Music and its Effects on One's Ability to Operate a Motor Vehicle

Grant Proposal

Luciana Piarulli

Massachusetts Academy of Math and Science at Worcester Polytechnic Institute

Worcester, Massachusetts

Author Note

A driving simulator will be used to conduct the experiment. The simulator will be provided by the University of Connecticut (UCONN).

Abstract

Many individuals listen to some form of audio entertainment while driving. Previous research has shown that different tones of music cause differences in how individuals drive a car. However, the tempo of the music has not been frequently considered, only the tone of the music. In this study, participants drove in a driving simulator to different speeds of music. An experiment was conducted in which a participant drove in the simulator with two different tempos of music. Participants did not participate in highway driving, as to keep the mean speed of the car consistent throughout the simulation. A random sample of speeds at different times in the simulation was collected from each condition, and the means of each sample were found. A two-sample t-test was used to compare the two means (fast music speeds > slow music speeds). Results from this experiment indicated a statistically significant difference in speeds between the two conditions (a= .05, p=2.22*10^-4). The results of this experiment suggest that individuals may tend to drive faster as the tempo of the music increases. This study seeks to investigate whether there is a relationship between the tempo of music and the overall speed of the car.

Keywords: music, emotion, driving, simulation, car speeds, distracted driving

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Mindmap:
https://www.mindomo.com/mindmap/ab42e0a8c5244c3eb639a333fc6515e3

Every day, millions of Americans drive or go for a ride in a car. Many of these automobiles contain a radio, Bluetooth speaker, or some other type of audio-listening device. In the past, it has been found that 75% of the time spent in the car is also spent listening to music from these devices (Ghojazadeh et al., 2023). Music has been previously shown to influence many different aspects of an individual, including their emotions (Chepenik et. al., 2007). In fact, it has been found that individuals are able to mentally differentiate between different tones of music by the time they are 5 years old (Dalla Bella et. al., 2001). Similarly, emotions are known to influence one's driving performance. Different emotions may cause an individual to drive faster, slower, more aggressively, etc., and can lead to serious car crashes, deviating from the road, and other injuries to an individual/group of individuals in a car.

To this day, it is not 100% known if music causes a change in driver performance; however, studies have shown that this might be a possibility. In 2009, a survey was conducted in which participants drove on a simulated roadway to different types of music. These researchers found a significant difference in the speed of the car while the driver was driving to happily connotated music (Pecher et. al., 2009). Similarly, another study was by conducted Chepenik et al in 2007 in which participants were asked to complete a memory game after listening to sad music. The participants also completed this same test in a control condition of no music. In the end, a significant difference was found in how much the participant could remember with and without listening to the music (Chepenik et al., 2007). These results suggest

that drivers may get distracted while listening to music, leading to them not noticing an increase in the speed of the car.

In the current study, a simulation will be conducted in which participants drive to one of three different conditions. Participants will randomly be separated into one of three groups, each with a different condition. The first condition will be a control condition, in which a driver will drive in silence in the simulation. The speed of the simulated car will be recorded, and the participant's heart rate will be monitored during the test. The second condition will involve similar measurement, but the driver will instead be driving to music with a tempo of less than 70 BPM. The third condition will also have the driver listen to music while driving, but the tempo of the music will be greater than 70 BPM. Music with lyrics will not be used, as this may introduce a confounding variable that should be avoided. After this, an ANOVA test will be conducted to determine if there is a statistically significant difference between the mean speeds of the three test groups. This test will also be used to determine a difference in average heart rate between the three conditions.

Music is not known to be a potential cause of car crashes. However, previous studies have shown that music may in fact be a catalyst of car crashes. An experiment will be conducted in which participants will drive in a simulator to one of three different conditions, including a control condition, a low tempo condition, or a high tempo condition. If a significant difference is found between conditions, recommendations can be made in suggesting what to listen to while driving. Results from this experiment may

cause fewer car crashes to occur every day, suggest what music is beneficial to listen to while driving, and what music is not beneficial to listen to while driving.

Section II: Specific Aims

This proposal's objective is to describe the relationship between music and driving since not much research has been done in this field.

Our long-term goal is to help determine what type of music is least beneficial while driving, (based on the tempo of the song), where the central hypothesis of this proposal is that faster-paced music will cause the greatest increase in the speed of the car. The rationale is that the pace of the music affects how the driver feels (Iwamiya, 1997), and the way the driver feels affects the on-road performance of the driver (Pecher et al, 2009). The work we propose here will attempt to establish a relationship between music and driving and explore what may cause this relationship to form.

Specific Aim 1: Determine if faster-paced music causes a driver to drive faster and if slower-paced music will cause a driver to drive slower.

Specific Aim 2: Determine if the tempo of the music affects heart rate while driving.

The expected outcome of this work:

It is hypothesized that the faster the tempo of the music is, the faster the car will drive. At the same time, it is also hypothesized that the faster the pace of the music is, the faster the driver's heart rate will also be.

Section III: Project Goals and Methodology

Relevance/Significance

It is not 100% known if music affects how an individual drives (Brodsky, 2002). Because music is not known to affect driving performance, listening to music could increase the risk of getting into car crashes depending on the type of music listened to, but it is not taken into consideration by most

individuals. If this relationship is established, recommendations could be made about which types of music are least beneficial to listen to while driving, which could then be shared with radio companies so they can change what type of music is played on the radio.

Innovation

Past studies such as the one conducted by Chepenik et al in 2007 examined the relationship between tone of music and speed of the car. However, the speed of the music has not been frequently taken into account. This study looks to focus on the relationship between the tempo of music and speed of the car instead of the tone of the music and speed of the car.

Methodology

Participants will be randomly assigned to one of three different groups, each with their own conditions. The first condition will involve the driver listening to music with a tempo of 70 BPM or less. The second will involve the participant listening to music with a tempo of 70 BPM or greater. The third will not involve the participant listening to music. Each participant will drive in the simulator for 30 minutes to music depending on the group that they have been assigned to.

Speed of the car in the simulation and heart rate will be measured during the experiment.

Specific Aim #1:

Determine the relationship between the tempo of a song and the speed of the car while a song is being played. The objective is to determine if the pace of a song causes the driver to drive faster or slower than if the driver is not listening to a song. Our approach (methodology) is to divide participants into three independent groups. Each group will drive in a driving simulator using the same program. One group will listen to songs with a tempo of greater than 70 BPM, a second will listen to songs with a tempo of less than 70 BPM, and a third will be a control group that does not listen to music. Our

rationale for this approach is that this approach provides a controlled environment for the drivers to drive in, and gives us a baseline to test each experimental group with.

Justification and Feasibility. Since driving with music is being tested as a distractor, it is unsafe to test this in actual driving conditions. Therefore, it was decided that using a simulator was an ideal environment to test in, since the driver can still drive similarly to a normal vehicle, but at the same time eliminates most risks of using an actual motor vehicle to test. In previous studies, such as a study conducted by Brodsky in 2002, significant results were obtained in a similar method to this, including having participants all drive in a simulation in the City of Chicago while listening to music (Brodsky, 2002). However, other studies were unable to determine if auditory stimuli had a significant effect on how a driver performs in a motor vehicle (Welz, 2020). Conditions from experiments could be combined and replicated in this current experiment to see if significant results can be obtained for the experiment that did not produce significant results in the past.

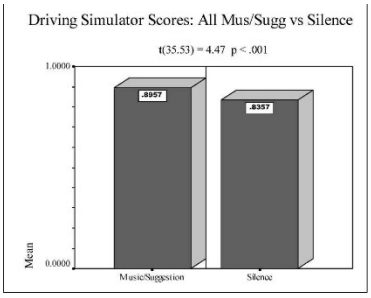

Figure 1: In a study conducted by Groene & Barrett in 2012, participants were given scores for correct driving maneuvers. This graph represents the mean score drivers received for correct defensive maneuvers during each treatment. As seen, the mean driving score was higher during the music/suggestion condition, and the p-value for obtaining these results was less than .001 (Groene & Barrett, 2012).

Summary of Preliminary Data: A preliminary experiment was conducted in which a participant first drove to High BPM music in a driving simulator and then drove to low BPM music in the same driving simulator. Using a two-sample t-test, the mean speeds of the car in each condition were compared. A p-value of p=2.22*10^-4 (a = 0.05) was found, suggesting that there is a significant difference in speeds between driving with high BPM music and low BPM music.

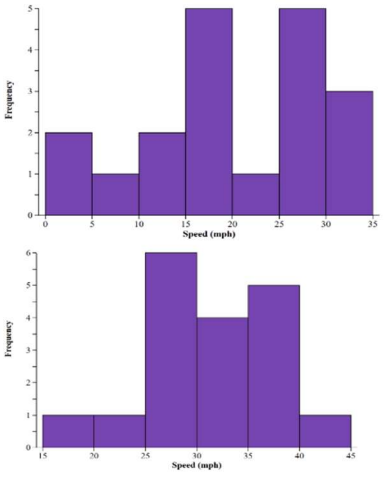

Figure 1B: Histograms of the speeds collected in each musical condition of the preliminary experiment. The lowest speed of the condition of low BPM music is about 15 mph less than the lowest speed collected during the high BPM condition, which could already suggest an overall difference in speeds when driving to each type of music.

Expected Outcomes. The overall outcome of this aim is to see if the pace of a song can cause a significant difference in the speed of the car. This knowledge will be used to make recommendations for music to play on the radio. If a relationship can be discovered between music and car speed, this could suggest that certain songs are less safe to play on the radio than others.

Figure 2: Example of a driving simulator. NOTE: this is not the same driving simulator that will be used to conduct this experiment, merely an example (Shirani et. al., 2024).

Potential Pitfalls and Alternative Strategies. We expect that some subjects may be overcome with "simulator sickness", in which their body becomes disoriented between not moving in the simulator and the expected movement caused by the simulator. Participants may experience dizziness, nausea, headaches, vomiting, etc (similar to motion sickness). (*Simulator Sickness | Carnetsoft Driving Simulator,* 2017). Participants will be asked beforehand if they are prone to motion sickness, and risks of obtaining simulator sickness will be discussed before participants begin the experiment.

Specific Aim #2:

Determine the relationship between the pace of music and heart rate. The objective is to determine if the tempo of music influences an individual's heart rate. Our approach (methodology) is to have participants wear an ECG while in the simulator and record average heart rate for the participant for the duration of the time they were in the simulator. Our rationale for this approach is that if music affects how someone drives, it must also affect other aspects while the music is being played. Taking these readings while the participant drives in the simulator allows data values to be collected simultaneously.

Justification and Feasibility. In this experiment, it is hypothesized that music affects how one drives. This may also affect other factors within the individual. Other studies have looked at factors such as galvanic skin response (Groene & Barrett, 2012). However, due to times constraints and feasibility, it makes sense to look at heart rate during the different conditions, since this can be widely interpreted with minimal difficulty.

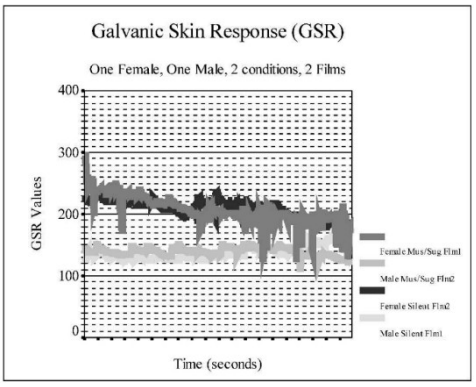

Figure 2: Figure 2 shows factors like the Galvanic Skin Response while driving to different connotations of music. In this graph, the first participant has a decreasing GSR rate for the different conditions in the study, and the other subject maintains cinstant GSR rates. (Groene & Barrett, 2012).

Expected Outcomes. The overall outcome of this aim is to determine if music affects the processes of an individual. This knowledge will be used to see how music affects an individual overall.

Potential Pitfalls and Alternative Strategies. We expect individuals do not normally wear heart rate monitors while driving, so this could influence results. However, participants will be warned beforehand that they will be asked to wear one of these monitors to take away some of the shock effect produced by having to wear the monitor.

Section IV: Resources/Equipment

A driving simulator will be used to ensure the safety of participants while performing the experiment. The simulator is being provided by the University of Connecticut in Storrs, Connecticut.

An EMG reader will also be used to read heart rate during the experiment.

The programs *City Driving* and *Asetto Corsa* will be used to perform the experiment. These are programs provided through the video game program *Steam.*

Section V: Ethical Considerations

Participants could develop a sort of "simulator sickness" while driving in a driving simulator, due to the disorientation caused the screen moving and the lack of expected movement that the participant has in the simulator. It has been found that younger people are more immune to this "simulator sickness", leading to them being better candidates for this study (Simulator Sickness | Carnetsoft Driving Simulator, 2017). Participants with licenses and permits will be preferred for this study, since they have had some previous driving experience.

Section VI: Timeline

Phase 1 - Research/Brainstorming

Pie charts & Mind Maps: 6/14-9/6

10 articles in project notes: 8/18-9/30

Add 2 patents to project notes: 10/1-10/7

10 additional articles to project notes: 10/22-12/5

Phase 2 - Pre-Planning/Mentor Finding

Communication to mentor: 10/3-10/10

Meeting w/ Dr. Jackson: 10/23

Resource gathering for simulator: 10/24-11/15

Simulator set-up at MAMS: 11/1-11/30

Deciding on music to use for experiment: 10/28-12/2

Methodology write-up: 10/29-12/2

Phase 3 - Data Collection

Gather participants: 11/2-12/12

Prelim data: 11/3-12/10

Condition 1 data collection: 11/15-12/15

Condition 2 Data Collection: 11/18-12/18

Control Group Data Collection: 11/21-12/21

Phase 4 - Analysis & Final Touches

Data analysis: 12/22-1/2

STEM Thesis: 1/1-2/28

Put presentation together: 12/1-2/5

Practice Presentation: 12/1-2/20

Section VII: Appendix

Section VIII: References

Brodsky, W. (2002). The effects of music tempo on simulated driving performance and vehicular control. Transportation Research Part F, 4(4), 219–241. https://doi.org/10.1016/S1369-8478(01)00025-0

Chepenik, L.G., Cornew, L.A., Farah, M.J., 2007. The influence of sad mood on cognition. Emotion 7(4), 802–811. DOI: 10.1037/1528-3542.7.4.802

Dalla Bella, S., Peretz, I., Rousseau, L., & Gosselin, N. (2001). A developmental study of the affective value of tempo and mode in music. Cognition, 80(3), B1–B10. https://doi.org/10.1016/s0010-0277(00)00136-0

Ghojazadeh, M., Farhoudi, M., Rezaei, M., Rahnemayan, S., Narimani, M., & Sadeghi-Bazargani, H. (2023). Effect of music on driving performance and physiological and psychological indicators: A systematic review and meta-analysis study. Health Promotion Perspectives, 13(4), 267–279. https://doi.org/10.34172/hpp.2023.32

Groene, R., & Barrett, S. (2012). The Effect of Music and Suggestion on Defensive Driving Responses of High School Students: Implications for Music Therapy. Music Therapy Perspectives, 30(1), 56–64. https://doi.org/10.1093/mtp/30.1.56

Iwamiya, S. (1997). Interaction between auditory and visual processing in car audio: simulation experiment using video reproduction. Applied Human Science, 16(3), 115-119.

Pecher, C., Lemercier, C., & Cellier, J. M. (2009). Emotions drive attention: Effect on driver's behaviour. Safety Science, 47(9), 1254–1259. https://doi.org/10.1016/j.ssci.2009.03.011

Shirani, N., Song, Y., Wang, K., & Jackson, E. (2024). Evaluation of Driver Reaction to Disengagement of Advanced Driver Assistance System with Different Warning Systems While Driving Under Various Distractions. Transportation Research Record, 0(0). https://doi.org/10.1177/03611981241252789

Simulator sickness | Carnetsoft Driving Simulator. (2017, May 5). Carnetsoft Car Driving Simulator for Training, Assessment and Research; Carnetsoft BV. https://cs-driving-simulator.com/simulator-sickness/

Welz, W., S. Voelter-Mahlknecht, C. Große-Siestrup, and G. Preuß. (2020). The Influence of Different Auditory Stimuli on Attentiveness and Responsiveness in Road Traffic in Simulated Traffic Situations. International Journal of Environmental Research and Public Health, 17(24) https://doi.org/10.3390/ijerph17249226