 28% of daily commuters spending more than 90 min going to and from work (Statistics Canada, 2015), and many commute at a time that they may also be tired, either early in the morning or in the late afternoon, after a hard day of work. Drivers may have strategies for dealing with long, familiar commutes, but they vary in effectiveness. Some activities, such as opening the car window or turning on the radio, have been shown to be ineffective in alleviating fatigue and boredom induced driving decrements (Heslop et al., 2010; Schwarz et al., 2012). Other activities, such as day-dreaming/mind-wandering, or engaging in distracting secondary tasks such as texting or cell phone conversations may significantly increase the driver's risk of collision (Galéra et al., 2012; Irwin et al., 2014; Lee et al., 2013). To drive optimally, commuters need to avoid both mental underload and mental overload. One strategy is to choose a relatively mild (undemanding) secondary task, to increase the mental demand of the drive, which would have the effect of helping the driver deal with boredom or mild fatigue.

In this study, we investigate the effects of listening to an audiobook, particularly as it affects performance in the sort of simple, relatively undemanding drives that might be associated with mental underload. Our choice to investigate audiobooks was based on a number of considerations. Secondary tasks vary in the extent to which they affect driving performance. The degree to which an activity has a negative impact on driving performance depends on how much the activity contributes to an individual's mental workload (Cantin et al., 2009). Activities such as listening to music contribute little to one's mental workload and have minimal effects on driving (Ünal et al., 2012) whereas texting contributes heavily to the mental workload due to both the visual and cognitive demands of the task (Irwin et al., 2014; Lee et al., 2013). There is evidence that performing some simple secondary tasks, game-like tasks, where drivers must pay attention to letters and numbers on a screen, may be useful in attenuating fatigue related driving impairments (Desmond and Matthews, 1997). However, these tasks are rarely employed in the real world. In contrast, audiobooks are becoming increasingly common (Milliot, 2017), and are often listened to while driving. There is relatively little research on the effects of audiobooks, but to this point, the evidence suggests that they interfere less with driving than talking on a hands-free cell phone or conversing with a passenger, but more than listening to the radio, when interference is measured in terms of increases in hazard response times compared to single-task driving (Biondi et al., 2015; Strayer et al., 2015).

Once we chose to investigate audiobooks, we began to wonder if there were situational factors or individual differences that might influence the effectiveness of audiobooks. Mental workload can be increased by increasing the complexity of a task or environment, making the inclusion of a secondary task more likely to cause mental overload (Palinko et al., 2010). The complexity of the driving environment can contribute to mental workload by increasing the number of stimuli that an individual has to attend. There are a number of factors that can make the drive more demanding, including traffic, scenery, intersections, and curvature in the roads. Because of these increased demands, in more complex driving environments, it is overload rather than underload that is the problem, and in fact, it is those situations where secondary tasks would be most deleterious to performance (Palinko et al., 2010). In contrast, simple road environments such long traffic-free straight roads on country roads contribute less to the mental workload of the driver, alleviating some of the risks associated with engaging in simple secondary tasks. In these less demanding environments, mental underload may be more probable, which the secondary tasks may help alleviate. Thus, there is a relationship between the complexity of the driving demands and the effects of secondary tasks (Biondi et al., 2015; Heslop et al., 2010; Liu and Wu, 2009; Strayer et al., 2015; Törnros and Bolling, 2006). The previous investigations of audiobooks did not look at the effects of the complexity of the driving task. Based on what is known about mental workload and attention, there is reason to expect audiobooks to affect driving differently in simple road and complex road environments due to the mental load associated with each environment (Cantin et al., 2009; Engström et al., 2005).

There may also be individual differences that may be relevant to the effects of audiobooks, particularly as they relate to executive function. Executive function is an individual's ability to maintain task related goals despite competing cognitive stimuli or distractions and is associated with better multitasking ability (Lambert et al., 2010). A common measure of executive functioning is the Operation span (OSPAN) task, which tests how well individuals are able to switch between answering math questions and keeping letters in memory (Sanbonmatsu et al., 2013; Strayer et al., 2015). In particular, there is a study that showed that individuals who scored in the top 5% of OSPAN scores seem to be relatively unimpaired by engaging in a secondary task while driving (Watson and Strayer, 2010). Although we did not restrict our search to the top 5% of the population, we compared high and low OSPAN scorers (median split) in terms of their response to the manipulations. There was reason to expect the benefits of audiobooks would be especially evident for those with high OSPAN scores, given that they seem to be better at multi-tasking.

We designed an experiment in a fully immersive fixed base driving simulator to test whether audiobooks can be used to improve driving performance in simple road environments, while at the same time trying to determine the individuals for whom and situations in which audiobook benefits are most evident. There were three factors: level of distraction (single task driving, driving + audiobook), road conditions (simple, complex), and OSPAN Score (low, high). We predicted that the secondary task would improve hazard response more in the simple environment than the complex environment. In particular, we hypothesized that audiobooks would improve driving performance in the simple driving environment because it would help combat underload. Drivers would be less likely to doze, daydream, or simply "gap out" on the simple road if there was something else to do while driving, such as listening to a story. In contrast, we predicted that audiobooks would not be beneficial in more complex drives, first because there is more danger of overload, and second, because the audiobooks could even distract in a more complex drive, when the demands of the driving task were greater (contributing to mental overload). We also predicted that individuals with low OSPAN scores would have poorer driving performance when engaging in a secondary task because of their relative impairments in switching their attention between tasks. With regards to the self-report measures, we predicted that drivers would rate their driving performance as better in the single task driving. However, we also predicted that the audiobook would only be perceived as distracting in the complex road environment.