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The Effect of Increasing Music Volume on Reaction Time

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The purpose of this study was to investigate the impact that music volume has on reaction time. The significance of this study is that music volume is often suggested to be one of the factors and/or distractions that lead young drivers under the age of 25 to experience a high rate of vehicular accidents, and the goal of this study was to quantitatively assess the effect of increasing music volume on the reaction time of subjects in this demographic. Tactile reaction time, using the Brain Gauge, was used to record simple reaction time and choice reaction time data for 20 college students while the Neil Diamond classic "Sweet Caroline" was played at approximately 0dB, 20dB, 40dB, and 80dB. The results demonstrate a significant increase in simple reaction time with increased music volume and shows that louder music impacts an individual's capacity to react to a stimulus. Although the study was not conducted while the individual was driving, the results strongly suggest that high music volume could significantly impair a driver's response time.

Citation

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Introduction

With more than 90% of American drivers listening to music while operating a vehicle, the distraction level of music volume is an important factor in safe driving. Statistical data has shown that drivers between the ages of 16-24 account for a high level of severe vehicular accidents, with several factors contributing to this problem [1]. Obviously, the inexperienced nature of younger drivers plays a role in reckless driving, as does the behavior of the driver. Distractions including the radio and cell phones have caused accidents in this group at alarmingly high rates, with cell phones quadrupling the risk of collision [2]. While cell phones pose a larger risk to safe driving than the radio does, few studies have fully explored the effect that various music volumes can have on a subject's reaction time.

Music has been around since the formation of language, and great complexities exist within music due to the wide variety of instruments, cultures, and emotions that music encompasses. The brain processes auditory signals in the auditory cortex of the brain which is found within the temporal lobes. As an overview, the musical stimuli reaches the cochlea which separates the music into individual signals and transmits the information through the auditory nerve to the brain [3]. Musical perception involves the perception of temporal processes which allows the timing of music to impact the internal tempo. As a result, drivers listening to high tempo music are more likely to exhibit reckless driving by speeding [1].

Background music is considered to be any music played at a volume below 40 dB, and it has been known to improve the reaction time of subjects. Studies have indicated that both auditory reaction time and visual reaction time decrease in the presence of background music due to the facilitation of processing the stimuli in the somatosensory cortex. One particular study investigated the effect that music genre has on reaction time, and proved that vocal music is significantly more disruptive than instrumental music [4].

While music has proven beneficial for multiple activities such as learning, this study hypothesizes that increased music volume will slow the reaction time of subjects under the age of 25. Loud music is pre-determined to be dangerous when driving as it can cause increased heart rate and distract the driver from important road sounds such as sirens or honking of horns [5]. A slowed reaction time whilst driving is dangerous, so the degree to which the reaction time changes is important in determining whether music has a significant impact on a young driver's ability to respond to a stimulus.

Methods

Participants

With younger drivers accounting for a high level of accidents, a group of college-aged students is selected as the subject pool. In the United States, drivers under the age of 25 are considered young drivers according to insurance companies. With this clarification, the study was further restricted to students meeting this criterion. A sample size of 20 individuals between the ages of 21 and 25 was selected for the study. Within this group, 11 subjects were male and 9 subjects were female. The group reported familiarity with the chosen song, "Sweet Caroline" by Neil Diamond, with an average of 3.9/5 on a familiarity scale, 5 being "extremely familiar".

Apparatus

The apparatus used for this experiment is the Brain Gauge (Cortical Metrics, Chapel Hill, NC), a cognitive assessment tool that was used to stimulate and record reaction time via the fingertips [6]. The device delivers a vibrotactile stimulus to digits 2 and 3 during the stimulus phase and is a response device during the response phase. For this experiment, reaction time and choice reaction time were recorded for each subject while listening to various volumes of the same song.

Reaction time is one of the best measures used to assess the speed of information transfer through the central nervous system (CNS) [7]. To record reaction time, the device delivers a stimulus to the third digit, and the subject responds by clicking the button of the second digit as quickly as possible. The Brain Gauge device also measures reaction time variability for both tests in this experiment. Reaction time variability is a measure of focus, or the brain's ability to concentrate on the task at hand, since increased variability within a trial demonstrates a lack of consistency in reaction time results. The Brain Gauge has demonstrated that reaction time variability is a better measure of focus than simple reaction time through trials with individuals in concussion and ADHD studies [6].

Choice reaction time is a more complex test that presents the subject with a choice. A stimulus is delivered to one of the digits, and, as quickly as possible, the subject must tap with the digit that was stimulated. The administered stimulus is randomly varied by the Brain Gauge device to ensure the subject is not capable of predicting the location of the stimulus. In both reaction time and choice reaction time tests, the period of time between stimuli is randomized (2 -7 seconds) and the severity of the stimuli decreases as the trial proceeds [8].

Procedures

All testing was done remotely and each subject performed the procedure on different Brain Gauge devices, but the test battery remained constant. A set of instructions accompanied with a survey for qualitative data accumulation were distributed to the tested individuals. Subjects were instructed to take the survey prior to completing the Brain Gauge procedure. A number was randomly assigned to each subject, and the procedure varied based on whether that number is even or odd.

Per the instructions, each subject sat at a table or desk in a quiet environment with the Brain Gauge on a flat surface. For the first trial, each subject completed the reaction time and choice reaction time tests with no musical stimulus. The subsequent trials instructed the subject to play the song “Sweet Caroline” by Neil Diamond at various volumes. This song was chosen to alleviate the factor of familiarity as all subjects were familiar with the tune. Subjects were restricted to using an apple iPhone to play the music at full speaker volume (74dB), ½ speaker volume (37dB), and ¼ speaker volume (18.5dB). To ensure the results of this experiment were not impacted by the learning effect, half of the subjects started with low volume and increased it with each test session while the other half started at full volume and decreased it with each test session.

Results

The reaction times for n=20 subjects across all 4 trials displayed an overall increase as the music volume increased. Fluctuations occurred amongst consecutive trials, yet all subjects showed a longer (slower) reaction time while listening to music as opposed to no music. This alone is a clear indicator of the effect music volume has on the reaction time of a subject.

Figure 1 shows the average reaction time increases as music volume increases by 36.63ms as the music volume increases from 0dB to 74dB. The average reaction time for the subject pool in a low distraction environment with no music is 229.72ms which is in agreement with the accepted values for young adult response time. Over the span of 74dB of music, reaction time increased, on average, by 16%. This is a notable increase in reaction time to tactile stimuli, even more so because visual and auditory reaction times are slower than tactile reaction time. A strong linear relationship is present in Figure 1 (note linear regression) indicative of a direct relationship between music volume and reaction time.

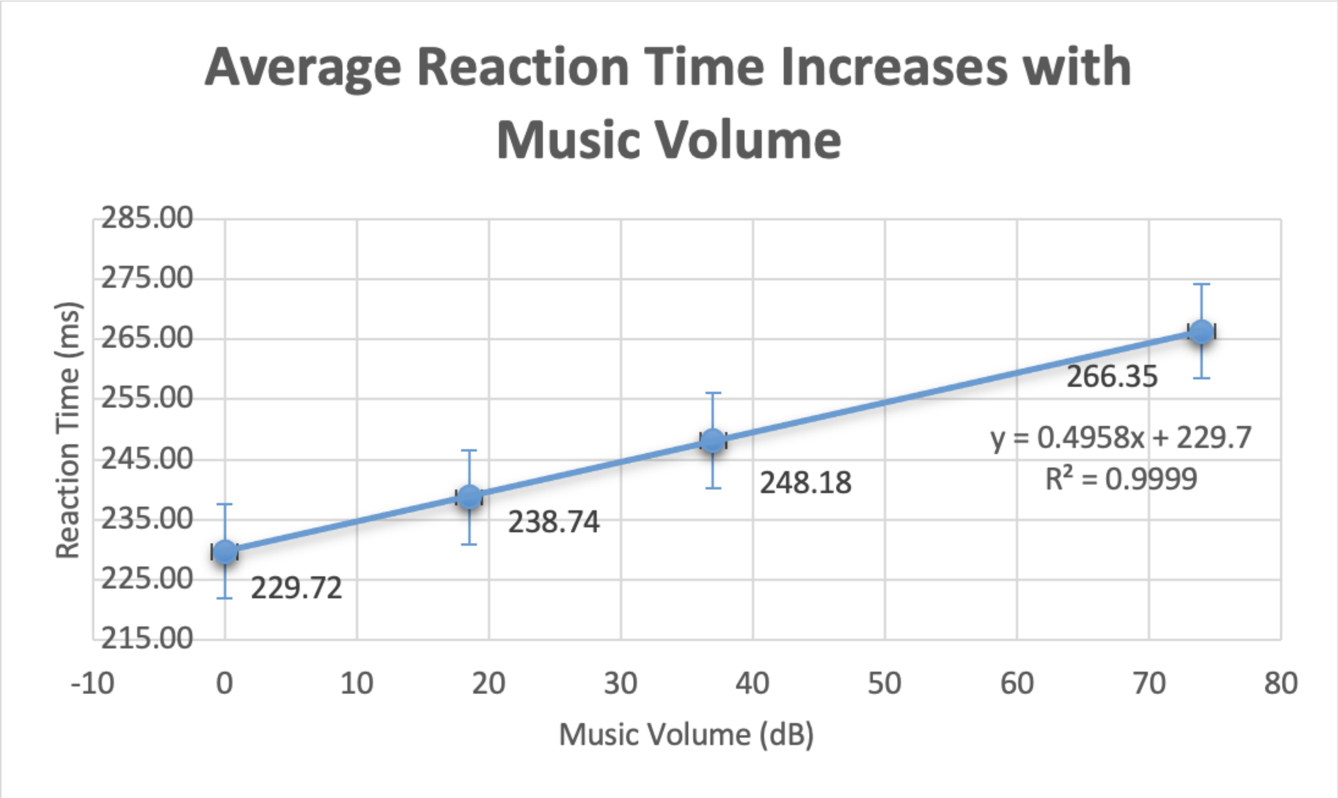

Figure 1. *The average of the reaction time in milliseconds for all subjects (n = 20) shows an increase with music volume in decibels. An overall increase of 36.63ms for the range of 0-74dB of music shows a linear relationship between music volume and average reaction time.*

Further analysis of the reaction time data was conducted to establish the significance of the collected data. A statistical Z-test was performed to establish the corresponding p-value, with a null hypothesis of no correlation between music volume and reaction time. The p-value is the probability that the hypothesis was falsely rejected, so a p-value less than 0.05 provides statistically significant evidence of a relationship between the music volume and the slowed reaction time. The p-value for low volume music compared to no music is 0.108, so the change in reaction time cannot be linked to music volume at this volume level. Conversely, the calculated p-values for the medium and high volume music proved statistically significant at 0.010 and 0.002, respectively. As a result, the null hypothesis of no relationship between music volume and reaction time is rejected.

Figure 2 shows the average reaction time data separated by gender. The subject pool (n=20) is comprised of 11 male subjects and 9 female subjects. The average reaction time under no musical stimulus is greater in the female group by more than 14 ms. Additionally, the female group demonstrates a greater increase in reaction time with increases in music volume than the male counterpart. The overall increase in average reaction time over the 74dB range of music is approximately 40ms for the females and 20ms for the males, suggesting that females are more susceptible to delayed responses in the presence of loud music.

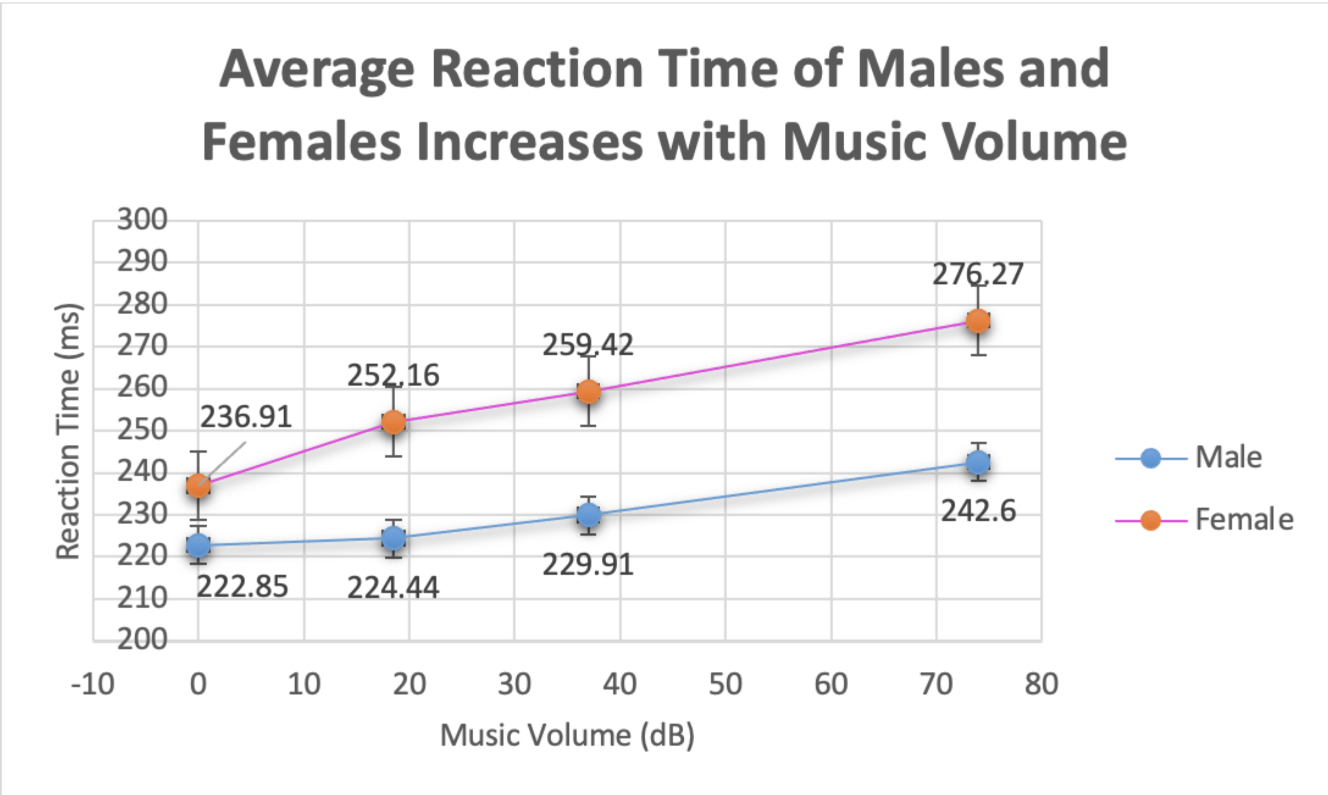

Figure 2. *Average female reaction time increases twice as much as the average male reaction time with increasing music volume.*

The reaction time variability was analyzed to ascertain the effect music volume has on the subject pool’s ability to focus. As seen in Figure 3, the average reaction time variability fluctuates with music volume with a relativaley major increase at the high volume of music. This apparent spike in reaction time variability with increased music volume is evident of young driver’s impaifed ability to focus at high volume levels.

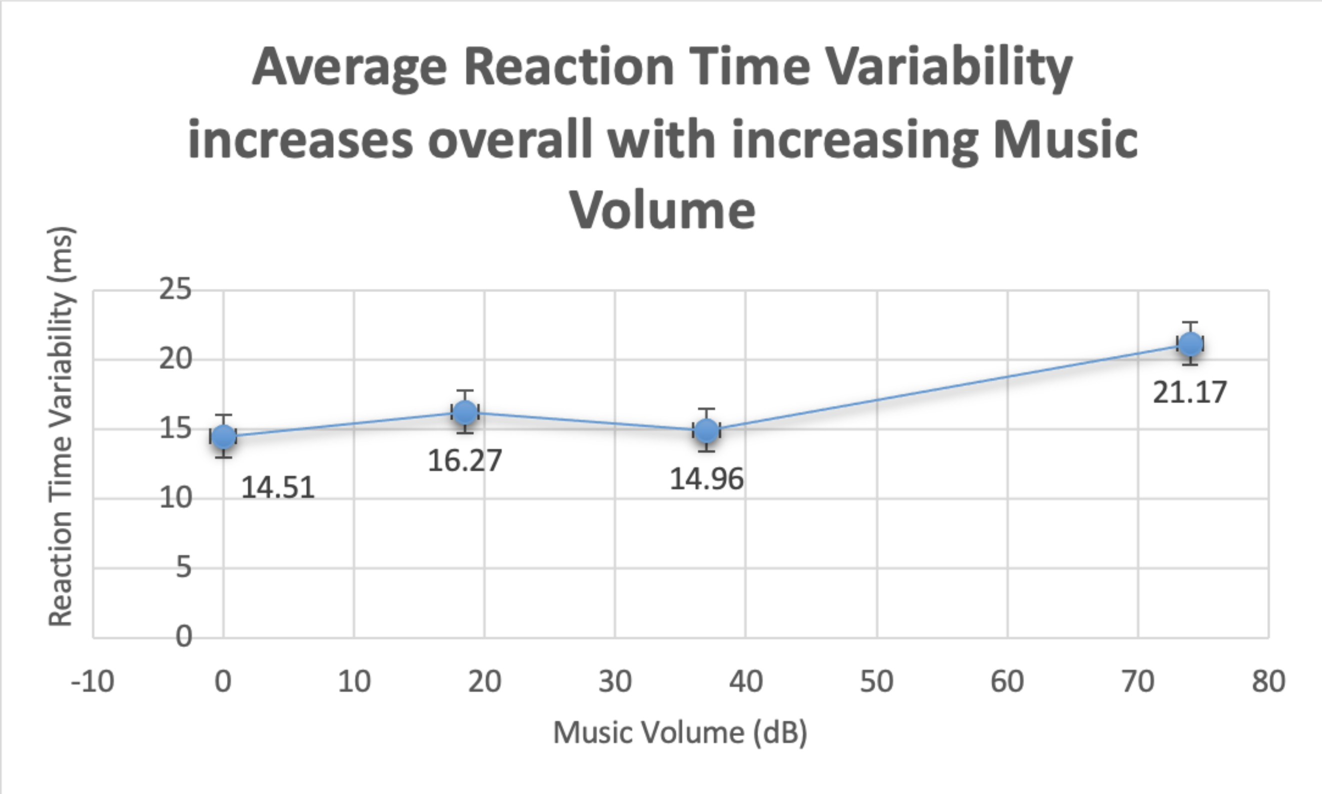

Figure 3. *The average reaction time variability is relatively stable at low and medium volumes, with an increase at the high volume level.*

While the average reaction time shows a strong direct relationship with increasing music volume, the average choice reaction time amongst the subject pool does not exhibit a relationship with music volume as seen in Figure 4. The normative choice reaction time for subjects under the age of 25 is generally between 350-400ms. All average choice reaction times amongst the subject pool are within this range, so no relationship between music volume and choice reaction time can be inferred.

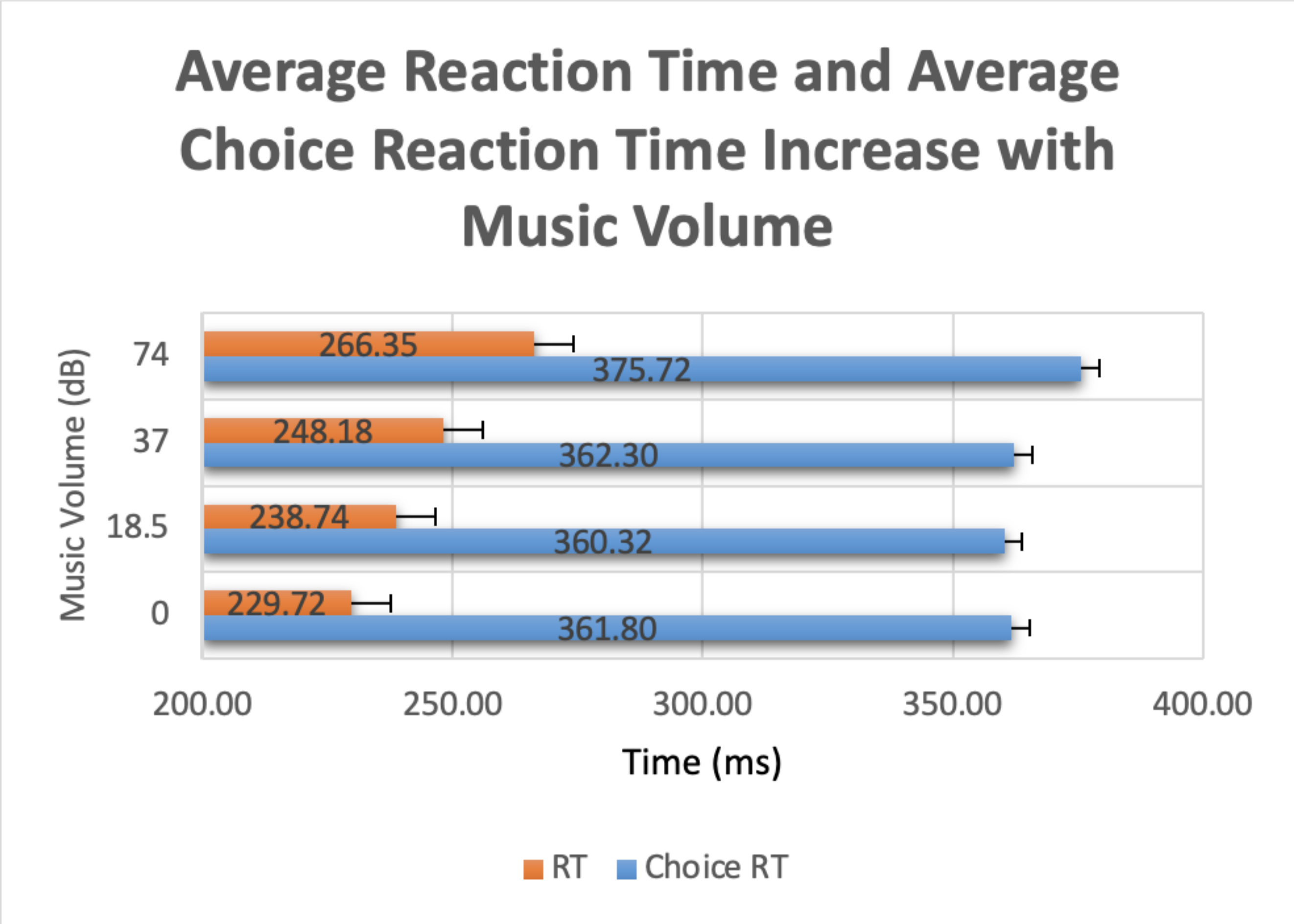

Figure 4. *The average reaction time increases with music volume while the average choice reaction time displays no distinct pattern with volume.*

The qualitative results of the pre-experiment survey pertained to the subject's identity (gender, age) and music affinity. The survey particularly asked "What genre of music do you listen to most often while driving?" to gauge the diversity of music taste within the group while remaining relevant to the application of young drivers. As seen in Figure 5, multiple genres are popular amongst the subject pool. It is noteworthy that the genre of the chosen song "Sweet Caroline" by Neil Diamond is "soft rock", yet 0 subjects reported listening to rock music whilst operating a motor vehicle.

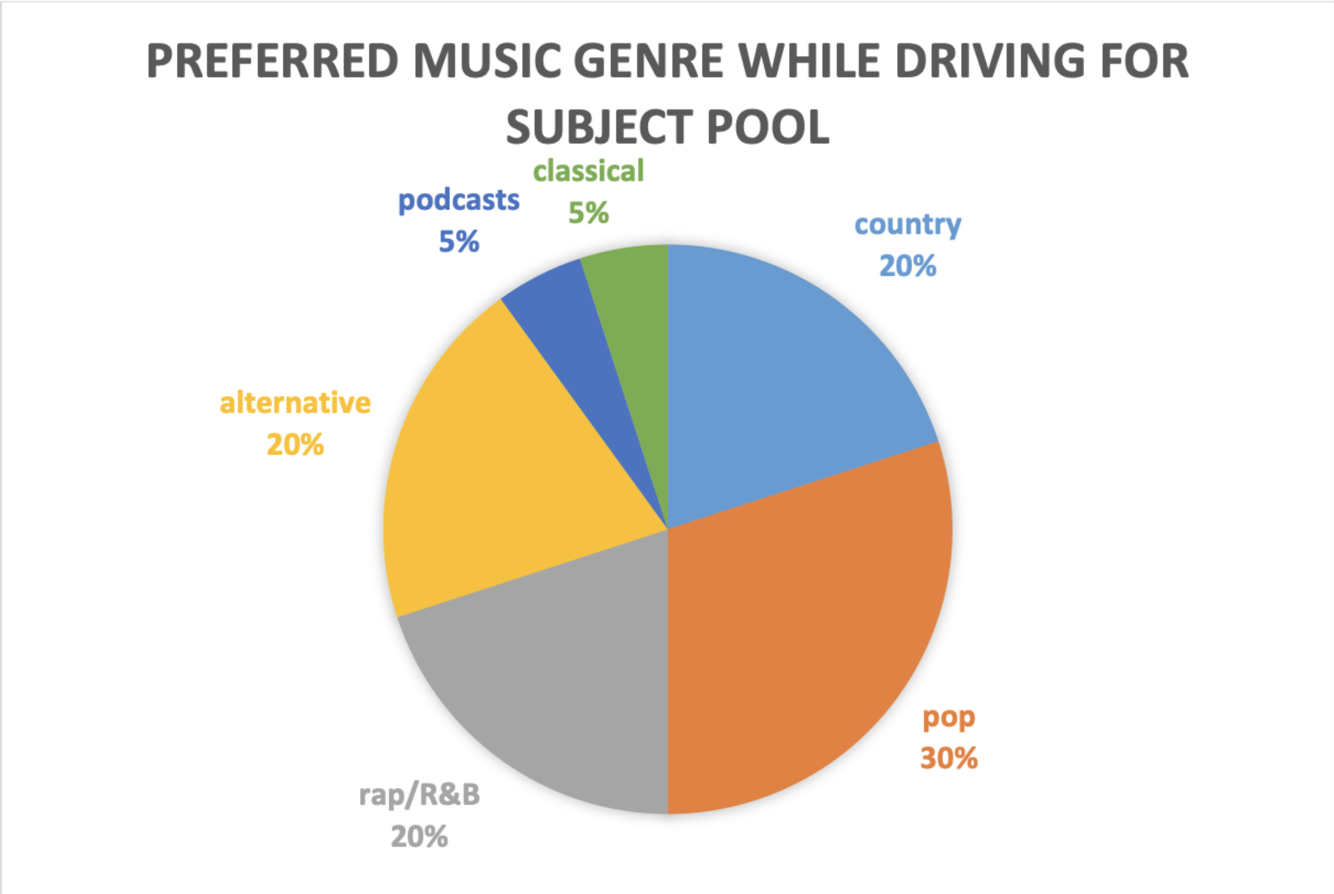

Figure 5. *Pre-experiment survey results demonstrated a diverse taste in music amongst the subject pool.*

Discussion

In this study, sensory metrics were acquired for 20 individuals. Reaction time and choice reaction time for each subject at 4 levels of music volume were obtained using the previously described Brain Gauge device. A pre-experiment survey was also conducted amongst the subject pool to gather information on each subject and his or her musical habits. In-depth analysis of the data yielded multiple significant findings indicative of the negative effects music volume has on the reaction time of young drivers.

A broad analysis of the average reaction time data for n=20 reveals a direct relationship between music volume and reaction time. As seen in Figure 1, the reaction time increases in a linear fashion as the music volume is increased from 0dB to 74dB. The presence of music stimulates the brain, and effectively delays the transfer of information through the central nervous system, resulting in a higher reaction time. As the musical stimulus increases in volume, the reaction time increases as well since the subject takes more time to process and respond to the tactile stimulus.

The reaction time data was further analyzed with subjects divided into groups based on gender and music affinity. No apparent pattern was identified in the reaction time data by subject preferred music genre. The reaction time data did differ by gender, as shown in figure 2. The female group reported higher reaction times than their male counterpart at all music volumes, 0-74dB. This is in accordance with previous studies that evaluate the differing reaction times of men and women [9]. The male group showed smaller reaction time increments between volume levels as well with the overall increase totaling nearly 20ms as compared to the female group’s 40ms increase. While the slower reaction time of women is well-documented, the increased effect of music volume on women as opposed to men has yet to be fully assessed. The results of this study suggest that women could be more susceptible to unsafe driving than men at high volumes of music based on the reaction time data.

The focus of the subject pool was studied via the reaction time variability. As seen in Figure 3, there is not a clear relationship between reaction time and music volume at lower volumes. There is, however, a notable increase in reaction time variability as the music is increased from 37dB to 74dB. Increased reaction time variability is evident of decreased focus. While statistically significant conclusions cannot be drawn from reaction time variability data, Figure 3 suggests that focus will continually decrease as the volume is increased past 74dB.

Like the reaction time variability, the choice reaction time minimally fluctuates at lower volumes with a notable increase at the high volume (74dB) as seen in Figure 4. The choice reaction time is slower than the simple reaction time as explained by Hick's Law [10]. As the number of choices increase, the resulting time is slowed since the brain must process all of the choices, and make a decision accordingly. Simple reaction time does not involve decision making or the interpretation of stimuli. Choice reaction time is also governed by the speed-accuracy trade-off which indicates that a subject may forgo accuracy to obtain a faster reaction time or vice versa [11].

This study serves as a general overview of the effect music volume has on the reaction time of young drivers. Future studies can build off of the conclusions made here to investigate other factors of music and the resulting effect on reaction time. Using Figure 5 as a guide, an exploration into how various genres affect the reaction time of young drivers could yield interesting results. Additionally, the simulation of driving could be improved upon with the integration of background sounds such as sirens or horns.

As the original intent of this study is to evaluate the effect of music volume on the reaction time of young drivers, the main conclusion of this report is the statistically significant direct relationship between music volume and simple reaction time. A limiting factor in this study is the use of the iPhone for speaker volume as the music source in a car can exceed 100dB on average. This makes the results of this study increasingly alarming as the obtained data proves increased music volume yields slower reaction times in people under the age of 25, and this could present a problem for safe driving as the delayed reaction time of drivers can mean the difference between life and death when operating a motor vehicle.

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