The Effects Of Music Background On Hazard Perception Among Young Adult Drivers

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Abstract

Drivers engage in a host of driving-unrelated tasks while on the road. When alone, drivers not only listen to music, but sing along pounding-out drum kicks and syncopated rhythms, play ‘licks’ in an air-guitar fashion, and even dance in their seat. 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. Although there are benefits for driving with music (e.g., entertainment, counteracting fatigue), adding music to a hazardous traffic road environment does decrease driver safety (e.g. distraction, miscalculations, violations). However, the literature reports contradictory evidence as whether music engagement is maladaptive by leading to decremented driver performance and compromises traffic safety, or adaptive for driving by increasing arousal generating positive moods.

The study is an attempt to better understand the effects of music on driver behavior by targeting video-based *hazard perception* test performance. The ability to read the road and anticipate hazardous risky situations is a cognitive skill found to associate with frequency of road accidents and traffic crashes. Study 1: 18 participants viewed movie clips of real-world hazardous road and traffic situations, pressing a response button each time they identified a hazard. Environmental road and traffic sounds (RS) were heard. The findings show that RS had no decrement on performance. Study 2: 36 participants performed same task as in Study 1, under three aural conditions: RS-alone; RS+driver-preferred music; RS+alternative music. The results show no effect of aural backgrounds including music on performance (i.e., visual perception and situational awareness).

A theoretical model is presented indicating that music background might potentially affect driving processes in later stages (e.g., response selection and/or response execution), indicating that driving performance deterioration could occur when drivers are engaged with music.

Keywords:
Video-based Hazard Perception Test; In-Car Music; Music Effects; Distraction; Cognitive Models Driving

1. Introduction

1.1 In-Cabin Music

Drivers engage in a host of driving-unrelated tasks while on the road. Brodsky (2018) pointed out that as if participating in the performance itself, drivers often accompany songs by singing the melody or vocalizing background fills and runs, pounding-out drum kicks and syncopated rhythms on the steering-wheel, playing 'licks' and solos in an air-guitar fashion, and even dancing in their seat. Most recently, Brodsky (2021) found that drivers believe background music is a natural and fundamental constituent of driving. Some benefits for driving with music include entertainment, stress reduction, combating boredom, counteracting fatigue, and emotional regulation (Dibben & Williamson, 2007). Yet, adding music to a potentially hazardous road environment may contribute to reduced safety. Four contraindications of driving with music have been delineated: (a) structural distraction; (b) perceptual masking; (c) capacity interference; and (d) social diversion (Brodsky, 2015).

The utility of *In-Car Music* is certainly disputed. For example, some findings claim that background music facilitates driver performance (Unal, de Waard, Epstude, & Steg, 2013; Unal, Platteel, Steg, & Epstude, 2013; Unal, Steg, & Epstude, 2012). Other studies claim that singing while driving alters peripheral detection skills (Hughes, Rudin-Brown, & Young, 2013). Further evidence demonstrates background music can hamper perceptual motor control leading to decrement of vehicular performance (Brodsky & Kizner, 2012; Brodsky & Slor, 2013).

Driving skills are not only a set of basic skills such as those related to operating a vehicle, but also comprise cognitive skills such as identification and mitigation of hazards.

1.2 Hazard Perception

Hazard perception (HP) is a cognitive skill found to associate with frequency of road accidents and traffic crashes (Borowsky et al., 2010; Borowsky & Oron-Gilad, 2013, 2016; Meir, Borowsky, & Oron-Gilad, 2014). In our effort to better understand the effects of music on driver behavior, we investigated the effects of music on hazard perception. In the most commonly used paradigm to evaluate hazard perception participant-drivers are asked to observe movie clips of traffic scenarios, and then respond each time they identify a hazardous situation (Horswill & McKenna, 2004; Horswill et al., 2015). This paradigm allows for reliable measurement of response sensitivity (% accuracy) in identifying hazards, and response latency (RTs timed response) of a button press.

2. Methodology

The current investigation employed a within-subjects design; every driver viewed movie clips in three aural background conditions. The data was analyzed as an outcome measure of the likelihood to identify the hazard. The study questioned if hazard perception is hampered more when driving with music compared to environmental road and traffic sounds (RS), and if driving with an alternative music background (AM) hampers hazard perception less than when driving with one's own preferred-favorite music (DM). From an etiological point of view, it would be an advantage to find the *stage* in which there may be a breakdown in the driving process (e.g., the visual perceptual level). But first, there was a need to investigate if hazard perception is at all affected by environmental road and traffic sounds (Study 1) prior to exploring the issues of background music (Study 2).

2.1 STUDY 1

Study 1 questioned if video-based hazard perception test (VBHPT) scores under an aural background of environmental road and traffic sounds (RS) would be similar to previously reported results by Borowsky et al (2013).

2.1.1 Participants

Eighteen (*N* = 18) undergraduates participated; each volunteered, signed a consent form, and received extra credit points. They were on average 25 years old (*SD* = 0.86), females = 78%, with eight years driving experience (*SD* = 1.19). All had normal or corrected-to-normal vision; all had normal uncorrected hearing. On average, the participants drove 15 trips per month (*SD* = 11.49), for the duration of 60 minutes per trip ($M_{\text{hours per/wk}}$ = 3.22, *SD* = 1.93).

2.1.2 Stimuli

Aural. 60-minute environmental road and traffic sounds (RS).

Visual. Thirteen short (M = 28.4s, SD = 5.80s) movie clips, shot from a video camera located in the vehicle. All videos had been previously authenticated (Borowsky & Oron-Gilad, 2013; Borowsky, Oron-Gilad, & Shinar, 2010; Kahana-Levy et al., 2019a, 2019b). All scenarios were based on events that a driver could experience every day. Each video clip was comprised of an average three events, with a test-set consisting of 43 events.

2.1.3 Equipment

Audio. RS was reproduced with an MP3 player coupled to two 4" full-range integrated amplified PC speakers, controlled at 60db volume.

Computing. The experiment was run on a desktop computer, 20" LCD computer screen, standard keyboard, and red response button (on right of the keyboard).

2.1.4 Procedure

Participants sat 65cm in front of a computer screen. After two practice runs, each participant watched 13 movie clips presented as a block in a random order. RS was heard throughout. When drivers identified a hazard, they pressed the red response button. After each movie clip, a text box opened on the screen for participants to type a short description recalling the event and the instigator that was identified; when more than one response was logged, the same number of text boxes opened for text entry.

2.1.5 Analysis and Results

Proportion of identification (%) of those who correctly identified a pre-defined target was tabulated employing a 42% threshold to indicate 'meaningful' events. Reaction time (RTs) between the onset of a hazard and the red button press response (the actual frame number) were transformed to milliseconds. The logged texts indicated that 95% of the responses occurred for the pre-defined targets of the movie clips; these were taken on-board for analyses. Almost every movie clip had at least one meaningful event; but one movie was dropped from all subsequent analyses as 94% of the sample did not identify a hazard in this movie clip.

Then the data of all meaningful events were pinned against previous data published by Borowsky et al (2010, 2013) and Kahana-Levey et al (2019a, 2019b). The analysis found that 11 movies and events were similar despite the addition of an RS aural background. Thereafter, the RTs of all meaningful events were analyzed to the same event in the same movie clip as previously published. The analysis found that 12 movies and events were similar despite the addition of an RS aural background. To scrutinize lack of differences in terms of response sensitivity and response time between the current Study 1 and the previous studies, we employed the Generalized Linear Mixed Model (GLMM) framework. For Identification (response sensitivity % Yes/No) as the dependent variable. we ran a logistic regression, where the 'study' (Borowsky et al vs. Study I) was included as a fixed effect and participants, events, and movies were included as random effects. The analysis revealed no significant differences ($F_{(1, 1664)}$ = 0.008, p = 0.928). To examine RTs as a dependent variable we ran a linear regression in a similar fashion; the analysis revealed no significant differences ($F_{(1, 458)}$ = 0.716, p = 0 .40).

2.1.6 Interim Discussion And Conclusion

Study 1 evaluated the effects of environmental road and traffic sounds (RS) on an VBHPT scores. Study 1 found no meaningful differences in sensitivity of drivers' ability to identify hazards, nor in their response times to an identified hazard. Therefore, we concluded that an RS aural background does not hamper VBHPT performance. In addition, Study 1 found no meaningful differences between Borowsky et al's (2010, 2013) original 10-item VBHPT, nor the additional three movie clips (from Kahana-Levey et al., 2019a, 2019b).

2.2 STUDY 2

In our continued efforts to target the utility of *In-car Music*, Study 2 examined the effects of music on driver's perception of threats and dangers on the road.

2.2.1 Participants

To calculate an estimate of sample size, an effect size as found in Brodsky and Kizner (2012) on the optimization of in-cabin music for safer driving was inserted in *G*Power* 3.1.; the result indicated that 24 participants were needed for a similar effect size $n_p^2 = 0.34$ at $\alpha = 0.05$ with power .95. Study 2 recruited $N = 36$ undergraduates; each volunteered, signed informed consent to participate, and received extra credit course points. These participants reflect 50% above the estimated 24-participant sample size required. The participants were roughly 25 years old ($SD = 1.15$), females = 58%, with about eight years driving experience ($SD = 1.79$). All had normal or corrected-to-normal vision; all had normal uncorrected hearing. On average, the participants drove 16 trips per month ($SD = 9.94$, Range 0-40), for the duration of 80 minutes per trip ($M_{hours/wk} = 4.19$, $SD = 4.65$, Range 1-25). A third (36%) reported to own an automobile. In general, the sample reported they 'very much' drive with music, listen to selections described as 'fast-paced' pieces, reproduced in the cabin at 'loud' volumes. Most of these drivers (82%) claimed to sing to songs heard while driving.

2.2.2 Stimuli

Aural. RS (environmental road and traffic sounds) was the same track used in Study 1; DM (driver preferred music) tracks brought by the participants, included 70 tracks (74% international English-language songs; 26% local Israeli Hebrew-language songs; AM (alternative music) background was provided by the experimenter (Brodsky & Kizner, 2012; Brodsky & Slor, 2013).

Visual. Study 2 employed the same movie clips used in Study 1. In each of the three blocks, four target movie clips were viewed (presented in random orders); another 18 clips of the same type and duration were viewed as *filler* clips (6 per condition) in an effort to generate *priming effects* of the music before the targets were viewed.

2.2.3 Equipment

Audio. RS was reproduced with the same audio equipment as in Study 1. An additional audio system was required for the music stimuli: Pioneer car-audio system coupled to Pioneer car-audio speakers. Both DM and AM reproduction volumes were controlled at 85db (15db above RS).

Computing. Study 2 employed the same computing equipment as in Study 1.

2.2.4 Procedure

Two days before each session, participants sent playlists of four music tracks and MP3 files via email. The participants sat 65cm in front of a computer screen. After a short explanation and two practice runs, every participant watched a succession of movies in three blocks counterbalanced across the sample in six presentation orders; each block reflects one of three aural conditions also counterbalanced across the sample in six presentation orders. A complete cycle of all possible combinations (6 x 6) required 36 subjects. RS was heard throughout. All other aspects were identical to Study 1.

2.2.5 Analysis and Results

Proportion of identification (%), and reaction time (RTs) were conducted in the same manner as in Study 1. Meaningful events (GTE 42%) were found in 10-out-of-12 movie clips; these 10 clips provided 15 meaningful events, with 11 meaningful events per condition.

Response sensitivity. A logistic regression model within the GLMM framework was employed. As the first order interaction effect was non-significant, it was removed from further analyses. The estimated mean probability of identification indicated that participants responded similarly whether or not music was heard in the background, as well as similarly to both types of music (RS: $EMn = .579$, $SE = .118$; DM: $EMn = .588$, $SE = .117$; AM: $EMn = .586$, $SE = .117$; $F_{(2, 1806)} = 0.021$, $p = 0.980$). The main conclusion of this analysis is that there were no significant effects of aural background (including music) on the probability to respond to a hazard.

Response time. A linear regression model within the GLMM framework was employed. Like Study 1, events were included only if response sensitivity was GTE 42% for a meaningful event in at least one condition. As the first order interaction effect was non-significant, it was removed from further analyses. The final model revealed that none of the fixed events were statistically significant (e.g., Music Condition: $F_{(2, 202)} = 0.132$, $p = 0.877$). On average, it took participants about 2.2 seconds to press the response button regardless of aural condition (RS: *EMn*

= 2.279s, *SE* = .400; DM: *EMn* = 2.284s, *SE* = .401; AM: *EMn* = 2.202s, *SE* = .400). The main conclusion of this analysis is that there were no significant effects of aural background (including music) on the time it took to respond to a hazard.

2.2.6 Interim Discussion And Conclusion

Study 2 evaluated the effects of aural backgrounds on VBHPT scores . Study 2 found no meaningful differences of aural background regarding the probability of drivers to identify hazards, nor on their response times to an identified hazard. Therefore, we concluded that aural backgrounds (including music) do not hamper hazard perception as demonstrated by VBHPT performance.

3. General Discussion and Conclusion

In our effort to better understand the effects of music on driver behavior we targeted hazard perception. By taking an etiological perspective, we raised the question if such a systematic breakdown would be found at levels involving visual perception. Yet, the results found no meaningful effects of music on drivers' ability to identify hazards, nor on their response times to an identified hazard. We therefore conclude that aural backgrounds (including music) do not hamper VBHPT performance.

Some limitations of the study should be noted. First, while our findings show that music had no effect on VBHPT performance, our experiment was done in a lab where each condition took about 10 minutes; this short exposure of music may not have been enough to produce music effects on hazard perception. Second, although a power analysis indicated that only 24 participants were required for the expected effect sizes, and we recruited 50% more than the estimation, it could be that additional participants are essential for much smaller variances than those estimated.

Although research efforts thus far have explored the *extent* to which background music might affect driver behavior, none have pointed to possible *sources* of breakdown within the driving process. The concept of modeling driver behavior (e.g., Witt, Wang, Fahrenkrog, Kompaß, & Prokop, 2019) brings forth models such as that developed by the BMW Group (e.g., *Stochastic Cognitive Model*) which consists of four submodules: (1) *information acquisition*, (2) the *mental* submodule, (3) *decision making process*, and (4) *action implementation*. In retrospect, we can perhaps look at the current null findings as a *prima facie* demonstration of how the effects of music on drivers do not occur on the detection level (attention and perception) or situation assessment (mental model), but rather target levels of response-selection (appropriate behavior) or operational execution (driver mitigation). This is then the direction of future research.

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