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A performance analysis of In-Car Music engagement as an indication of driver distraction and risk

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ABSTRACT

Drivers engage in a host of driving-unrelated tasks while on the road. They listen to music, sing-along, and accompany songs by pounding-out drum-kicks and syncopated rhythms on the steering wheel. However, there is controversy over in-cabin music: Does background music facilitate driver performance via increased arousal leading to more focused concentration, or cause distraction placing drivers at greater risk. In an effort to shed light on the debate, the current study evaluated music engagement by employing Music Performance Analyses with audio recordings from three simulated driving conditions. The results indicate that as the perceptual demands of the primary driving task increased, the secondary music activity was hampered, and subsequently sub-optimal vocal and percussive performances were demonstrated consisting of intonation errors, rhythmic inaccuracy, lack of synchrony, inconsistent and unstable temporal flow, neglect of text, and lyric replacement. The findings seem to point out that drivers allocate greater reserves to music than previously considered, and as drivers do not withdraw altogether from music engagement under high-demand driving conditions, driving may be under-resourced. Exploring active music engagement while driving might assist traffic safety researchers in decoding the effects of In-Car Music on driver behavior.

1. Introduction

Drivers engage in a host of driving-unrelated tasks while on the road. Walsh (2010) argued that especially when drivers are alone, they not only listen to music but sing along in a karaoke-like fashion, as well as tap along on the steering wheel. Brodsky (2015) pointed out that *as if* participating in the performance itself, drivers often accompany songs by singing the melody or vocalizing background fills and runs (which he coined *Car-aoke*), and they pound-out drum kicks and syncopated rhythms on the steering-wheel (or gearshift or dashboard), play 'licks' and solos in an air-guitar fashion, and even dance in their seat. Car-audio has developed from the 1950s throughout the 1990s as an integral feature component of the automobile. From the turn of the millennium, surveys have reported that the most popular location where people engage in music listening is the car (for a comprehensive review, see: Brodsky, 2015). As drivers envisage feeling secure and protected by their automobile, the last thing they would ever think about is how safe it may be to turn on the radio, toggle a channel knob, adjust the volume, flip a cassette tape, swap a CD, or thumb-scroll through a playlist – and sing along with the music. It does seem that a central belief of drivers is that background music is as much of a natural and fundamental constituent of driving as is accelerating, looking ahead, steering, and braking. Today there are countless fixed on-board in-cabin technologies (i.e.,

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automotive entertainment features), as well as portable 'nomadic' devices that connect to in-cabin systems via Bluetooth; all of these offer drivers an opportunity to engage with music. Among the sources that provide music tracks for drivers are broadcast and satellite radio, compact disk players, digital music players, personal flash disks, smartphones, and notebook tablet computers.

While there seem to be a handful of benefits for driving with music including entertainment, stress reduction, combating boredom, counteracting fatigue, and emotional regulation (Clarke, Dibben, & Pitts, 2010; Dibben & Williamson, 2007), by adding music to a milieu consisting of driver performance and vehicular control within a highly dynamic and potentially hazardous traffic-based road environment, there may also be some shortcomings as far as personal safety is concerned. For example, Brodsky (2015) delineated four contraindications of In-Car Music: structural distraction resulting from poor HMI ergonomics and mechanical configurations; perceptual masking; capacity interference to central attention subsequent to overtaxed cognitive faculties; and social diversion. Further, Brodsky documented evidence for three ill-effects that hamper drivers: Music-evoked Driver Arousal, Music-generated Driver Distraction, and Music-induced Driver Aggression. Nonetheless, there is a controversy about the *utility* of In-Car Music within the annals of the transportation and traffic safety literature. Thus far, there has been no overriding verdict regarding the *adaptive* versus *maladaptive* nature of in-cabin music background. For example, Unal (Unal, de Ward, Epstude, & Steg, 2013; Unal, Platteel, Steg, & Epstude, 2013; Unal, Steg, & Epstude, 2012) claimed that In-Car Music facilitates driver performance, and demonstrated increased arousal leading to more focused concentration. The studies revealed drivers to intuitively implement cognitive strategies to reduce task-demands on the road by blocking-out auditory distracters such as radio broadcasting and music background. Unal et al. concluded that In-Car Music does not impair driving performance. Further, in a highly cited survey study, Dibben and Williamson (2007) determined that unlike verbal conversation with either accompanying passengers present in the vehicle or with a distant caller by which drivers are required to sustain a necessary level of attention, in-cabin music engagement offers drivers much more flexibility to 'start and stop at will with no ill consequences'. On the other hand, Hughes, Rudin-Brown, and Young (2013) found that singing while driving altered driving performance and significantly impaired hazard perception. Moreover, (Brodsky, 2002, 2013, 2014, 2015, Brodsky & Kizner, 2012; Brodsky & Slor, 2013) demonstrated that background music caused distraction, and placed drivers at greater risk for increased driver miscalculation, inaccuracies, deficiencies, errors, traffic violations, and driver aggressiveness. Brodsky and Slor presented evidence that listening to preferred music hampered perceptual motor control leading to a decrement of vehicular performance with increased incidents, events, and near-crashes.

It should be pointed out that all research efforts thus far have investigated the extent to which *passive listening* affects driver behavior and vehicular control. That is, driving while background music was heard in the cabin. In general, this body of research puts forth studies that have employed simulated driving tasks, driving simulators, closed-circuit test-tracks, and real-world on-road 'naturalistic' driving – all the while monitoring braking RTs, cruising speed, longitudinal acceleration, lateral deviations from the mid-line of the lane, and various driver deficiencies. For the most part, these investigations have been modelled on platforms and paradigms used previously to examine the effects of mobile phones in vehicles. However, one landmark study from the later corpus went further than all the others in that it documented the dysfunctional impact that 'conversation' had on driver behavior. Crundall, Bains, Chapman, and Underwood (2005) examined if drivers adapted to the flow of conversation while driving on urban roads, and subsequently demonstrated how drivers adjusted to traffic-related environmental demands. Crundall et al. demonstrated that depending on the traffic conditions, drivers tended to slow down the pace and density of discourse; they referred to the phenomenon as 'conversational suppression'. This single effort not only revealed the degree to which engaging in verbal conversation as a secondary task impinged on the primary task of controlling a vehicle, but was instrumental in confirming that increased risks of mobile phone use were well beyond what had been accepted by federal safety agencies as pertaining to physical structural distraction caused by mechanical manipulation of hardware. Namely, Crundall et al. discovered that *conversation* itself was a contributory factor for inattention to the road through capacity interference of cognitive faculties that were otherwise engaged. Strayer and Drews (2007) confirmed that when drivers become involved in a phone conversation, their attention is drawn away from the information in the driving environment that is necessary for safe operation of the motor vehicle. Then, in a later study Strayer et al. (2013) rated the workload of several auditory-based secondary tasks and employed the *Cognitive Distraction Scale* (items scored between 1 and 5) for such ratings. They found listening to talk radio (1.20) or an audio book (1.70) associated to small cognitive increases in distraction. It is important here to note that these two secondary tasks are seen as *passive* listening because drivers are not immersed in phonological activity, and hence mental involvement is not sufficient to be measured as a large cognitive distraction. Yet, Strayer et al. also found that when drivers conversed with a friend on a hands-free (2.30) or hand-held (2.40) or cell phone, or when they conversed with a passenger (2.35), then cognitive distraction was measured as moderate. Finally, driver interaction with voice-command personal assistant operating systems (3.10) were measured as a large cognitive distraction. Therefore, given the above-mentioned debate about the utility of music background while driving, it would seem warranted to explore driver behavior in a more *active mode of music engagement* rather than as passive listening. Such an effort may lead to a greater understanding concerning the consequences of In-Car Music on driver behavior.

In the current study, the secondary driving task was placed in the forefront of examination. It was expected that as the perceptual demands of the primary driving task increase from stationary parking through low-demand driving to high-demand driving, music performances of drivers would be hampered. For example, one might envision a decline of music performances as revealed by corrupt executions consisting of intonation errors, rhythmic inaccuracies, lack of synchrony,