The effects of Deviant sound on driver performance

Dissertation submitted in partial fulfilment of the requirements of Cardiff Metropolitan University for the Degree of Bachelor of Science
DECLARATION

I hereby declare this dissertation is the result of my own independent investigation under the supervision of my tutor. The various sources to which I am indebted are clearly indicated. This dissertation has not been accepted in substance for any other degree and is not submitted concurrently for any other degree.
Acknowledgements

Firstly, I would like to thank my supervisor for his continuous support throughout the year. The guidance given allowed me to further my understanding of the course and gain a new perspective on topic areas, in which I had limited knowledge.

... 

Secondly, I would like to thank my family who played a vital role in aiding my desire to complete a degree. In particular, my Mother and Father for encouraging me to perform to the best of my ability, as well as teaching me to always see the end goal.

... 

I'd also like to thank all participants who gave their time to allow the completion of the current study. Without the participants, none of this would have been possible.
Abstract

Findings from previous research demonstrated that novel sounds can capture attention, resulting in a lowered performance when a cognitive task is being measured. Driving ability is dependent on variant factors, which can be reduced when a deviant sound is introduced. The completion of driving whilst performing a secondary oddball task, often answering a cellular device, has resulted in reduced ability. The study therefore aims to test whether deviant sounds can reduce driver ability, in comparison to quiet and non-deviant sounds. The study measured lap speed crash rates, hypothesising that both will increase under deviant sound. 30 participants completed all three sound variant laps, using a simulated driving experience.

There was no significant effect between sound and lap speed, or sound and driver crash rates. F, (1.672, 48.479) = 1.772, p > .05, = .185, $\eta^2_p = .058$).

F (2, 58) = 1.573, p > .05, = .216, $\eta^2_p = .051$.

Although the study revealed that there were no significant effects, unsupportive of past research, it did show that lap times were faster under deviant sound, as well as more crash rates (mean average).

Because of this, the study concluded that deviant sound can affect driver performance. However, further testing is needed to support this.
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CHAPTER ONE

1. INTRODUCTION

1.1 Daily life and sound extraction

Within day-to-day life we extract visual and auditory information necessary for the completion of daily tasks. To complete each task to an optimum level is a vital aspect of life, however discouraged by distracting items that are unknowing to the individual. The information extracted is dependent upon the given environment they are found within, with primitive processes largely governing the success rates of survival (Wang, Lundgen, Hong et al, 2017). The ability to simultaneously extract relevant information, whilst also filtering irrelevant stimulus, has long been a process thought to exist amongst humans (Withington, 2000). Because of this, research into the ability for sound and visual stimulus, classically considered irrelevant, capturing attention has become widely researched within recent decades. With further heavy focus towards sound stimulus (Hughes, Vachon, & Jones, 2005). Whilst the capture and processing of sounds have largely digressed away from predator survival, the sudden fluctuation and increase within technology has created new threats whereby sound can distract an individual’s ability to perform. Automotive transport has been an ever-increasing form of travel, since the creation of cars in the late 1800’s (Benz Patent Motor Car, 1885-1886). Driving is a complex task requiring a person’s fullest attention, a heightened level of practical skills, as well as the ability to predict future outcomes based on one’s own performance, the surroundings and that of other drivers (Wester et al, 2007). When driving, a person is susceptible to an array of sounds, both externally, and internally through the car mechanics. Internal sounds of cars are designed to benefit a driver’s performance, using feedback technology. Notification systems alert drivers under different circumstances, for instance: alerting the driver when a manoeuver is required, altering the driver when a change in driving habits is needed, and alerting the driver when destinations have been reached, (Wang et al, 2017).

Sound capture, and sound processing, can be a vital instrument for the success rates of driving. The reduction in a person’s attention within daily life is normal, with daydreaming and irrelevant stimulus expected to occur. However, a reduction within a person’s attention whilst driving severely inhibits performance, increasing the chances of harm to the driver, pedestrians, and other road users, (Crundall et al, 2005). The National Highway Traffic Safety Administration, (NHTSA, 2016), reported that driver inattentiveness and driver distraction accounted for 25-80% of all traffic accidents, (see for review: Klauer et al, 2006). An inability to filter out irrelevant and deviant sound stimulus is a leading factor for driver inattentiveness, thus resulting in an overall distracted driver. Inattentiveness is the process whereby delays in
recognition of potentially hazardous stimulus are a direct result of secondary stimulus that are not required to accomplish the task of driving, (Automobile Association Foundation for Traffic Safety; see for review: Treat, 1980). On-board stimulants are a leading cause of driver distraction, including the uses of: mobile phones, music, and passenger communication, (NHTSA, 2013, 2016). External sounds also capture attention. However, these are usually lost amongst background noise meshing together under the sound of the car itself and uses of on-board auditory stimulus. These sounds are believed to increase a driver's failure to look, hear oncoming road users, as well as giving an overall lowered performance. This reduced performance has accounted for 400 to 1469 fatal crashes in Britain in one year alone. (Department for Transport, 2015, 2016). Furthermore, Stutts et al. (2003) indicated that a further 17-25% of all road accidents are classified as driver inattentiveness, according to law-enforcement personnel, with the majority of drivers blaming an inability to hear due to on-board sound and communication. Self-report studies from drivers within the United Kingdom (UK) suggested the majority of road users were indifferent or reluctant to state that their ability was impaired by auditory stimulus. Moreover, the majority of participants were unaware that their on-board actions could cause a reduced performance, (Young, & Regan, 2007). A follow up study using observations yielded results suggesting that 1 in 6 drivers, on average, were engaging within activities considered distracting. This included: communication with passengers, excessive music, and communication through mobile phones, hands free systems and navigation systems, (measurement of 11,000 drivers on roads in St. Albans, England; Young, & Regan, 2007).

1.2. How sound captures attention

Because of this, it is important to understand the ways in which auditory information can elicit attention capture, resulting in negative implications on a driver’s ability to perform. Vachon, Marsh and Labonte (2017) stated that attentional capture can be classically explained in terms of a stimulus considered irrelevant or unrelated to a current task, involuntarily directing attention away from a goal due to the nature and environment of a broken concurrent stimulus. The environment an individual is in, is important for the ability for sound to capture attention, (Theeuwes, Olivers, & Belopolsky, 2010). Theories regarding auditory attention capture have largely been divided into two main concepts, termed the duplex model of auditory distraction, (Hughes, Vachon, & Jones, 2005). The duplex model theorised that auditory information acquires attention in two distinct ways. Firstly, interference-by-process (irrelevant sound effect) and attention capture mechanisms (deviant sound effect). The deviant sound effect, or attention-capture mechanisms, reflect a general form of auditory distraction. Therefore, grabbing attention from a given focal task, due to the addition of a sound that deviates from a concurrent auditory sequence, regardless of the task being performed, (Hughes, 2014). The violation within a strand of information results in a relapse of opportune task performance, as attention is either lost or divided between the two sounds. The deviant sound effect occurs when a sound deviates from a concurrent auditory sequence. Bregman (1990) stated that a disruption will occur when the secondary stimulus (deviant sound) breaks the chain of a concurrent auditory sequence, as well as being different to the environment it’s heard within.
Therefore, a sound that is different to the sequence, yet fits the environment it’s heard within (e.g. a single bird chirping within the woods) would not be classically defined as a deviant sound. This is deemed as an Auditory Scene Analysis, (Bregman, 1990). Auditory scene analysis is governed by two main mechanisms, primitive and schema based. Primitive based mechanisms stem from auditory information that is present within an environment, as well as processing normative sounds. Schema based mechanisms are that of perceived outcomes. Thus, perceived outcomes can be violated by deviant sounds, (Parmentier et al, 2011). Similarly, Winker et al, (1995) suggested that sound violation occurs when an auditory event representation system fails to protect the individual.

1.3 Implications for driving

The violation within a strand of auditory information can therefore result in relapses of attention towards a given task. Deviant sound effects whilst driving can therefore reduce a driver’s ability to successfully perform, or perform to a usual standard, (Sokolov, 1963). This being said, not all sounds that occur will be considered as deviant. For instance, the use of music whilst driving has been shown to reduce ability to drive dependent on the pitch and tempo of the music. Additionally, an individual listening to their own music will knowingly perceive the outcome based on their music preference. Because of this, it is unfair to assume that all sounds deviant in nature will capture attention. Music that the driver does not know however, has an increased chance of attentional capture. Driver Distraction Expert Working Group Meetings, (AAA, Foundation for traffic safety, 2001; NHSTA, 2000), suggested that auditory distraction is the result of on-board features rather than external sounds, with the perceived helpful nature of devices often proving to produce to opposite. The use of helpful technology within cars has been largely documented, with results often showing negative implications. For instance, Ranney, & Pulling, (1990), used oddball tasks requiring participants to attention switch between driving and mobile phone use. Results indicated that attention switching between mobile phone use, including: making calls, receiving calls, and replying to messages, resulted in an overall lessened driver performance. Lower performance was measured by poor lane keeping, over braking, and under/over acceleration, (results were particularly worse for participants over the age of 55). Furthermore, the ability to focus on driving was returned when the oddball task was removed, highlighting the effects of sound on driving ability, (Stein, Parseghian, & Allen, 1997). Driver performance can be measured in three distinct groups, as hypothesised by Rasmussen, (1987). Firstly, skill-based behaviours, including items such as lane keeping, and car manoeuvring. Secondly, knowledge-based behaviours, including items such as: route planning, road speeds, and gear control. And thirdly, rule-based behaviours, including speed limits, traffic light stops, and overtaking. Skill based behaviours are largely the result of progressive experience with older drivers (up to a certain age), thus hard to reduce when a secondary source is introduced. Rule-based behaviours, as well as knowledge-based behaviours are processed dependent on where the driver is situated. Because of this, it is possible to gain attention from deviant sound within these two processes. When a secondary stimulus is added, (e.g. talking to passengers, texting, and making phone calls), it can further result and prolong attention capture, particularly when the audio isn’t necessary...
to a given task, (Brookhuis et al, 1991; Crundall et al, 2005; Strayer & Johnston, 2001). The ability for auditory information to capture attention of rule-based behaviour has been documented.

Furthermore, majority of road traffic accidents take place within areas considered familiar to the driver, (AAA, Foundation for Traffic Safety, 2001), suggesting that attentional capture is more predominant in areas that are well known to individuals. For instance, the 'information system mechanism protects against irrelevant information from grabbing attention. Lavie, (1995), stated that processing task-irrelevant information is related to the cognitive load of the primary task. Because of this, a task that requires more attention can be said to have a reduction in the ability for a secondary source to gain attention. However, this would therefore suggest that driving within local areas (retrospective of the driver) that are well known, (low load), will have an increased potential for irrelevant information to grab attention, compared to roads that are new, or require focus (e.g. motorways/highways), (Lavie et al, 2003 2004). Wertheim, (1978), suggested that alertness is reduced when driving on roads considered familiar, with alertness being measured through the use of electroencephalogram on brain activity. Alertness was reduced by 50% when driving on roads that individuals were familiar with, and up to 65% when driving on roads used daily. Furthermore, driver performance in regard to errors is increased when low arousal is present, (Campagne et al, 2004). Driver arousal is reduced when driving on both long roads, such as motorways, and roads driven daily. Because of this, it is understandable to suggest that deviant sounds will have a greater effect on roads a driver has previously driven upon. (Ford, & Hillyard, 1981), disrupted serial recall using deviant sounds alongside a sequence that matched the environment and task being performed. Results suggested that temporal deviation effect and changing-state effect were suggestable, however noted that the deviation effect could be ascribed towards the attentional capture mechanisms. Because of this, schema-based perceptions of driving can largely be affected by deviant sounds, (Noorden, 1975).

1.4 Aims and Hypothesis

Previous research regarding driving has indicated that driver inattention is a leading cause for road accidents. In addition, Hughes, Vachon, & Jones, (2005), studies on deviant sounds suggest that attention can be reduced when a sound deviates from a given sequence. Because of this, the current study aims to test whether driver performance is reduced when deviant sounds are introduced amongst a background sound. Studies such as Lavie et al, (2003), indicated that deviant sounds are have an increased likelihood to cause attentional capture amongst familiar roads. Whilst this would indicate roads that are a daily use, the current study will measure laps upon a given track. An increase within number of laps on a single track should become ‘familiar’. Whilst it will not represent a daily use, it should be enough to overtime reduce arousal, increasing the likelihood of deviant sound theory taking effect. In addition, performance will be measured using hazard perception (crash rates), and lap time through speeds. Wang et al, (2012), study tested individuals ability to calculate speed
dependent on pitch frequencies of inboard sound. The study measured quiet sounds, low-cut sounds, (below 600 Hz), and high-cut sounds, (above 600 Hz). The study found that when high cut sounds, and no sounds were played participants severely over and under estimated the speed a car was traveling. Because of this, the current study hypothesises that when an external auditory stimulus is added, (deviant sounds), and the speed of the car will increase, resulting in faster lap times. Furthermore, quiet studies that only use in game sounds, will have slower speeds. Secondly, the addition of a deviant sound will result in decreased hazard perceptions (higher crash rates). Klauer et al, (2006), showed that driver inattention resulted in increased traffic accidents. Because of this, the current study should fine that when deviant sounds are introduced, attention will be captured, resulting in the focal task attention being reduced long enough to result in increased crash rates.
CHAPTER TWO

2. METHOD

2.1 Participants
The study presented was comprised of 36 undergraduate students attending a university within the south of Wales. Age of participants wasn't a measured statistic, however ranged between 18 and 30, in order to narrow the margin of driver experience. In addition, sex of participants was ignored to reflect driver performance in general, rather than a difference between sexes. Participants were initially selected using opportunity sampling through the use on an online study application, (SONA-system). The system presented participants with a brief overview of a study, with the requirements necessary. Snowball sampling was later added to contact participants willing to take part but who could not sign up using the online application. Regardless of how participants were sampled, requirements needed to be met. Participants were informed that they must be between the ages of 18 and 30, as well as having a full United Kingdom, (UK), drivers licence. Moreover, any individual involved within an automobile accident within the past 12 months was unable to take part, due to potential harm the study could have produced.

2.2. Design
A within design was implemented within the study, due to participants completing every variable within the study. The study was compromised of one independent variable, (IV), and two measurable dependent variables, (DV), through the use of two one-way ANOVA’s. The IV for the study was comprised of three sound files. Sound files were divided into three groups to measure the effect deviant sounds had on driver performance, using quiet and non-deviant sounds as comparison. Quiet sound founds contained no sound, lasting approximately 5minutes. Non-deviant sounds consisted of 5minutes of road traffic background noise. The background noise contained auditory information including; distant construction, distant traffic, distant car horns, and engines revving. In addition to this non-deviant sounds including both text tones and ring tones were included. Each sound (text tone and ring tone) lasted for 2 seconds, with each sound playing twice through the course of five minutes, at random intervals. These intervals were; 5minutes, 46 seconds, (phone ring), 6minutes, 21 seconds, (text tone), 8minutes, 14 seconds, (phone ring), and 9minutes, 37 seconds, (text tone). The deviant sound files included the same traffic auditory information as non-deviant sounds, however differed in the deviant sounds and intervals.

Deviant sound files included two sets of animal roars. The two roars were similar, however different in their pitch. Similarly, each sound file lasted for 2 seconds, with two appearances each within the background noise. Intervals included, 10minutes, 52 seconds, (lion roar 1), 11minutes, 44 seconds, (lion roar 1), 11minutes, 46 seconds, (lion roar 2), and 13minutes, 37 seconds, (lion roar 2). Sound files were created using an online soundboard and converted to work on windows media player. Each variation, (quiet, non-deviant, and deviant) sounds were changed when a participant completed
one of the measured laps. Participants were measured individually; however sound files were divided into three variations to reduce order effects. Orders included:

1. Quiet, non-deviant, deviant
2. Quiet, deviant, non-deviant
3. Non-deviant, deviant, quiet
4. Non-deviant, quiet, deviant
5. Deviant, non-deviant, quiet
6. Deviant, quiet, non-deviant

In the result of participants taking longer than five minutes to complete a lap, the same audio cue would repeat retrospective of the given order, (e.g. whilst completing measured lap 1, the same audio file would loop if the time was longer than five minutes and change when the lap was completed).

2.3 Material

A consent form and information sheet were given to participants. Participant information sheets provided participants with an overview of the study, including the aims, potential understanding and benefits towards deviant sound theories, as well as possible harm that may arise. Participants were then able to fill out a consent form, as well as agreeing for their information to be used. Participants names were not used within the study, and their name not necessary on the consent form, as long as a signature and student identification number, (ID), was provided).

The IV of sound was implemented through high definition NPNG-2017 headphones, and played for the tested three laps, however worn for all six trials. Both DV’s were measured using a simulated driver experience. Simulated experiences were performed through the use of FORZA-Motorsport-GT5, (SONY, 2013), a racing simulator. The devise was tested using a gaming console, the PlayStation3. Participants were provided with a replicated car interior including; driver seat, and driver console including, steering wheel, brake pedal, accelerator pedal, and flappy paddles used to shift through gears. A 32” Panasonic TV provided an interior visual of the provided car, including rev counter, speedometer, (MPH), and rear-view camera. A standard Ford Focus-2013, was used as a standard car, due to it being the most road predominant car provided by the game. In addition to this, all participants completed laps on the same track, in this case the Cape Town Ring, (4.4KM), was used, and as an average time to complete the lap was 220 seconds. The track was used with no other drivers present to ensure that performance was not due to other driver influence. Because of these hazards were documented as crashes. Crashes included; driver leaving the track onto grass verges, coming into contact with a wall and/or barrier. The DV of speed was measured using an internal clock the game provided upon completion of the desired laps. Time was measured in minutes, seconds, and milliseconds, (e.g. 00.00.000), and converted into seconds and milliseconds. Driver speed was not calculated, however provided to give participants a reference to their speed due to a lack of on-board feeling a car provides (car shaking and feeling gear change when driving a car).
In game sound was provided throughout all six laps. In game sound included the sound the car produced, as well as completion buzzers when a lap was completed. Headphones connected to a computer were worn throughout, this reduced external sound participants may have experienced within the laboratory. Sound was emitted though the headphones when a participant began their fourth lap, (the first of three measured laps). Sounds were played using windows media player that used the fifteen-minute sound file, divided into three five-minute sections for each lap.

2.4 Procedure

Participants were measured within a laboratory room in a south west University. Participants were tested individually and given a 45-minute period to complete the test. Upon arrival participants completed both consent form, and participant information sheet, as well as being given verbal instructions of how to device worked and how it would be measured. Participants were informed that they could driver however they wished, giving them the freedom of driver style and speed. This reduced chance of individuals not comfortable with driving fast attempting too and crashing more often, reducing the validity of the study. After this the game was activated and participants began their first lap of six. Participant speed was monitored throughout each lap through the use of a secondary monitor providing in-game feedback. This feedback included; speed, time, acceleration, braking, and damage to vehicle. Damage to vehicle was ignored, due to prolonged track time (six laps) resulting in general damage to tires. Because of this, hazards were measured using crashes. Upon completion of lap 1, participants were notified of the beginning of test lap 2, and again for test lap 3. When participants came to the end of their 3-test lap they were informed that the remaining three laps would contain auditory information through the headphones they were provided. Participants were given a verbal cue before sound was emitted to reduced chances of the sound catching participants off guard, potentially resulting in a crash. On beginning of lap 4 sound was played through the headphones. Sound was played in an order that matched the participant order, for instance;

1. Quiet lap, non-deviant, deviant.

Order cues were reset every six participants. Participant lap times and crash rates were recorded by hand on a templated results page, and later converted into excel. When participants had completed all six laps, the screen providing visual information turned black, and audio also stopped notifying participants the test had come to an end. On completion of the required laps, participants were provided with a verbal debrief including a set of three questions,

- How did you find the test?
- Did you feel that sound impacted your performance?
- Which sounds, if any, where hard to ignore?

Questions were not used within the final assessment but used to see whether participants felt that deviant sounds impacted their performance. Participants were then asked if they wished to see their results, this included both speed and crash rates.

2.5 Statistical analysis

To analyse the data, two one-way ANOVA’s were used. This method of analysis was used as the sample was a within design, with one independent variables, and two dependent (time of lap, and crash rate), with ratio data being collected. Moreover, this
analysis allowed for an effect to be established, as well as correlations to be drawn from each variable, to see whether they were affected separately, or concurrently. IBM SPSS 22.0 statistical programme was used to conduct the analysis.
CHAPTER THREE

3. RESULTS

3.1 Sound variations and lap time

Table 1. Showing difference in mean time of laps completed, under three sound variants. A clear difference within mean time can be seen across some variables. A difference between deviant and quiet, and non-deviant and quiet can be seen. However, there is no noticeable difference, (significance), between non-deviant and deviant mean laps. Mean lap times were fastest within deviant sound trials, (236.228), and slowest in quiet sound trials, (240.670).

<table>
<thead>
<tr>
<th>Sound Condition</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiet</td>
<td>240.670</td>
<td>32.103</td>
<td>30</td>
</tr>
<tr>
<td>Non-Deviant</td>
<td>236.518</td>
<td>29.511</td>
<td>30</td>
</tr>
<tr>
<td>Deviant</td>
<td>236.228</td>
<td>27.886</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 1. Descriptive statistics of mean lap time amongst sound variants.

Figure 1. Displaying data present within table 1. Trends within the data-set are clearer to see, with faster lap times producing a smaller bar within the graph. There is a clear difference between non-deviant and quiet trials, as well as deviant and quiet sound trials. 

Figure 1. Bar graph showing mean lap scores amongst sound variants.
Results were measured using a one-way repeated-measures ANOVA. The two dependent variables were measured separately from one another, thus being tested through two one-way ANOVA’s. This was done in order to test for sphericity of the null hypothesis between the two dependent variables.

A Mauchly’s test of sphericity indicated a significant result between sound and lap speed, \( \chi^2 (2) = 6.122, \ P < .05, = .047 \)

The results of the one-way repeated-measures ANOVA showed that there was no significant main effect on sound variant and lap speeds,

\( F, (1.672, 48.479) = 1.772, p > .05, = .185, \eta^2 p = .058 \)

Bonferroni post hoc tests indicated that participants lap times were faster under deviant sound trials, (mean = 236.229; SD = 27.888). Quiet lap sounds were found to result in the slowest lap times, (mean = 240.670; SD = 32.103, \( p = .000 \))

All lap time variables were not significantly different from one-another.

### 3.2 Sound variations and hazard perception

Table 2. Showing the difference in mean hazard perception, (crash rates), for each sound trial. Similar to lap times, it is clear to see that mean crash scores were the most under deviant sound trials, (5.3000). Furthermore, quiet lap mean crash scores were the lowest, (4.5667).

<table>
<thead>
<tr>
<th>Sound Condition</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiet</td>
<td>4.5667</td>
<td>2.67406</td>
<td>30</td>
</tr>
<tr>
<td>Non-Deviant</td>
<td>5.1667</td>
<td>3.00670</td>
<td>30</td>
</tr>
<tr>
<td>Deviant</td>
<td>5.3000</td>
<td>2.11969</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 2. Descriptive statistics of mean crash rates amongst sound variants.

Figure 2. Displaying data present within table 2. Trends within the data are not as clear as lap times. Mean scores for crash rates are harder to differentiate differences, however show quiet sounds as the least number of crashes.
The results of this one-way repeated-measures ANOVA again showed no significance between crash rates and sound trials,

\[ F (2, 58) = 1.573, p > .05, \eta^2 p = .051 \].

Bonferroni post hoc tests showed that participants had more crash rates when under deviant sound variants, (mean = 5.3000; SD = 2.11969), compared to quiet variants, consisting of the least about of crash rates, (mean = 4.5667; SD = 2.67406). However results were not significant, suggesting results were due to chance.
CHAPTER FOUR

4. DISCUSSION

4.1 Summary of results and hypothesis

The present study was conducted due to a lack of research surrounding theories regarding deviant sound effects. Additionally, the implications deviant sound theories have on everyday life tasks has been under studied, particularly regarding the negative effects the effect can have on driving. Psychological research into the reasons for driver error were largely centred towards the way in which cognitive processes can be altered. Because of this, the present study aimed to test whether deviant sound effect can cause a reduction in driver performance. Two main hypotheses were drawn based on previous research. Firstly, the addition of a deviant sound will reduce driver performance due to attention capture process (Hughes, Vachon, & Jones, 2005), resulting in increased crash rates. Secondly, overall driver speed will increase, due to speed focus being diverted towards sound capture, thus leading to faster lap times (Wang et al, 2012). Results drawn indicated no significant effect between deviant sound, driver crash rates, and lap speed. Whilst driver crash rates were most when a deviant sound was implemented, as well as lap times fastest, there was not enough of a margin between other samples to state a significant reaction. Therefore, the study did not support the hypothesis.

4.2 Comparison of the current findings with driving statistics

Past research regarding driver effort and inattentiveness suggested that driver crash was due to driver inattentiveness the current study did not support this statement, with research indicating no significant effect between driver inattentiveness, (attention capture), and driver crash rates (Brodsky, 2015). However, previous research also indicated that on-board stimulus that was considered deviant, e.g. navigation audio, unknown music, and mobile phone use, resulted in poorer driver performance (Stutts et al, 2003). Majority of trials within the current study indicated that deviant sounds resulted in higher crash rates, compared to both quiet and non-deviant sound trials. Furthermore, crash rates were higher than trial laps, indicating that crashes may have been due to sound, regardless of no significance. On the other hand, a lack of significance in regards to crash rate and deviant sound may indicate that results were due to chance or a secondary source. For instance, fluctuations within crash rates may have also been the results of: boredom, practice, and innate competitiveness to perform better. In addition to driver error, previous research indicated that speed is also ambiguous whilst a deviant item is introduced alongside a speed task (Wang et al, 2009). The current study indicated that lap times were fastest (mean average) when a deviant sound was concurrent to the auditory sequence, with non-deviant sounds also faster than quiet laps. Because of this, it can be suggested that previous research regarding speed is supported, as results indicated speed awareness was reduced under sound trials. Whilst previous research on speed used external guesses, the current study allowed participants to view their speed, (MPH), suggesting that visual focus was momentarily lost, resulting in faster corners to be taken, increasing both lap speed and potential crash rates.
Additionally, familiar road research (Lavie et al, 2003) suggested that driver error was most predominant on roads familiar. Familiar roads resulted in lower arousal when driving, leading to a greater chance of inattentive (Campagne et al, 2004). Participant lap times within the current study showed increased speed along each six laps. Because of this, it may be suggested that participants practice and familiarity of the track increased lap time. However, deviant lap trials experienced greater number of crash rates, as well as faster lap speeds, (mean average, based on majority of trials). Whilst no significance was found, the results would indicate that increased laps reduced arousal allowing for deviant sounds to capture attention. Previous research regarding mobile phone use was not supported (NHTSA, 2013, 2016). Non-deviant laps were found to have no correlation to lap time (speed) and driver crash, (Hazards). Previous research found that use of mobile phones when performing the task of driving reduced driving performance, including: reduced ability to lane keep (Ranney, & Pulling, (1990). Due to a lack of significance, these were refuted. The current study used follow-up questions to see if participants believed their performance had been effective. Results found that participants, (particularly under the age of 25), used mobile phones whilst driving. Because of this, the attribution to text tones and phone calls was within their perceived scene analysis whilst driving, meaning attention was not captured. On-board auditory information, (navigation system, indicators, car horns, etc.), were not used within the study. Because of this, past research regarding in car sound distraction is neither supported or refuted (Lundgren et al, 2017).

4.3. Comparisons of the current findings and deviant sound theories

Research surrounding deviant sound theory suggest that deviant sound captures attention, reducing readily available attention given to a task (Hughes, & Jones, 2003). Violations within strands of concurrent auditory information that differs, (e.g. different to the environment it’s heard in, pitch, and frequency), (Hughes, 2014). The current study used deviant sounds, (lions roaring, and text tones), alongside a concurrent auditory sequence, this being road traffic. The background sequence provided participants with a narrative, of which an auditory scene analysis would be created. Deviant, and non-deviant sounds were played alongside in 1-2 second intervals, randomly spaced across the five-minute background noise. This therefore created a violation, being a deviant sound effect. The current study would therefore expect to find higher crash rates and faster speeds along deviant sound trials. However, deviant laps were not significant in their findings, unsupportive of previous research. Auditory scene analysis was not compromised, of which would have resulted in attentional capture (Winker, & Shroger, 1995). Due to a lack of knowledge surrounding the simulator, participants would have no pre-existing schemas and scene analysis. Because of this, the addition of both concurrent sound and deviant sound may have been perceived as the norm of the simulator. Because of this, sound violation would not have been expected, potentially explaining a lack of significance (Noorden, 1975). For instance, participants may not have associated the simulation with driving, meaning no sound was pre-conceived.
4.4 Considerations

The present study used a simulated driving experience, on a PlayStation, to measure the effects deviant sounds have on driver performance. Previous research surrounding driver ability was measured using real cars, within standardised environments (Ranney, & Pulling, 1990). The use of a simulated driving experience allowed for certain variables to be controlled. For instance, participants did not worry about traffic, damage to property, inexperience driving a different car, as well as accessibility to study location. However, the use of a simulation to measure driving ability involved limitations. Firstly, simulated experiences require less attention needed to complete compared to driving. For instance, participants did not need to focus upon: damage to vehicle and property, road traffic and other car users, and potential pedestrians. Because of this, participants experienced no repercussion for crash rates, removing a negative stigma for crashing within trials. Secondly, FORZA-motorsport-GTA5, is a video game requiring individuals to complete laps. The game is a commercialised game, with other alternatives that produce similar experiences. Because of this, the study was biased towards individuals of which had previous experience with the current game, or a similar one. For example, 95% of all male participants had experienced a driving simulation prior to the study. Comparatively, 93% of all female participants had never experienced a simulated experience. Therefore, results (in particular crash rates), may have been the result of prior practice.

Furthermore, simulated experiences give limited physical feedback to the driver. (Bellem, et al, 2016), calculations of speed, braking distance, and optimum gear change are dependent on sound, as well as the physical sensation an automobile provides, (e.g. biting point). The simulator provided no physical feedback, lowering the ability for participants to estimate distances, braking ability, and speed. Previous research that took place with an automobile would have meant participants would require all knowledge theorised by Rasmussen, (1987). For example, skill-based behaviour, knowledge-based behaviour, and rule-based behaviour. The simulator used within the current study removed skill-based behaviour, (e.g. need to stay in lanes, gear changes, checking mirrors etc.), as well as removing rule-based behaviour, (e.g. road speed, and indication). Unlike previous studies, the removing of the behaviours reduces attention needed by participants. Because of this, participant focus was not divided across all aspects of driving, as the test did not require them to not crash, or lane keep. Therefore, less to focus on may have increased attention given to one aspect of driving, making it harder for a deviant sound to capture said attention.

In addition to simulator limitations, previous studies surrounding deviant sound involved the completion of a task, whilst performing, or ignoring a secondary oddball task (Vachon, Hughes, & Jones, 2005). The completion of a task whilst also attention switching between a secondary task, as well as ignoring a pitch deviant sound increased the chances of participants being affected by deviant sound. The present study used one independent variable, with two dependent variables being measured. However, participants were required to complete one task, and were not advised to ignore sound, or complete a secondary task. Because of this, background deviant sound paired alongside a foreign simulator task, may have resulted in new auditory scene analysis. By this, deviant sounds and quiet sounds may have been processed as a normative sequence, compared to if a sound was directed to be ignored. Lastly,
previous research conducted in both fields, deviant sound, and driving statistics, involved large groups and meta-analysis. For instance, inattentive driving ability across St. Albans, England, was measured using 11,000 participants (Young, & Regan, 2007). The present study used 30 undergraduate students. The lack of participants is a limitation as an increase in participants would have seen a wider selection of results. In addition, undergraduate students ranged from 18-30. Younger drivers within the study as well as some older participants, would have reduced overall experience. Furthermore, younger drivers (who have recently passed) were more likely to drive fast, according to Parker et al (2013). Because of this, crash rates within the study may have been the result of young novice drivers, and inexperience, rather than a deviant sound effect.

Future studies associated to deviant sound effect on driver performance should use large scale participants, such as: Young, & Regan (2007), to increase the potential of deviant sound effect taking place, rather than results yielded resulting from potential practice. Furthermore, deviant sound measures should use a secondary oddball task whilst driving to test whether the effects of deviant sound are more prevalent whilst performing a task, of which can then be associated to the use of on-board technology cars provide. Similarly, variations of simulated driver experiences should be used. For instance, DVLA hazard perception should be used to assess whether deviant sound effect prevents the driver from noting potential hazards. A test-retest could be used to measure effect change.

4.5. Conclusion

The current study used a robust, initiative way to examine the effects of deviant sound on driver performance. A within design meant that samples completed all sound variants of the study, being the independent variable, (quiet, non-deviant, and deviant). Previous research on deviant sound and driving was limited. Because of this, the study focused on two groups of previous information, driver inattentiveness and deviant sound theories. Past research on driver errors indicated violations within sound causing momentary relapses in attention. Past research on deviant sound theories indicated that sound files that are different to a concurrent sequence, as well as perceived auditory scene analysis capture attention. Because of this, the current study used deviant sounds amongst a concurrent sound sequence to create a violation, supporting both deviant sound theories and driver inattentiveness statistics. Unlike previous research however, the current study did not show a significant effect between sound groups and driver performance, both in lap speed and driver crash rates. Because of this, the hypothesis was unsupported, as well as previous research used to establish a hypothesis. This being said, the study has left room for further research, with knowledge on factors that may have skewed results.
REFERENCES


AAA Foundation for Traffic Safety, Washington, DC, USA.


Wang, M., Yi Ci Li., Chen, F., (2012). How can we design 3D auditory interfaces which enhance traffic safety for Chinese drivers? Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications. AMC. 77-83.


• APPENDIX

Appendix 1. Participant information sheet

PARTICIPANT INFORMATION SHEET

Reference Number: AD06

Title of Project: An investigation into the effects of background sounds on driving performance

Background

This study is being conducted in attempt to understand the effect background sounds has on driver performance. Previous studies have highlighted the negative effects sound has on driver performance, with reference to short bursts of sounds that draw attention away from the focal task (e.g. text tone), long enough to cause a reduction in driver performance. An investigation into additional sounds, those often considered alternate to driving norms, will increase the understanding of sound on driver performance.

What would happen if you agree to participate?

You will be contacted by the research through direct email to arrange a date. The session will take place at a time convenient for you, with a time slot of half an hour given. You will perform the test in a small room alone, located in the labs at Cardiff Metropolitan University. Before the test takes place, you will be given a verbal briefing of what the research requests you do. If satisfied, a set of forms will be given and required to be read and signed (an acceptance of the aims, and consent).

Data collection will take place in January. You will complete the test in a laboratory setting, of which will require you to switch off any electrical devices that may hinder the results (mobile phone, auditory devices etc.). Your driving performance will be measured using lap times using FORZA motorsport video game via PS3. Sounds will be played through headphones which you will be told to ignore. Before testing commences, you will have some practice trials to get you used to the game.

Exclusion Criteria

If items below apply, you are unable to take part within the given study

• Under the age of 18 years
• Diagnosed with an auditory impairment
• Over the age of 30
• If you have experienced a road traffic accident in the last 12 months then we strongly advise that you do not take part in this study.
Potential risks
Taking part within the study should result in no risks. However, unexpected sounds will be played, of which may cause small increases in heart rates similar to that when something unexpected captures your attention. Your performance will not reflect on your ability to drive a car in the real world.

Potential benefits
There will be no direct benefit for you but it will be part of my undergraduate project.

Participant confidentiality and anonymity
You can withdraw from the study at any point during the testing session. However, data may not be withdrawn after this date as no identifying information will be taken from you. Only my supervisor and I will see the raw data.

Contact details
For any queries regarding the study, contact Nick Perham, study supervisor. email-nperham@cardifmet.ac.uk

When read, sign to indicate you understand the aims and understanding of the study

_______________________________ Date _____________________
Reference Number: AD06

Participant name and Student ID Number:

Title of Project: An investigation into the effects of background sounds on driving performance

Name of researcher: [Redacted]

**Participant to complete this section:** Please initial each box.

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free to withdraw at any time before leaving the experiment, without giving any reason.

3. I agree to take part in the above study.

_______________________________________  ___________________
Signature of Participant  Date

_______________________________________  ___________________
Name of person taking consent  Date

____________________________________
Signature of person taking consent

____________________________________
• DECLARATION OF WORD COUNT

• Abstract ...................................................................................................................... 2,185
• Introduction ............................................................................................................... 2,185
• Method ....................................................................................................................... 1,508
• Results ...................................................................................................................... 529
• Discussion ............................................................................................................... 2,011

Total (excluding abstract) ......................................................................................... 6,233