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Driving with music: Effects on arousal and performance

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ABSTRACT

In the current study, we aimed at exploring the influence of music on driving performance, arousal and mental effort while carrying out a monotonous car-following task in a low-complexity traffic setting. Participants ($N = 47$) were randomly assigned to loud and moderate volume music groups, and completed one drive in the simulator with music and another drive without music (control condition). In addition, during both of the drives we monitored driving performance and recorded participants' heart rate to track physiological indications of arousal and mental effort. Results revealed that listening to music had no effect on accuracy of car-following, and even had a positive effect on response latencies to speed changes of the lead vehicle and on lateral control. Importantly, arousal was higher in the presence than absence of music irrespective of the volume level, suggesting that loud volume music was not more arousing than moderate volume music. In addition, mental effort, which was inferred from the physiological measurement of heart-rate variability, did not differ in conditions with and without music. These findings indicate that listening to music does not impair performance in a monotonous car-following task, and might even improve some aspects of performance as a result of increased arousal.

1. Introduction

Among the various secondary tasks that drivers engage in while driving, listening to music or the radio seems to be the most common (Dibben & Williamson, 2007). Interestingly, drivers report listening to music habitually, and simply for the purpose of "killing time" on the road (North, Hargreaves, & Hargreaves, 2004). Why do drivers need to "kill time" while driving? Can such a need for listening to music be related to the driving task not being sufficiently stimulating all the time? Indeed, the driving task can be monotonous at times, especially while driving in highly predictable environments that are low in complexity. Research indicates that such environments can elicit the experience of adverse driver states, such as boredom or drowsiness resulting from lack of external stimulation (Nelson, 1997; Thiffault & Bergeron, 2003). Importantly, such states might incline drivers to be prone to inattention errors, such as failing to notice changes in the traffic environment on time, which might increase accident-likelihood (NHTSA, 2008). Hence, monotonous driving conditions low in complexity can be quite challenging to handle, as drivers might find it hard to focus on the important aspects of the driving task due to the lack of arousal and stimulation. In the current paper, we explore whether listening to music might provide the external stimulation needed to defeat boredom and to keep focused on the driving task in situations where both the driving task and the traffic environment are monotonous, such as car-following in low-complexity traffic. Importantly, we not only study the influence of music on performance in such monotonous low-complexity situations, but also whether arousal is a relevant process variable explaining how music may influence driving performance in monotonous conditions.

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Studies on music and driving typically regard music as a secondary task that might be distracting to the driver. Various scholars have examined to what extent music disrupts one's driving performance (Beh & Hirst, 1999; Brodsky, 2002; North & Hargreaves, 1999; Pêcher, Lemercier, & Cellier, 2009). Interestingly, in simulated driving studies, impairment in driving performance with the presence of music was seldom reported (Brodsky, 2002; Pêcher et al., 2009). In addition, drivers have been found to adopt cognitive or behavioural compensatory strategies while listening to music to cope with increased task demands and protect their driving performance, especially when they were in relatively high-complexity traffic settings (Hughes, Rudin-Brown, & Young, 2013; Ünal, Platteel, Steg, & Epstude, 2013; Ünal, Steg, & Epstude, 2012) or/and when music-listening was somewhat cognitively demanding, such as when the volume was high (see North & Hargreaves, 1999). For instance, as indicative of cognitive compensations (see Hockey, 1997), drivers invested more mental effort when driving and listening to music in a high-complexity traffic setting, and prioritized the driving task by blocking-out radio-content to a large extent while driving (Ünal et al., 2012, 2013). Also, drivers who listened to demanding types of music (i.e., high volume and high tempo) were found to have longer lap times (due to lower speed) in a computer-based racing game as compared to drivers who listened to less demanding types of music (i.e., low volume and low tempo; North & Hargreaves, 1999). This finding indicated that drivers might compensate for the cognitive load induced by certain types of music by reducing their vehicles' speed. So, there is evidence suggesting that when the traffic demands or listening demands (or both) are high, drivers cope with the increased task demands by adopting compensatory strategies. In many cases, however, driving does not take place in complex environments. Indeed, driving often involves monotonous conditions that are very low in complexity, such as prolonged driving on rural roads or car-following for extended periods. So, would drivers employ compensatory strategies while driving in low-complexity traffic settings as well? And how would music affect their driving performance?

To our knowledge, little is known about the influence of music on task performance in monotonous driving conditions. A study that examined the influence of loud music on driving performance in various conditions, including two driving tasks that took place in a highly-predictable environment (namely monotonous driving and car-following tasks, respectively), revealed that listening to loud music did not impair driving performance (Ünal et al., 2012). Specifically, music had no influence on the lateral vehicle control of participants in a monotonous driving task, while in a car-following task they even appeared to better respond to speed changes of the lead vehicle. These findings provide some preliminary evidence that the presence of music may increase vigilance while following a car in low complexity situations. However, the car-following task that was used in that study was relatively short (6 min), and was embedded within a hectic driving environment with many critical incidents, meaning that it was not monotonous. Hence, the questions of whether music would have no or positive effects on task performance in monotonous conditions in low-complexity settings and how performance is maintained in such conditions remain open.

Investigations regarding prolonged and monotonous driving conditions in the presence of other types of secondary tasks and in-vehicle distracters, such as talking on a mobile phone, indicate that such secondary tasks do not necessarily impair driving performance. For example, although some studies showed a negative influence of using a mobile phone on car-following performance, as reflected by delayed responses to speed changes of the lead vehicle (Alm & Nilsson, 1995; Brookhuis, De Vries, & De Waard, 1991; Brookhuis, De Waard, & Mulder, 1994; Lamble, Kauranen, Laakso, & Summala, 1999), this tendency of having higher response latencies was absent while driving in low-complexity traffic with less perceptual load (Strayer, Drews, & Johnston, 2003). In addition, lane-keeping performance, which is an indication of lateral vehicle-control, was maintained in car-following tasks that were accompanied by a secondary task such as dialling a number or executing a working memory task on a mobile phone (Alm & Nilsson, 1995; Lamble et al., 1999). Importantly, some studies revealed that car-control performance even improved in low-complexity driving situations with the presence of a secondary task as compared to when there was no secondary task (Atchley & Chan, 2011; Brookhuis et al., 1991; Verwey & Zaidel, 1999). For instance, drivers who were required to carry out a concurrent mobile-phone task exhibited less swerving on the road as compared to drivers who did not have the additional mobile phone task (Brookhuis et al., 1991). These findings indicate that, different to those observed in complex driving conditions, secondary tasks might not necessarily have adverse consequences on driving performance in monotonous conditions that are low in complexity. This raises the question of which processes will enable driving performance to be maintained or even improved in the presence of a secondary task such as music.

As stated earlier, monotonous driving in situations characterized by low complexity is associated with low-arousal driver states such as boredom, drowsiness or fatigue, and drivers lack vigilance when they experience such states (Nelson, 1997; O'Hanlon, 1981; Thiffault & Bergeron, 2003; Wertheim, 1991). One potential explanation for drivers performing well in monotonous conditions in the presence of secondary tasks is that these tasks may increase arousal to a more optimal level that would increase vigilance (Atchley & Chan, 2011; Heslop, Harvey, Thorpe, & Mulley, 2010). This argument is in line with predictions of the Yerkes–Dodson law (Teigen, 1994; Yerkes & Dodson, 1908), which posits that the relationship between task performance and arousal can be depicted by an inverted U-shaped curve. When one's arousal level is too high or too low, performance is predicted to be inhibited, while a moderate arousal level is expected to result in higher performance. Easterbrook (1959) explained this phenomenon by the cue-utilization theory, suggesting a link between arousal and attention. More specifically, Easterbrook (1959) argued that both under-arousal and over-arousal would have a negative influence on attention by impairing the efficient processing of the relevant cues needed to perform well on a task. However, a moderate level of arousal was associated with facilitating selective attention and the processing of relevant cues, resulting in a better performance attainment. Based on Easterbrook's framework, we assume that in monotonous driving situations that