INTELLIGENT MUSIC SELECTION TO INFLUENCE DRIVER BEHAVIOUR

An Empirical Study

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Keywords: Music perception, Music cognition, Utility music, Functional music, Driver behaviour.

Abstract: There is a belief that driving competency and style is influenced by music choices, yet there is little scientific study into the effects music choices have on the way people drive. This paper describes a preliminary explorative study conducted to find evidence of music influencing driving behaviour to justify further research into the area. Three main effects were considered in this study: 1) that music either enhances or impedes the driving activity; 2) that driving behaviour is influenced by whether the subject likes the music being played; 3) that driving behaviour is changed by the tempo of the music being played. The speed holding ability of 39 experienced drivers employed in a large company was tested using a vehicle simulator to observe evidence that speed holding control is influenced by one or more of the main effects.

1 INTRODUCTION

Audio entertainment is a prevalent activity in vehicles that accompanies driving and is almost as old as the automotive industry itself, dating back to 1930. Nowadays, it is hard to imagine vehicles without factory installed entertainment options, such as radios and CD players. Furthermore, automakers are constantly seeking ways to improve vehicle entertainment offerings to keep up with advancements in consumer electronics and consider this area an important aspect of product differentiation and competitive advantage.

There are many audio entertainment options including news, talk shows, books on tape, foreign language tutorials, and of course music. From this set of options, music is probably the most common audio activity in vehicles, especially among younger drivers. Therefore, the focus of this paper and associated project will be on music even though the concepts developed could apply and be extended to other audio options, like the news.

It is believed that music may significantly influence driving performance and safety. In fact, music as well as other forms of entertainment may serve as a remedy against boredom and driver fatigue during long and/or repetitive drives. On the other hand, music is rarely cited as a source of distraction (Bayly 2008).

Experimental psychology offers a compelling argument that there is a strong relationship between music, the listening situation, and arousal (a state of heightened physiological activity), and the performance of the accompanying task. In this case, the listening situation refers to the driving environment. It is also known that drivers often instinctively regulate music based on the driving situation; playing high tempo loud music on an empty highway to fight boredom, and turning the volume down while performing a difficult manoeuvre in congested urban traffic (Dibben, 2007). If the car music system can sense the environment and automatically select the most appropriate music for the given condition it might improve driving performance and safety while enhancing the music listening experience.

In recent years there have been significant advancements in three relevant areas that make the development of such a system possible.

Digital Music - The rise of digital music enabled instantaneous access to a vast variety of the musical choices. First of all, MP3 players, such as the iPod, allow storage and direct access to thousands of user owned songs and provide a variety of ways to arrange, on the fly, the music being played. Music played can be selected by artist, genre, playlist, random shuffle, or user-defined tags, such as mood, without the need of changing CDs or tapes. More

MacNeille P., Theisen K. and Gusikhin O..
INTELLIGENT MUSIC SELECTION TO INFLUENCE DRIVER BEHAVIOUR - An Empirical Study.
DOI: 10.5220/0003687800830090
In *Proceedings of the 8th International Conference on Informatics in Control, Automation and Robotics* (ICINCO-2011), pages 83-90
ISBN: 978-989-8425-75-1

recently, access to music has been further expanded by the introduction of mobile internet music players, such as the Slacker mobile player and iPhone applications of Pandora and LastFM. These players can tap into virtually unlimited internet musical collections using 3G networks or Wi-Fi, allowing for high control over music selection. As a result music could be used to achieve very specific ends in very specific circumstances.

Vehicle Sensory, Navigation and Traffic Information - The rapid growth of the number and quality of vehicle sensors allows reliable identification of the driving situation, and bio-physical state and emotions of the driver. Furthermore, with the proliferation of navigation and traffic information services we can identify not only the current driving conditions but also the upcoming driving environment. This would allow for upfront planning of the next music choice.

Advances in the Music Knowledge Methods and Tools - MP3 players allow for music selection guidance using MP3 ID3 tags. Selection based on these tags is either limited to editorial data, such as artist and genre, or requires the daunting task of organizing the entire music collection into special purpose playlists or tagging each individual song. Recognizing the need for a more elaborative music selection and fuelled by the digital music technology and web 2.0 phenomenons there has been significant growth in internet-based music services in the last decade. These services are a class of recommender systems that allow organization and selection of music by different qualitative criteria far beyond simply genre and artist. These services range from playlist generation and automatic tagging of privately owned digital music to personalized internet radio stations. The core of these services is a knowledge base comprised of an extensive musical catalogue. Different services exploit information in the knowledge base in different ways to customize music selections for individual listeners. Methods used range from collaborative filtering or tagging by the listener community to elaborate annotations by professional musicologists regarding the qualitative features of a song from its digital properties. As a result, the availability of such music knowledge enables music classification based on the anticipated cognitive response and appropriateness for different driving environments.

These advances create promise for a system that can automatically select the next music piece that is most appropriate for the given driving environment and influence desirable driver behaviour. In order to accomplish this task one of the main questions is, how does the music influence driving behaviour? In this paper we report the results of the preliminary study to explore such an influence based on the different types of music.

This paper is organized as follows. The next section presents a review of the current state-of-the-art in music knowledge methods and tools, and reviews the products that explore this knowledge to provide personalized music recommendations or even a music station. Section 3 describes the experiment and section 4 reviews the results. Finally, the paper will conclude with summary and future research recommendations.

2 MUSIC RECOMMENDATION TECHNOLOGIES

Up until now people have had two main options for car entertainment: broadcast based (radio) and private selection based (MP3, CD, etc.). With the broadcast based option listeners get to listen to new and unexpected songs. To contrast this, private owned collections provide the ability to listen to music that the listeners own and thus presumably like. In addition, they can listen to certain songs whenever they like, however this option lacks the excitement of new and unexpected music. iPod Shuffle was an attempt to somewhat remedy this issue by randomly picking songs from a private collection. This technique of random music selection can be considered one of the first music recommendation techniques.

In the last few years there has been tremendous internet-based growth of personalized musical services dubbed Music 2.0 similar to Web 2.0. These services attempt to capture personal musical preferences of the given listener through interactive voting and try to offer musical choices that correspond to their musical tastes. Some of these services organize the personal music library in playlists according to given criteria, some select music from the personal collection on the fly, and some work as internet radio. In the case of personal internet radio the stations provide an interactive capability to tailor the station to the user's personal preferences by skipping a song, banning certain songs, or expressing that they really like a song. Personalized Internet music services, such as Last.fm, Musicovery, or Pandora, take the listening experience to a whole new level by allowing users to create their own personalized radio stations and music experience instead of simply listening to what the station chooses to webcast.

Last.fm (http://www.last.fm/) uses collaborative filtering to recommend music you might like. Collaborative filtering works by keeping track of songs the user likes and listens to and is based on the assumption that the musical taste of the specific listener can be matched against the community. Last.fm uses what they refer to as Scrobbling to keep track of the music you listen to for use with collaborative filtering techniques and to chart popular music. One of the drawbacks of collaborative filtering is that it only works well with popular songs because songs lesser known might not have substantial data. Another problem with this approach is that it does not take into account the structure of the song.

Musicovery (http://musicovery.com/) allows users to intuitively find music based on their mood and preferences for different genres and time periods. This is accomplished through a graphical interface based on Liveplasma technology and the "mood pad". Forty musical parameters are used to describe each song and place it on the mood pad according to the likeliness that the song will please the user according to their selected mood. Mood is selected on a two dimensional scale with the y axis ranging from calm to energetic and the x axis ranging from dark to positive.

Pandora (http://www.pandora.com/) bases its music recommendation on the Music Genome Project. The Music Genome is a database of songs where each song is described by a set of characteristics. Each characteristic is referred to as a gene and different songs have different numbers of genes. For example, a rock song may have 150 genes while a classical song may have 500 genes. These genes are collected into logical groups called chromosomes and a set of chromosomes make up a genome. Musicologists carefully classify each song in the database by this method so that songs can be compared on the basis of their genes taking into account that some genes are more important than others.

Listeners can tune into a currently playing station or create their own personalized station. Stations are started by entering the name of a song, artist, or album which is referred to as the seed of the station. This seed is then examined to determine which distinguishing aspects of a song are present in its genome and populate the station with songs with similar features. While listening to music users can provide feedback regarding whether or not they like a selected song. Future music selections use this feedback to refine the importance of each gene to an individual listener.

Users can listen to Pandora online or on the go with Pandora mobile. In the last two years Pandora has been integrated into many telematics systems and constitutes a popular vehicle infotainment option.

In general Internet music stations provide listeners with music they like based on feedback from the listener. They usually allow users to create multiple stations based on specific music features, such as an artist or genre. Users can switch between multiple stations or allow the system to switch for them through a random shuffle mode, such as Pandora mix mode. Since this shuffle is random, these systems do not take into account the listeners environment.

More recently products are being developed which include music selection based on the user's current environment and personal context.

Nike+ is one example, which is currently widely available to consumers. This system has users place a sensor in the bottom of their running shoe that keeps track of each step taken. A user can then choose between using the Nike+ Sportband or their iPod. Either option provides runners with information about their pace, distance, calories burned, and more. After a run, users can log on to the Nike+ webpage and upload information from their run to track their progress, set goals, and connect with other runners.

If paired with an iPod nano, users can create their own personalized playlists to accompany their workouts or download popular workout playlists (referred to as Sport iMixes) from iTunes. US patent 20060107822 A1 filed by Apple claims the capability of affecting a user's mood and behaviour during an activity, such as exercise, by controlling the speed of the music being listened to. The speed of the music can either be selected to match the pace of the activity or to drive the pace of the activity.

In a research context, several universities have projects underway which aim to use Bio feedback to select the music being played. The hypothesis behind these applications is that a user's context affects what they want to listen to. The University of Maryland Baltimore County has developed a concept called XPod which is intended to reside on a PDA (Dornbush, 2007). Once XPod is initiated, a BodyMedia SenseWear device is used to wirelessly transmit data to a server to determine the user's level of activity and emotion. Data collected by the BodyMedia device includes transversal and longitudinal acceleration, galvanic skin response, skin temperature, heat flow, and nearbody temperature. This information is used to determine if the user is in an active, passive, or resting state and is passed to a neural network engine which compares the user's current activity level, state and time to past song preferences to make the next music selection. This selection is then sent back to the client device. Lifetrack and AndroMedia are two additional developments that utilize sensor data to extract contextual information and recommend suitable songs for the current situation.

Based on this discussion it is reasonable to assume that context-aware music selection would be not only possible, but also very beneficial within the driving environment. Modern vehicles already know a lot about drivers and driving conditions (current and upcoming through digital maps) and this information can be used to select a specific song (or station). Following existing research in context-based music selection the vehicle system can learn the preferred music in the given driving conditions. However, it is possible that not only driving environment and conditions influence the music we prefer, but also music influences the driver's behaviour. Thus a more ambitious goal would be to not only select the music preferred for the conditions, but also select the music that can provide a subtle influence on the driver's behaviour.

The next section describes our first attempt to answer the question does music influence driver behaviour and is there some kind of general pattern how it influences behaviour.

3 THE EXPERIMENTAL PROCEDURE

For this study there were 39 subjects, 16 female and 23 males, who were all Ford Motor Company employees with at least 2 years driving experience. The largest age population was 41-50 years old as shown in Figure 1, which differs from many studies based on college aged students. A list of songs was selected from several genres and drivers were asked to select the genre they liked the best and the genre they liked the least. Each driver then drove a simulator without music, with their favourite genre of music, and with their least favourite genre during which their speed and throttle position was monitored. The data was later studied to determine if there was any change in driving behaviour between those three conditions.

Three hypotheses were tested in the experiment. The first that music does influence driving, the second that hearing music you prefer or dislike affects driving and the third that music tempo affects driving.

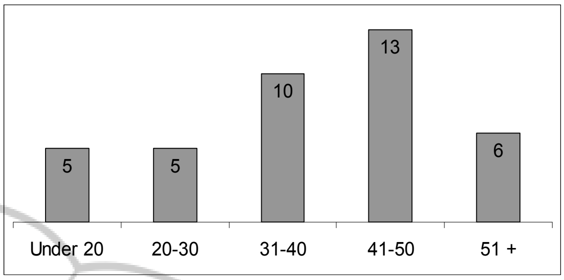

Figure 1: Distribution of ages by categories of study participants.

To test these hypotheses, each of the subjects was brought into a room with a vehicle simulator, and asked to complete a questionnaire about their demographics and musical preferences.

Next the subject was given a driving task. In this task the subject is asked to drive the simulator at an appropriate speed without help from a speedometer. In this way the subject is forced to judge speed on the basis of optical flow rather than watching a speedometer. The course is on a 2-lane one-way road without stop signs or traffic lights with a striped centreline and solid shoulder lines that curve and change altitude. The landscapes surrounding the road are generally rolling hills covered with grass and occasional trees. There are very few other vehicles on the road and the environment is visually sparse. If the subject drives too fast he/she will lose control of the car and skid off the road with the appropriate tire squeal sounds.

The task is fairly difficult for many people, in that many subjects' speed drifted considerably. Because the simulator is not motion-based there are no proprioceptive sensations of movement such as the feeling of lateral acceleration from rounding a curve or the feeling of acceleration or deceleration from applying the throttle or brake respectively.

Each driver was asked to perform this driving task two times: once while listening to their favourite genre of music and once listening to their least favourite. Genre preferences were identified from the questionnaire they answered before realizing they would be driving to their least favourite music. To ensure results were not biased by the order the genre was played, alternate subjects heard their favourite and least favourite genre first. Each run was divided into 6 parts:

1. **The Music is off and the Speedometer is Displayed**. This period from 0-120 seconds was used to get the subject up to normal driving speed and to get adjusted to judging speed on the simulator.

2. **The Music is off and the Speedometer is off**. This period between 120-240 seconds was used to establish a baseline for the subject's speed holding without a speedometer, which was continued throughout the remained of the experiment.

3. **The Music is Turned on at 240 Seconds** with the first song of the chosen genre. Alternate subjects had the songs ordered with increasing tempo or decreasing tempo.

4. **Song 2 is played**

5. **Song 3 is played**

6. **Song 4 is played**

The purpose of this procedure was to look for evidence of 3 main effects: that music influences driving, that the subjects' like or dislike of the music influences driving, or that tempo influences driving.

3.1 The Questionnaire before the Drive

Several questions were asked of drivers before the drive to frame their general disposition about music. The subject's age group was asked because there is considerable evidence that musical preferences are set at particular times in a person's life, and the popular music of that time may influence their lifelong preferences. In our study 24 of the 39 subjects answered "yes" when asked if their current favourite genre is the same now as when they were growing up. This is consistent with the findings of (Mulder et al., 2009) and others who found that music taste is well developed in adolescence and crystallizes in middle age. It was also found that preferred artists may change a lot during a lifetime, but genre preference is much less likely to change and style is by far the most stable.

The selection of genres used for this study was somewhat arbitrary. There are several systems of genre, and the understanding of genre types may differ between individuals to some extent. When asked, 36 of the 39 subjects reported that they felt the songs in the playlist for their favourite genre were representative of that genre.

Pop and Rock were substantially more popular than all other genres (see Figure 2) and Alternative and Electronica were ranked lowest. Pop and Rock are likely the best known and most familiar genres while Alternative and Electronica are less known which may account for their apparent lack of popularity in our study. No attempt was made in this study to find out what were the true preferences of the subjects other than asking them what they like to listen to. Selected questions from the questionnaire include:

1. List the nine genres in order of preference.
2. Is your favourite genre in the list
3. What was your favourite genre growing up?
4. Is your favourite growing up still your favourite today?
5. How much time do you spend listening to music in a day?
6. What kind of music do you listen to in a car?
7. Gender
8. Age group
9. Most prominently listened to type of music
10. Average number of hours spent listening to music in a day
11. Subject's overall impression of vehicle audio entertainment.

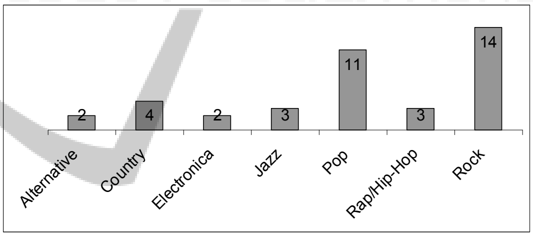

Figure 2: Number of subjects that selected each genre as their favourite.

3.2 The Playlists

Nine commonly defined genres were selected and populated with four songs each in order of changing tempo. With some subjects the tempo increased while with other subjects the tempo decreased. The songs averaged 3 minutes and 44 seconds long, with the longest being 5 minutes and 37 seconds and the shortest being 2 minutes and 46 seconds. Each playlist averaged 14 minutes and 33 seconds with the longest (Rock) 20 minutes and 8 seconds and the shortest (Reggae) 10 minutes and 33 seconds.

3.3 The Vehicle Simulator

The vehicle simulator (Figure 3) consists of two seats, a steering wheel and a pedal cluster from a Ford Motor Company vehicle mounted on a stationary frame. Computers create engine sounds through an audio system and display a synthetic scene with the appearance that the subject is driving a car on the road with no stops. The scene is a loop that repeats several times during a single course.

The simulator also has LCD screens in the location of rear-view mirrors, in the location of a centre-stack display and the instrument cluster.

The computer system is capable of playing playlists from the Rhapsody™ music player, timed to start with a delay of 4 minutes from when the simulator begins a course.

Figure 3: The stationary vehicle simulator at Ford Research and Innovation Center that was used for this experiment.

3.4 The Final Questionnaire

Throughout the experiment the subject was not informed specifically what the experiment was trying to determine. However, at the end of each run the subject was asked to fill out a questionnaire consisting of questions about what they thought of the music. The questionnaire questions follow:

1. Do you think the music you just heard was representative of the _________ genre?
2. Did you like the music?
3. Did you know any of the songs?
4. If yes, which song did you know?
5. Were you bored while driving?
6. Do you think the music you listened to influenced your driving?
7. If yes, how was your driving influenced?
8. Do you have any other comments regarding your drive?

4 RESULTS

With respect to the first main effect, that music influences driving behaviour, we found 48% of the cases where we felt we could observe a change immediately after the music began to play. Figure 4 shows a case where the subject's speed increases and speed fluctuations become more pronounced when the music starts. In Figure 5 the least favourite music is played and speed decreases instead of increasing. This supports the second main effect that like or dislike of the music also influences driving behaviour.

One observation from comparing Figure 4 and Figure 5 is that while in both figures speed holding variability increased after the music started, in Figure 5 where the music is the least favourite the variability is lower, which indicates that different music can have different effects on the driving behaviour.

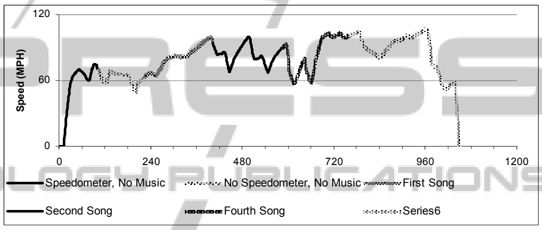

Figure 4: This graph shows the speed holding behaviour of one subject exemplifying the effect of music on some drivers' speed holding behaviour. Immediately after music from the favoured genre begins to play at 180 second the driver's speed increases and fluctuates with greater amplitude.

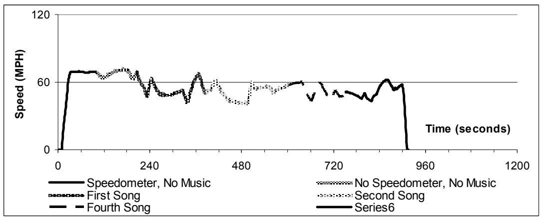

Figure 5: This graph shows the speed holding behaviour of the same subject as in Figure 4 when listening to the least favoured genre. As in Figure 4, speed holding becomes more erratic when the music is played, but the speed decreases instead of increasing.

Figure 6 and Figure 7 demonstrate the same pattern for a different subject. This subject had much better speed control than the subject of Figure 4 and Figure 5, but still exhibited finer speed control fluctuations when listening to the least favourite genre in Figure 7 when compared to the favourite genre in Figure 6.

It should be noted at this point that speed holding profiles such as the one in Figure 4 are indicative of speed being controlled by vehicle dynamics. In these cases, the subject increases speed to over 100 MPH where the simulator is very difficult to control in the curves, so the subject slows in the curves and then picks up speed on the straightaway. Other subjects are apparently able to maintain a more steady speed as with the subject in Figure 6 and Figure 7. Most likely the two types of subjects are controlling their speed in different ways.

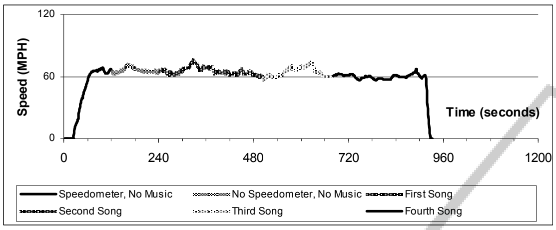

Figure 6: This is one example of a subject with good speed control listening to their favourite genre.

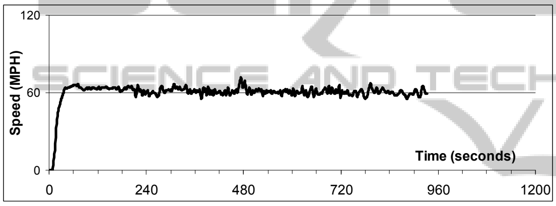

Figure 7: This is the speed holding model for the subject of Figure 6 while listening to the least favourite genre.

We also looked at the data for evidence that a driver listening to the favourite genre will travel at a different speed than a driver listening to the least favourite genre. There were 6 subjects out of the 39 (15%) that exhibited faster driving when listening to their least favourite genre than when listening to their favourite genre. The opposite was true for 7 out of the 39 (18%) that drove faster when listening to their favourite genre. Examples of the shift in driving speed are found in Figure 8 where the subject drives faster when listening to the favourite genre and in Figure 9 where the subject drives slower while listening to the favourite genre.

The third main effect that this study was intended to test is whether or not musical tempo influences how fast a subject drives. This general idea is supported by considerable research (Turley, 2000), (Miller, 2003) that temp may influence how quickly shoppers move through a grocery store or eat their dinner in a restaurant. One might also conjecture that musical tempo could alter how fast a subject will drive in the simulator.

We found that 5 out of our 39 subjects (13%) speed up as the tempo of the music is increased and that 4 out of 39 (10%) drove at a slower speed. Two examples of this are found in Figure 10 and Figure 11.

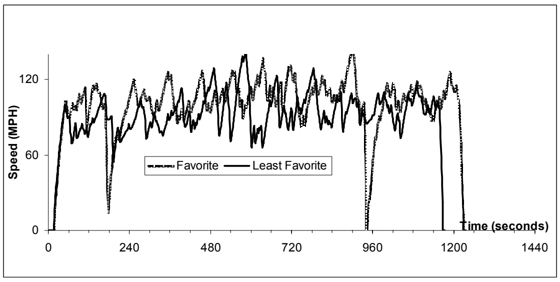

Figure 8: Subject drives at a higher speed while listening to the favourite genre. Just before 960 seconds while listening to their favourite genre, the drive loses control of the car and spins out due to excessive speeds.

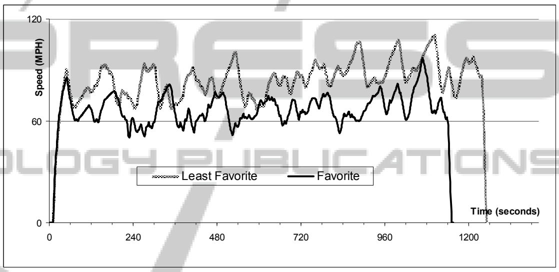

Figure 9: Subject drives at a lower speed while listening to the favourite genre.

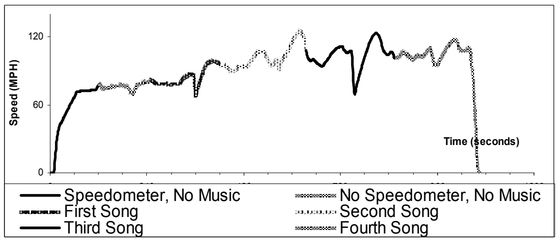

Figure 10: This figure shows speed holding for a subject listening to the least favourite genre while the tempo increases. It demonstrates that some subjects' speed increased as the tempo increased.

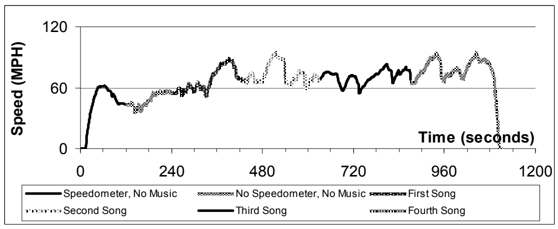

Figure 11: This graph shows the speed holding for a subject listening to the favourite genre while the tempo increases. The speed gradually increases as the tempo increases.

5 CONCLUSIONS

The advancements in personalized digital music technologies and their integration into vehicle systems create promise for the next generation of automotive music entertainment that will match specific music with the driving environment and influence driver behaviour in the desired direction. Although there is a substantial amount of anecdotal evidence that music influences the way we drive, the research of this subject to support the development of an automatic recommender system is rather limited. This paper describes our preliminary study into the influence of music on driving behaviour. In our study 89.7% of the subjects exhibited some change in driving behaviour during the experiment, of which a significant fraction of the subjects exhibited this change immediately when the music was turned on. However, the specific change in behaviour in response to the music preference or tempo appears to be very personal. More work in this area is warranted to explore these results further. Larger data sets are needed to sufficiently characterize driver behaviour as a result of the music they listen to. Naturalistic studies would be very beneficial to eliminate the effects of a reduced visual scene and lack of proprioceptive inputs on speed control. Relevant methods of classifying both music and driver behaviour need to be discovered and implemented in future experiments.

ACKNOWLEDGEMENTS

The authors wish to thank Michael Gunawan, a 2009 Ford Motor Company High School intern who was instrumental in conducting the experiment in this paper and analyzing the data.

REFERENCES

Bayly, M., Young, K. L., and Regan, M. A., Sources of Distraction inside the Vehicle and Their Effects on Driving Performance in Young, K. L., Lee, J. D. and Regan, M. A. (Eds.), Driver distraction: Theory, Effects and Mitigation, Boca Raton, *FL: CRC Press*, 2008, pp.191-213.

Dibben N. and Williamson, V. J.; An exploratory survey of in-vehicle music listening, *Psychology of Music October 2007 35*: 571-589.

Dornbush, S., Joshi, A., Segall, Z., Oates, T.; A Human Activity Aware Learning Mobile Music Player, Juan C. A., J. C., and Shapiro D. (Eds.), *Advances in Ambient Intelligence: Frontiers in Artificial Intelligence and Applications*, Volume 164, 2007: 107-122.

Miller, J. M.; Peden, B. F.; Complexity and Degree of Tempo Modulation as Factors in Productivity; Psi Chi *Journal of Undergraduate Research; The National Honor Society in Psychology* Vol. 8, No. 1, 2003: 21-27.

Mulder, J., Bogt, T., Tom F. M., Raaijmakers, Q., Gabhainn, S. N., Sikkema, P., From death metal to R&B? Consistency of music preferences among Dutch adolescents and young adults; *Psychology of Music* January 2010 vol. 38 no. 1: 67-83

Turley, L. W.; Milliman, Ronald E.; Atmospheric Effects on Shopping Behaviour: A Review of the Experimental Evidence; *J BUSN RES 2000*. 49. 193–211; 2000 Elsevier Science Inc.