Driving Simulator: Driving Performance Under Distraction

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Driving Simulator: Driving Performance Under Distraction

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The Department of Computer Science

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Kaushik Pilligundla

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Driving Simulator: Driving Performance Under Distraction

By

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THE DEPARTMENT OF COMPUTER SCIENCE

SAN JOSE STATE UNIVERSITY

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ABSTRACT

This pilot study used a driving simulator experiment to look into how podcast consumption affects driving performance as a continuous distraction. Three volunteers conducted three trials in the study, each with a different driving scenario. Data analysis was done to compare two conditions. The first condition is the Audio, where volunteers listen to podcasts while driving. The second condition is no-audio condition. The no-audio condition had nothing to play in the background. We used eye-tracking technology to gather gaze data. The study's findings using the post survey and eye fixation data indicate that listening to podcasts leads to continuous distraction while driving which may impair situational awareness and attention to surroundings. On the other hand, the absence of audio stimulation can increase attention and awareness while driving. These findings underline the need for drivers to be aware of audio distractions while driving and have significant consequences for road safety.
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# TABLE OF CONTENTS

1. Introduction ............................................................................................................. 1

2. Literature Review .................................................................................................. 3
   2.1. Previous Studies on Distracted Driving ......................................................... 3
   2.2. Use of Driving Simulators in Research ......................................................... 4
   2.3. Use of Eye Trackers in Research................................................................. 6

3. Methodology ......................................................................................................... 10
   3.1. Research Design ............................................................................................ 10
   3.2. Technologies and Implementation ............................................................... 11
      3.2.1. Matlab .................................................................................................... 11
      3.2.2. Titta ...................................................................................................... 13
      3.2.3. PsychToolbox ....................................................................................... 15
      3.2.4. Tobii Fusion Pro .................................................................................. 15
      3.2.5. Logitech G29 Steering Wheel .............................................................. 16
   3.3. Eye Tracking Data .......................................................................................... 17
   3.4. Data Analysis ................................................................................................ 18

4. Analysis .................................................................................................................. 19
   4.1. Pupil Diameter ............................................................................................... 19
      4.1.1. Results of t-test ...................................................................................... 19
   4.2. Gaze Patterns with and without Audio ....................................................... 20
   4.3. Defining a Region of Interest ....................................................................... 22
   4.4. Extreme Left and Right Regions of the Display ......................................... 24
   4.5. Podcast Trial Survey Response .................................................................. 26

5. Results and Discussions ....................................................................................... 27
   5.1. Interpretations of Results ........................................................................... 27
5.2. Limitations of the Study and Future Scope……………………………………...28

6. Conclusions………………………………………………………………………………31

7. References………………………………………………………………………………32

8. Appendix………………………………………………………………………………34

8.1. A brief history of horses……………………………………………………………34

8.2. Why do we dream………………………………………………………………...35

8.3. How does Stretching change your body…………………………………………36
LIST OF FIGURES

Fig 1. Driving Simulator .................................................................11
Fig 2. Steering Wheel ..................................................................11
Fig 3. Driving Scenario 1 ..............................................................12
Fig 4. Driving Scenario 2 ..............................................................13
Fig 5. Driving Scenario 3 ..............................................................13
Fig 6. Titta calibration ...............................................................14
Fig 7. Titta Eye Images ..............................................................14
Fig 8. Mean Pupil Diameter by Audio Condition .......................20
Fig 9. Scatter Plot of Eye Gaze Location with Audio ..................21
Fig 10. Scatter Plot of Eye Gaze Location without Audio ..........22
Fig 11. Situational Awareness with Audio ..................................23
Fig 12. Situational Awareness without Audio ............................24
Fig 13. Number of Times the participant looked at the extreme 300 pixels .......................................25
1. INTRODUCTION

With the extensive use of in-car technologies producing new and possibly fatal distractions for drivers, distracted driving has become an increasingly severe issue in recent years. Even for a little period of time, drivers who take their hands, eyes, or minds off the road increase their risk of being in a fatal collision [1]. Many individuals now routinely listen to podcasts while commuting or running errands in their cars thanks to the broad availability of smartphones and in-car technologies that make it simple for drivers to access audio information. Podcasts are becoming increasingly popular while driving for a variety of reasons. For starters, podcasts are an engaging and enjoyable way to pass the time on lengthy rides, especially for single drivers. They can help to relieve boredom and give entertainment that is suited to individual preferences. Furthermore, many podcasts are instructional or informational, allowing drivers to learn new things while driving. The convenience factor is another reason for the popularity of podcasts while driving. With smartphones and other mobile devices becoming more widely available, it is now easier than ever to access and listen to podcasts while on the go. Many podcast apps allow users to pre-download episodes, allowing drivers to listen to their favourite programmes without using up their data quota or relying on a solid internet connection.

Concerns regarding the potential risks of distracted driving are raised by listening to podcasts. Drivers who are actively listening to audio content are mentally and intellectually focused on the content, which causes them to get distracted from the road in front of them. As a result, individuals could overlook vital audio and visual cues like horns, warning signs, and traffic signals that are essential for safe driving. Performing extraneous activities while driving, such as listening to audio content, might make it more difficult for drivers to maintain their focus on the road and respond to unforeseen circumstances. This is due to the fact that driving includes numerous cognitive processes that demand a lot of mental energy, such as visual perception, motor coordination, and decision-making. Drivers may not have enough cognitive resources to devote to
all of these activities while they are also processing audio input, which can result in mistakes, poor judgement, and delayed responses.

The amount of mental processing or effort needed to execute a task is referred to as the cognitive demand. The degree of difficulty of the concepts being learnt, the volume of information supplied, the complexity of the work, and the person's past knowledge and abilities can all have an impact. If the podcast is informative or educational, the listener may need to pay attention to complex ideas, retain information, and make connections with prior knowledge. This would increase the cognitive demand required to process the information. While driving, listening to a podcast can be a kind of cognitive distraction, which can divert the driver's focus from the road and raise the chance of an accident. Although if it doesn't need visual attention or physical manipulation, listening to a podcast can nonetheless use cognitive resources that might otherwise be utilised for driving-related tasks including observing the surroundings, seeing risks, and making judgments.

The use of audio content while driving has become increasingly common in recent years, with podcasts being one of the most popular choices. However, the potential impact of listening to podcasts on driving performance and safety remains a topic of concern for researchers and policymakers alike. To address this issue, this study aims to investigate the effects of listening to podcasts on driving performance using a driving simulator and gaze data. By conducting a pilot study with three participants, this research design seeks to shed light on the relationship between audio distractions and driving safety. Through careful experimentation and data analysis, this study hopes to provide valuable insights into how drivers can safely and responsibly engage with audio content while behind the wheel.
2. LITERATURE REVIEW

2.1 Previous Studies on Distracted Driving

The effects of distracted driving on new drivers are discussed by Klauer, S. G. et al.[2]. It discusses the connection between multitasking and the probability of collisions or near-collisions, especially for new drivers. This essay also emphasises distracted driving as a harmful behaviour that contributes to the high rates of road fatalities and injuries among young and inexperienced drivers. The study discovered that among rookie drivers, engaging in any secondary tasks while driving was much more likely to result in a crash or a near-crash. The study also discovered that whereas beginner drivers performed secondary activities more frequently with time, experienced drivers' incidence of high-risk secondary task performance did not alter over time.

The objective of McEvoy, Stevenson, M. R., & Woodward, Ms’ study was to determine the prevalence and types of distracting activities involved in serious crashes and to explore the factors associated with such crashes. According to the study, driver distraction was a factor in 13.6% of all crashes, with over 30% of drivers (433, or 31.7%) citing at least one distraction at the time of the crash. The main sources of distraction were chatting with other passengers, being unfocused, and external stimuli. The study found that distracted driving is prevalent, that it can result in crashes, and that the reported types of activities are diverse [3].

The main point of this study is to look at the prevalence and predictors of distracted driving behaviour among newly licensed teen drivers. Gershon, Zhu, C., Klauer, S. G., Dingus, T., & Simons-Morton, Bs’ study analyses data from Data Acquisition Systems (DAS) implanted in the private vehicles of 83 teenage drivers to document driving performance variables such as secondary task involvement and driving environment features. According to the study, teenagers participate in potentially distracting secondary activity in 58% of analysed road clips, with the most common forms of secondary jobs being interaction with a passenger, talking/singing (no passenger), external
Driving Simulator: Driving Performance Under Distraction

distraction, and texting/dialling the mobile phone. The study identified societal norms, peers' risky driving practices, and parental limits as major determinants of distracted driving behaviour among adolescent drivers. The study makes recommendations for interventions to prevent distracted driving behaviour [4].

This study [5] compared the effects of cognitive and visual distractions on driving safety and looked into how low-perceived-risk secondary tasks affected lateral driving performance. 17 seasoned non-professional drivers were enlisted for the study to take part in two different secondary tasks: a cognitive task including talking and a visual task requiring following vehicles. The study assessed how these tasks affected lane-keeping proficiency, lane deviation, and lane deviation growth rate. The research discovered that, in contrast to the control condition of no task, lane-keeping skills were actually improved under cognitive distractions like discussion. However, lane deviation and its growing rate during visual distractions, such as watching for oncoming cars, increased with the length of the distraction. The fact that lane departure increased much higher during visual than cognitive distraction suggests that visual distractions seriously compromised driving safety. These findings imply that drivers underestimate the dangers of visual activities and that visual distractions pose a greater threat to driving safety than cognitive ones. In order to decrease the incidence of traffic accidents brought on by distracted driving, the study advises that these findings be applied to the establishment of cutting-edge driving assistance technologies and enhanced professional driver training programs.

2.2 Use of Driving Simulators in Research

Konstantopoulos, Chapman, P., and Crundall, Ds’ study discusses the advantages and disadvantages of using driving simulators in research studies, particularly when investigating the effect of visibility on drivers' visual attention [6]. This study confirms prior findings that driving experience affects visual search, and it also uses a driving simulator to examine how visibility affects drivers' visual attention.
Similarly, Brookhuis, and de Waard, Ds’ study highlights the significance of a driver's mental burden being at an ideal level for adequate driving performance, as well as the difficulties associated with doing real-world research on this topic [7]. It emphasises the advantages of employing sophisticated driving simulators, which offer a lab-like setting with accurate settings and allow for the monitoring of drivers' mental workload through physiological indicators like heart rate and brain activity. It implies that the use of physiological measures is promising for capturing mental workload in simulator driving research by providing examples of prior psycho-physiological investigations carried out in driving simulators.

The goal of this study [8] was to compare the self-assessed driving skills, visual and cognitive capacities, and driving performance in various circumstances between young and older drivers. This was done using a driving simulator. The study's objectives were to identify the cognitive abilities—such as attention, executive functions, anticipation, planning, and mental flexibility—that pose challenges for elderly drivers and to investigate compensating techniques that would lower their risk of injury. According to the study, older drivers were less adaptable than younger drivers in adjusting the initial plan to avoid roadworks, but they made no errors in picking the right course of action. Elderly drivers also showed the ability to handle sudden occurrences when they were predictable, but they were shown to be potentially dangerous when events occurred outside of their visual area or when they were unpredictable. Elderly drivers on the driving simulator had no accidents, despite apparent declines in their visual exploration and cognitive abilities. According to the study, older drivers were able to implement suitable and efficient compensatory techniques to lower their chance of suffering an accident when operating a vehicle. The paper makes recommendations for further investigation into methods to improve these tactics and deepen our knowledge of the driving challenges faced by elderly drivers. This might assist senior drivers in developing coping mechanisms to get around their limits. The study's overall conclusion is that with the right interventions and compensating methods, senior drivers can maintain their driving competence.
This article [9] examines how quickly drivers react in a driving simulator environment, with a particular emphasis on young drivers under the age of 26, who are frequently at fault in collisions. Each participant in the study provided basic information, which was later examined using mathematical-statistical methods to determine the effects of gender, experience, and alcohol on reaction times. A smaller sample of drivers were asked to participate in driving simulations while under the influence of alcohol as part of the study's examination of how alcohol affects reaction times. The key benefit of utilising a driving simulator is that it enables researchers to model scenarios like drunk driving that could be undesirable in actual traffic. To determine the statistical significance of the findings, the study employed a variety of statistical techniques, including the one-sample t-test, paired-samples t-test, independent-sample t-test, and correlation analysis. With an emphasis on the impacts of alcohol, the study's main objective is to offer insights into the variables that affect drivers' reaction times and could possibly cause accidents.

This study [10] explores whether driving performance is impacted by loud music and whether this effect is mediated by mental effort. In both challenging and routine driving scenarios, the researchers tested participants' driving abilities in a driving simulator with and without music. The study discovered that listening to music while driving required more mental effort, proving that it can be a distracting aural stimulation. The study also discovered that drivers who listened to music had performance levels comparable to those of drivers who did not, indicating that drivers may cognitively counteract the distracting effects of music by managing their mental effort.

2.3 Use of Eye Tracker in Research

Stapel, El Hassnaoui, and Happee conducted a study using driving simulators and eye trackers to determine how accurately gaze behaviour can reflect driver awareness of specific road users [11]. The results of this study suggest that driver perception is more than just what they can
see straight ahead, and that monitoring drivers' awareness of individual road users can help improve their feedback.

The gaze scan method [12], automatically quantifies the size, length, and make-up of extensive lateral glance scans that drivers do as they approach a junction. The system recognizes lateral saccades and combines them with gaze scans, marking the beginning and finish of each scan in terms of time and eccentricity. By quantifying the quantity, direction, size, and time of gaze scans, the system significantly enhances previous eye tracking and mobility studies and helps us understand how people scan their surroundings.

Similarly, using remote eye tracking to measure the cognitive load of drivers in a virtual car while they engage in verbal dialogues [13]. The study combines driving performance data with cognitive load estimations based on physiological pupillometric data and finds a strong correlation between the two measures. The study also offers a novel pupillometric measure of cognitive strain that exhibits promise for monitoring variations in cognitive load over a period of several seconds.

Li, Huang, Z. (Joy), & Christianson, Ks’ study investigates the relationship between perceived advertising efficacy of tourism photos with text incorporated into natural landscapes and visual attention [14]. The researchers tracked participant gaze patterns as they viewed photos with various text features using eye-tracking technology. Additionally, participants were asked to respond to a questionnaire about how effective they thought the photos were as advertisements. The study looked at two variables: the amount of text messages (single vs. several) and the participants’ comprehension of the text language (understand vs. not comprehend). Regardless of whether participants understood the text language, the findings demonstrated that text within the landscapes of tourism pictures captured the majority of viewers' visual attention. Participants watched photos with text in a known language for a longer period of time than they did photos with text in an unknown language, and they watched photos with a single text message for a longer period of time than photos with several text messages. Participants also reported a higher perceived advertisement efficacy for travel photos with text in a recognized language. Overall, the research points to the
importance of text in tourism images in grabbing viewers' attention and enhancing their perception of the success of the advertisement, especially when the text is delivered in a familiar language and in a single message style.

In order to evaluate the impact of motion input on trainee performance, El Hamdani's research investigates the effect of motion cues on braking performance in driving simulators [15]. With the aid of an eye-tracking device, data from the driving simulator, and participant feedback, the study investigates how three different motion cue levels—"No motion," "Mild motion," and "Full motion"—affect braking smoothness and gaze fixation. The study contrasts two road conditions that include and exclude pre-braking warning indicators and speed feedback from the speedometer. The findings show that gaze fixation on the track and braking smoothness both benefited from a full degree of motion signals. Additionally, in all scenarios—without and with warning signs—participants were able to brake more gently from 5 to 0 ms in the final 240 m before the stop line, as opposed to the strongest braking from 25 to 0 ms produced under the conditions with no motion cues. The study also discovered that underestimating actual speed and focusing more on the speedometer were caused by a combination of the mild motion conditions and warning indications.

This study [16] sought to determine the effects of various musical genres on teenage drivers' driving habits and environment-scanning abilities in metropolitan settings. The study used a driving simulator and eye tracking glasses to gather information on the participants' behaviour while operating a vehicle while listening to various musical genres, including Croatian pop, international pop, metal, Balkan folk music, classical music, and no music. Balkan folk and metal music resulted in the highest average speed and the fewest glances at road signs, according to the study, which also found that other music genres and the no music condition had a similar effect on driving speed and visual scanning.

This study [17] examined the effects of listening to music and singing along to music while driving on driver performance and workload. To this end, twenty-one participants completed a
simulated drive with and without music, or while singing along to music, while also performing a peripheral detection task. The results showed that singing while driving was perceived as more mentally demanding and led to slower and more variable driving speeds compared to driving without music. Listening to music was associated with slower speeds and fewer lane excursions than driving without music, but both music conditions resulted in slower response times to the peripheral detection task and less deviation within the lane than the no music condition. Overall, these findings suggest that singing while driving can impair hazard perception and increase mental workload, but does not affect driving performance more than listening to music alone. However, drivers' attempts to compensate for the increased mental workload by slowing down may not be sufficient to prevent performance decrements.
3. METHODOLOGY

3.1 Research Design

The purpose of this study's research was to use a driving simulation experiment to investigate how podcast listening affects driving performance. This pilot study sought to enlist people who had experience driving, a current driver's licence, and had listened to audio while driving. Three volunteers in a pilot study who underwent a total of three trials were used in the study to accomplish this. The driving simulator that was used in this study to offer a controlled setting for assessing driving performance in various scenarios. The simulator has a steering wheel and was created to seem like a regular car. Curvy roads were included in the demanding driving scenarios to test the participants' car-controlling skills.

Each participant conducted three trials, each of which had a unique set of driving circumstances. Each driving scenario lasted four minutes, making the entire experiment last about 24 minutes. This length was chosen to keep participants interested in the simulation. During each trial, participants drove twice, once with audio and once without. At the conclusion of the trial, participants in the audio experiment were required to listen to a podcast and reply to questions about the audio.

The podcast was chosen to serve as a representative example of how listening to audio content while driving may actually occur in the real world. Questions based on the podcast's content were developed to make sure that participants were listening to it while operating a motor vehicle. Also, participants were advised to keep their attention on the road at all times and to avoid looking at the podcast screen until they were responding to questions.

Eye-tracking technology was used to record the gaze information during each trial. Eye movements were tracked by the eye-tracking device, allowing comparisons to be made across trials with and without podcasts. The capacity of participants to focus on the road and their surroundings while listening to podcasts while driving was examined using the eye-tracking data.
This study aims to explore the association between listening to audio content while driving, particularly podcasts, and any possible effects it may have on driving safety. Audio material has grown in popularity among drivers recently, and distracted driving is a severe problem that puts everyone's safety at risk.

Fig 1. Driving Simulator
Fig 2. Steering Wheel

3.2 Technologies and Implementation

3.2.1 Matlab

Since MATLAB offered smooth connection with the Tobii Pro Fusion Eye Tracker and the Logitech G29 Wheel, I chose to use it to code my driving experiment. I was able to capture gaze data quickly and use the Logitech G29 wheel to drive the driving simulator thanks to MATLAB's support for these particular devices. Additionally, I was able to modify and improve the experiment design to meet the objectives of my particular research thanks to MATLAB's flexible programming language. Overall, MATLAB was the best option for this driving experiment due to its interoperability with the required hardware and programming freedom.
This MATLAB program makes use of Psychtoolbox to open a window, start a video, and let the user move a dot across the screen using a Logitech G29 wheel. The program initially launches a window and loads the movie named in the variable "moviename." It then sets the initial position of a dot on the screen. The code then enters a loop where it continuously gets the next frame of the movie and displays it on the screen until the end of the movie. Within the loop, it also retrieves the position of the Logitech G29 wheel and calculates the movement of the dot based on the position of the wheel. The logic for calculating the movement of the dot involves normalising the joystick position to a value between -1 and 1 and then multiplying it by a speed factor. If the absolute value of the normalised joystick position is less than 0.05, the dot is considered to be at rest and the movement is set to 0.

Fig 3. Driving Scenario 1
3.2.2 Titta

Titta is a piece of software that makes it simple to incorporate Tobii eye trackers into studies created in MATLAB using PsychToolbox. It offers a user interface for using the eye tracker and gives access to all configuration and functional options for the supported Tobii eye trackers.
When Titta.calibrate() is used, a display consisting of a blue circle and a stylized head indicating the participant's current position and orientation is shown. The head display, which functions as a mirror, offers real-time pupil-size data. The person must position their head so that it is perpendicular to the blue circle. For precise placement, the reference point can be chosen. The eye images can be seen on the screen by selecting the toggle button for the eye images. Once the participant is positioned correctly to ensure reliable tracking across the whole width of the screen, they are asked to look at the four fixation targets in the corners of the screen.

It is required to link the times of events during the experiment to particular episodes in the eye-tracking data in order to analyse the recorded gaze location signals. This is commonly accomplished by maintaining a timestamped log file on the experiment computer that contains statements indicating when an event of interest occurred. Through the Titta.sendMessage() function, which adds its own timestamp for the message representing the moment the function was invoked, Titta offers message log capability.

![Fig 6. Titta Calibration](image1.jpg) ![Fig 7. Titta eye images](image2.jpg)

Titta provides users with a variety of data saving options, including using Titta.saveData() to save all data from a recording session directly to file, Titta.collectSessionData() to get all data for
the user to store themselves in a file, or consuming individual data streams and saving them to file for more flexible applications [18].

3.2.3 PsychToolbox

Psychtoolbox is used to display a video file and track user input. The Screen function from Psychtoolbox is used to open a window on the selected screen, and open the video file. The GetMovieImage function is used to retrieve the next frame of the video, and the DrawTexture function is used to display it on the screen. The FillOval function is used to draw a red dot on the screen at the current position of the dot. It takes several arguments: the window to draw in (win), the colour of the dot, and the dimensions of the oval.

3.3.3 Tobii Fusion Pro

Tobii fusion pro eye tracker was used for the experiments, The Tobii Fusion Pro Eye Tracker is a sophisticated eye-tracking system that utilises Tobii's patented 3D eye model to deliver high-quality gaze data. Equipped with two eye-tracking cameras, it is capable of capturing up to 250 images per second, ensuring that eye movements are tracked with high accuracy and precision. The system's bright and dark pupil illuminators are designed to provide superior data regardless of eye shape, ethnicity, or age. Additionally, the Tobii Fusion Pro Eye Tracker has fully embedded processing and illumination control, allowing it to operate autonomously and maintain tracking robustness in different lighting environments. The system is also capable of capturing pupil data at the same sampling rate as the gaze data, ensuring a complete and accurate analysis of eye movements. An eye-tracking experiment is set up and executed by a MATLAB script utilising the Titta Toolbox, a MATLAB toolbox for interacting with Tobii eye-trackers. The script specifies a number of parameters and settings for the experiment, including the timing of the stimulus.
presentation, the background and fixation cross colours, and whether animated calibration should be used. The Tobii eye-tracker is then configured by the script using the Titta Toolbox and the eye-tracker's default settings for the Tobii Pro Fusion. Additionally, it alters the setup and calibration interfaces' colours to conform to the earlier scripted specifications.

The script enters dummy mode, which simulates the behaviour of the eye-tracker without really connecting to it, if the variable dummy_mode is set to 1. Without the requirement for a real eye-tracker, this is helpful for testing the experiment. In the event that the dummy_mode variable is set to 1, the script then conducts a calibration procedure. In order for the eye-tracker to record the participant's gaze location at each calibration point, the participant must stare at each point in turn while calibration points are displayed on the screen. If the value of doBimodalCalibration is set to true, the calibration process is carried out independently for each eye. The script begins the main experiment loop after the calibration step is finished. This loop displays a fixation cross for the amount of time specified (fixTime), then a stimulus for the amount of time specified (imageTime). The eye-tracker is used to capture the participant's gaze during the stimulus presentation. The loop keeps going until all of the stimuli have been shown.

3.3.4 Logitech G29 Steering Wheel

The driving experiments for this research utilised a Logitech G29 steering wheel. This steering wheel has a 900-degree rotation, force feedback, and is specifically made for racing games and simulations. The wheel is made of high-quality materials and has a comfortable grip, which allows for precise and responsive steering during the driving tasks. In addition, the force input from the wheel improved the realism of the driving simulation, increasing the participants' interest in the activity. Driving studies were successfully carried out using the Logitech G29 steering wheel, which also offered the participants a high level of control and realism.
3.3 Eye Tracking Data

There are several elements in the eye tracker data created in the .mat file that offer crucial details about the eye tracking experiment. The 'TobiiLog' component is a structure with 62 fields that deal with calibration, data, settings, and system information for the eye tracker. The 'calibration' component is a cell that houses data on the eye tracker's calibration. The 'data' component is a structure that holds details about the eye tracking data gathered throughout the experiment, including eye movement coordinates, gaze positions, and pupil size. The 'expt' component is a structure that contains details on the experimental setup, such as the stimuli given to the subjects. The 'geometry' component is a structure that details the design of the eye tracker, including the placement of the eye camera and the screen. The "messages" component is a cell that records details about the events that have taken place during the experiment, such as the start and end of the presentation of the stimuli. The Settings' component is a structure that holds details about the calibration and sampling parameters of the eye tracker. The 'systemInfo' component, which is also a structure, offers details about the computer system utilised for the eye tracking experiment, including the operating system and RAM size. When seen as a whole, these elements give a thorough overview of the eye tracking experiment, and their analysis can reveal information about the participants' eye movement patterns and task performance.

Last but not least, a script reads eye tracking data from a .mat file and extracts information like device time, system time, gaze coordinates, origin, and pupil diameter. The script also reads messages and their associated timestamps from a different cell array. The script then compiles all of the extracted parameters, together with the appropriate system time and device time, into a single matrix. The messages are then added to this matrix in the order of their timestamps, with each message appearing right before the subsequent data sample. The combined matrix together with all the messages and parameters are then written to a CSV file. This script's goal is to prepare the eye tracking data for analysis and visualisation in the research project's later stages. In essence, the
script makes sure that every data sample is correctly timestamped and that every message is in line with the data samples it refers to.

### 3.4 Data Analysis

Because of Python pandas' powerful data processing capabilities and user-friendliness, I decided to use it for my study of eye tracking data. It was simple to clean and preprocess my data because the library offers a broad variety of data manipulation methods like merging, filtering, and grouping. In addition, pandas provides a variety of statistical operations and visualisation tools that help me see the underlying trends and patterns in my data. Overall, I found that processing, analysing, and visualising the eye tracking data with Python pandas substantially expedited my workflow.
4. ANALYSIS

4.1 Pupil Diameter

The mean pupil diameter measurements of two groups—one that listened to audio (all_audio) and another that did not (all_no_audio)—are compared using a two-sample t-test. The statistical test examines the null hypothesis that there is no difference between the two groups. In other words, it determines whether a substantial difference exists between the means of two groups, regardless of the difference. The test yields a p-value, which, supposing the null hypothesis is true, indicates the likelihood of detecting a difference as extreme or more extreme than the one observed. The null hypothesis is rejected and it is determined that there is a significant difference between them if the p-value is less than a preset significance level, often 0.05.

4.1.1 Results of the t-test

| Max pupil diameter with audio: 6.8330078125 |
| Max pupil diameter without audio: 4.184188842773438 |
| t-statistic: -75.86186060301344 |
| p-value: 0.0 |

The t-test= -75.861, p < 0.001 indicates statistically significant difference between the groups that listened to audio (all_audio) and those that did not (all_no_audio) in terms of the mean left pupil diameter measurements.

The group that listened to audio had a maximum left pupil diameter measurement of 6.83 mm, whereas the group that did not listen to music had a maximum measurement of 4.18 mm. This implies that participants in the audio group had, on average, larger pupils than participants in the no-audio group.

The difference between the means of pupil diameter with and without audio is quantified by the t-statistic. The t-statistic in this instance is -75.86, which has a very high absolute value. This
Driving Simulator: Driving Performance Under Distraction

shows that there is a substantially bigger difference in mean left pupil diameter between the two groups than would be predicted by chance alone. The p-value is a measurement of the likelihood that such a significant variation in mean pupil diameter between the two groups could have been discovered by accident. The p-value in this instance is 0.0, which is below the usual significance level of 0.05. This indicates that there is a statistically significant difference in the mean left pupil diameter between the two groups, and it is highly improbable that this difference is accidental.

![Mean Pupil Diameter by Audio Condition](image)

**Fig 8.** Mean Pupil Diameter by Audio Condition

**4.2 Gaze Patterns with Audio and Without Audio**

A scatter plot can be created to show where the participant is gazing on the simulator screen while they are driving by tracking the x and y coordinates of their gaze points. The participant's
most focused attention on the screen may be determined using this scatter plot, as well as how this varies in response to various audio stimuli. The scatter plot shows the gaze points' x and y coordinates as distinct points on a two-dimensional plane, with the x-axis denoting the screen's horizontal dimension and the y-axis its vertical dimension. We can see the user's awareness during audio playback and how it shifts in response to various audio stimuli thanks to this display. By comparing the scatter plots generated with and without audio, we can determine how the presence of audio affects the user's attention and gaze behaviour.

![Scatter Plot of Eye Gaze Locations with audio](image)

Fig 9. Scatter Plot of Eye Gaze Locations with audio
The participant's gaze behaviour while operating the simulator with and without audio was significantly different, as seen by the scatter plot created from the eye tracking data. Particularly, the participant's attention is mostly on the path ahead while listening to the podcast. The scatter plot, which reveals a concentration of gaze points in the area of the screen's centre, supports this. The participant's gaze is more dispersed and dispersed throughout the display without music, showing less focused attention on any one specific place.

4.3 Defining an Interest region

Awareness is a key component of safe driving since it affects a driver's capacity to recognize and respond to potential road hazards. A specific region of interest for analysis and a study of driving behaviour with and without audio cues are two methods for measuring driver awareness.
The usage of audio cues may have affected the driver's situational awareness as shown by a comparison of the two circumstances in the pie chart below.

**Fig 11. Situational Awareness with audio**

The participants tended to stare outside the centre of the screen more frequently when audio was not playing throughout the experiment than when it was, according to an analysis of the gaze data collected.
4.4 Extreme Left and Right Regions of the display

This analysis's goal is to determine how frequently the participant viewed the screen's extreme left and right corners both with and without audio during the experiment. The first 300 pixels from the left edge and the final 300 pixels from the right edge of the display are referred to as the left and right regions of interest, respectively. Prior to printing the results, the algorithm counts how many times the participant independently examined these parts with and without audio. This information can be used to determine whether the participant's gaze behaviour toward certain areas of the display was affected by the audio in any way.
Fig 13. Number of Times the participant looked at the extreme 300 pixels

These numbers represent the number of times participants glanced at the display's 300 left- and rightmost pixels both with and without audio. It is clear from the data that participants paid greater attention to the extremities when there was no audio present as opposed to when there was. In particular, participants looked at the first 300 pixels to the left 1,140 times without music and just 591 times with audio. In a similar vein, participants looked at the top 300 pixels to the right 395 times without audio and only 103 times with audio. The lack of audio in the simulation may have increased participants' awareness of their surroundings and caused them to glance at the left side of the screen more frequently, where oncoming vehicles would be, more often.
Participants may have been more alert without the distraction of the podcast if they paid greater attention to the extreme left and right portions of the screen when there was no podcast. When driving, it's crucial to stay alert and constantly scan the area to identify any potential dangers. Without audio, participants appeared to be more aware of their surroundings and actively scanning for potential threats since they focused more on the screen's edges. In contrast, participants of the podcast group may have been more preoccupied with the audio cues and less aware of their surroundings, which may have increased the risk of accidents.

4.5 Podcast Trial Survey Response

The average proportion of questions with the correct answers was 82.05%, according to the findings. Being able to appropriately respond to the questions is a good sign that listeners were paying attention to the podcast while behind the wheel. The participants were cautioned to always keep their eyes on the road and to avoid staring at the podcast's source, which is equally important to note.
5. RESULTS AND DISCUSSIONS

5.1 Interpretation of Results

The t-test results indicate that there is a statistically significant difference between the two groups (podcast vs. no-podcast) in terms of the mean left pupil diameter. On average, the group who listened to the podcast had bigger pupils than the group who did not. Additionally, the audio group's maximum pupil diameter was larger than the no-audio group's. The fact that the participants were driving on a simulator leads us to believe that the audio group's greater pupil diameter may signify a higher degree of cognitive load, presumably as a result of the added work of processing auditory information (i.e., listening to the podcast). Their ability to focus and concentrate may have decreased as a result of the increased cognitive load, which could affect how well they drive.

The participant's attention and focus are significantly impacted by the presence of audio stimuli, according to the scatter plot analysis of the participant's gaze behaviour while operating the simulator. Particularly, the scatter plot demonstrates that when listening to the audio, the participant's sight is primarily focused on the road ahead. However, in the absence of audio, the scatter plot demonstrates that the participant's general awareness is raised, with their attention spots more diffused and spread throughout the screen. This means that the lack of audio cues may encourage the driver to be more aware and observant to their surroundings, rather than focusing just on the road ahead. In conclusion, the scatter plot analysis provides important insights into how the presence or absence of audio stimuli can alter the driver's attention and awareness while driving.

The absence of podcasts may have had a favourable impact on the participant's attention and situational awareness while they were operating the simulator vehicle, according to a study of the gaze data that was gathered. Participants were more likely to gaze away from the centre of the screen when audio was not playing, which shows that they were more focused on the road and any potential dangers. It follows that driving without podcasts may increase driver awareness and safety.
as they focus more on the road surroundings, particularly the areas outside of their immediate range of vision.

According to the findings, the inclusion of audio in the simulation may have influenced participants' gaze behaviour and awareness of their surroundings while driving. The study of gaze data revealed that when there was no podcast, individuals looked at the screen's extremities more frequently, presumably indicating increased vigilance and attention to possible threats. The numbers show that, in the absence of noise, participants were more likely to glance to the left of the screen, where approaching automobiles would be. This would mean that the lack of podcasts made it easier for participants to concentrate and actively monitor their surroundings for hazards. However, using podcasts may have caused users to become more focused on the podcast and less alert of their surroundings.

5.2 Limitations of the study and Future Scope

First off, the pilot study's use of a driving simulator might make it harder to generalise the findings to actual driving situations. The behaviour of participants in a simulated environment can be different from how they would act on real roadways, potentially reducing the external validity of the study. To learn more about how listening to podcasts affects driving safety, future research should take into account reproducing the study in actual environments. It should be noted that the driving simulation was carried out in a controlled laboratory environment, which might not accurately reflect real-world driving conditions, is one limitation of this study. For instance, it's possible that the illumination in the lab doesn't precisely replicate the lighting on the road, which could affect how correctly the measurements of the participants' pupil diameter are taken. By running the simulation in a more realistic environment, such as on a confined course with varying lighting conditions, future studies may be able to overcome this issue.

Another drawback is that the study only looked at how one particular type of podcast affected attention and performance while driving. This study did not examine the potential effects of
various forms of audio material on driving safety. The study also didn't look into any potential variations in how audio content would affect drivers of different ages or experience levels. Future studies could fill in these knowledge gaps by analysing a range of audio content and studying the potential variations in impacts on other demographic groups.

The use of eye-tracking technology in a driving simulator may not accurately replicate the complexity of real-world driving, even though the study discovered substantial changes in gaze behaviour between those who listened to audio and those who did not. For instance, the simulator did not incorporate elements that can affect drivers' attention and driving ability, such as traffic congestion or unforeseen road conditions. Future research could overcome this restriction by conducting tests in real-world driving scenarios and accounting for outside factors that might affect the outcomes.

In addition to the limitations and future research directions mentioned earlier, there are several other aspects that deserve consideration for further investigation. Firstly, the current study had limited diversity in the collected data, particularly in terms of the participants' age groups, driving experience, and distance driven. It is important to address this limitation by including a more diverse sample in future studies. Moreover, during further discussions, some individuals mentioned that listening to podcasts actually helped them concentrate on the road during long drives. Exploring this perspective and examining potential variations in the effects of podcasts on different driving contexts and individuals would provide valuable insights. Looking ahead, it would be worthwhile to develop an in-car system that incorporates eye-tracking technology, which could serve as an alert mechanism to notify drivers when their attention is diverted from the road. Such a system would provide real-time feedback and contribute to enhancing driving safety. By integrating advancements in eye-tracking technology with intelligent algorithms and sensory inputs from the vehicle, this system could detect signs of distracted driving and issue timely alerts to mitigate potential risks.
Furthermore, it would be beneficial to expand the experiments beyond the currently conducted daytime sessions. Including late-night driving experiments, when individuals are more prone to drowsiness and reduced alertness, would provide valuable insights into how audio content, such as podcasts, impacts driving performance under different physiological conditions. This would help to further understand the hypothesis in a broader context and highlight potential implications for road safety interventions. Lastly, leveraging the data and insights collected from these experiments, one promising avenue for future research is the development of a machine learning model. By applying advanced statistical techniques and incorporating the wealth of data captured during the experiments, a machine learning model could be created to predict and analyse the effects of various audio content on driving safety. This model could contribute to identifying patterns, factors, and potential risks associated with distracted driving, ultimately leading to the development of targeted interventions and strategies to promote safer driving behaviours.
6. CONCLUSIONS

The goal of this study was to use a driving simulator experiment to explore the effect of podcast listening on driving performance. In a pilot study, three participants participated in three trials, each with a distinct driving situation. Each trial consisted of driving twice, once with audio and once without, followed by questions regarding a podcast. During each trial, eye-tracking technology was utilised to gather gaze information, data analysis was performed to compare the findings of the podcast and no-podcasts groups. According to the findings, podcast listening can impair situational awareness and attention to surroundings, whereas the absence of audio stimuli can lead to heightened vigilance and focus on the road ahead.
REFERENCES


8. Appendix

8.1 Podcast Quiz

8.1 brief History of Horses

https://forms.gle/SGfNgx3UErnTqFuN8

A brief history of horses

* Indicates required question

1. Horses appear more than any other animal in cave paintings *

Mark only one oval.

☐ True
☐ False

2. Where did horses disappear from? *

Mark only one oval.

☐ America
☐ India
☐ Africa
☐ Eurasia

3. People began breeding horses for? *

Tick all that apply.

☐ Less aggression
☐ Speed
☐ Enhanced endurance
☐ Shiny coats
☐ Greater weight bearing abilities

4. Which empire developed horseback postal relay system *

Mark only one oval.

☐ Roman Empire
☐ British Empire
☐ Mongol Empire
☐ Ottoman Empire
8.2 Why do we Dream

https://forms.gle/ehX9i8EyLMZUt6s3A

Why do we dream?

1. How did the Mesopotamian kings record their dreams? *
   Mark only one oval.
   - Books
   - Leaves
   - Wax Tablets
   - Carvings

2. What did Sigmund Freud's propose about dreams *
   Mark only one oval.
   - He proposed that humans are born with a blank slate and all knowledge is acquired through experience.
   - He proposed that our dreams are a collection of images from our daily conscious lives.
   - He proposed that personality is determined by genetics and cannot be influenced.
   - He proposed that mental illnesses are caused by physical imbalances in the brain.

3. Reverse learning holds that while sleeping, mainly during REM sleep cycles your neocortex reviews the neural connections and dumps the unnecessary ones *
   Mark only one oval.
   - True
   - False

4. What does the continual activation theory propose? *
   Mark only one oval.
   - The continual activation theory proposes that dreams are a way for your brain to simulate potential future scenarios, helping you prepare for possible threats or opportunities.
   - The continual activation theory proposes that dreams are a byproduct of random firing of neurons during sleep, without any particular function or purpose.
   - The continual activation theory proposes that dreams are a manifestation of your subconscious desires and fears, providing insight into your deepest motivations and anxieties.
   - Dreams result from your brains need to constantly consolidate and create long term memories to function properly.

5. The podcast connects dreams to healing *
   Mark only one oval.
   - True
   - False
8.3 How Stretching Actually Changes your Body

https://forms.gle/ehX9i8EyLMZUt6s3A

How stretching actually changes your muscles?

* Indicates required question

1. Why do athletes stretch before an activity *
   Mark only one oval.
   - [ ] To avoid muscle strains and tears
   - [ ] To cool down their core temperature
   - [ ] To improve mobility during the activity
   - [ ] To reduce lactic acid build up

2. Which of the following stretching techniques was mentioned? *
   Tick all that apply.
   - [ ] Foam rolling
   - [ ] Dynamic stretching
   - [ ] Isometric stretching
   - [ ] Static stretching
   - [ ] Passive stretching

3. Improved flexibility reduces the chance of incurring a certain types of muscle injuries? *
   Mark only one oval.
   - [ ] True
   - [ ] False

4. Frequent stretching also makes last changes to your brain? *
   Mark only one oval.
   - [ ] True
   - [ ] False