# DRIVER DISTRACTION AMONG COMMERCIAL VEHICLE OPERATORS: A STUDY USING A DRIVING SIMULATOR TO ENHANCE CONTROL

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**Abstract –** Driver distraction continues to be a topic that is regularly at the forefront of public discussion concerning safety on America's roads and highways. This paper reports the simulator application and experimental design for a study sponsored by the U. S. Department of Transportation's Federal Motor Carrier Safety Administration, which attempted to create a unique approach to studying driver distraction among CMV operators. The results of the study found that engaging touchscreen devices (MP3 players) led to over three times the level of cognitive distraction, while cell phones caused two to three times greater cognitive distraction than the baseline scenario. In addition, the study validated previous scholars' research claims about the usefulness of driving simulators and provided next steps for future research efforts.

**Key words**: Distracted Driving, Driving Simulation, Commercial Motor Vehicles

## 1. Introduction

This paper explores a study performed at the University of Central Florida's Institute for Simulation and Training. This study developed a method for quantifying how different distractors affect driving performance. The researchers specifically measured changes in driving performance resulting from internal and external distractors to the vehicle. This study uses two different electronic devices as internal distractors and when external distractors were present, researchers used three types of external distractions—two work zones and an accident—to affect the driving performance of CMV Operators. The following sections will describe the developed research methods and the utilized distracted driving performance measures.

## 2. Background

Distraction was identified by the U.S. Department of Transportation in the late 1970s as a "contributing factor to motor vehicle crashes in reviews of accident causation" [Tre1, Zai1, Jon1]. In 2000, the National Highway Traffic and Safety Administration (NHTSA) expanded on this assertion with updated studies employing advanced statistical and technological analysis. The NHTSA went as far as to say that, "driver inattention is one of the most common causes of traffic crashes" [Ran1]. The level of distracted driving related crashes remains consistent over the past two decades. Articles from over a decade ago attempted to place the number of reported crashes caused by driver distraction to be around 25% of all accidents [Zai1, Ran1]. with other works asserting the number is between 35-50% [Sus1, Wan1].

Different avenues of research into distracted driving abound such as analytical statistical investigations of crash reports, naturalistic, and simulation-based studies. These research methods produced a greater understanding of the three main types of distractions that occur while operating a motor vehicle: visual, cognitive, and manual. Visual distraction is any observation that takes your attention off the task of driving. Cognitive distraction is mental processes that distract you from driving and slows your reactions. Lastly, manual is any action that takes your hands off the wheel. Numerous studies point out that all of these distractions reduce driving performance,

leading to traffic collisions [Cai1, Hor2, Str1, Str2, Str3, Str4].

Virtual reality investigatory approach became more common a decade ago and uses driving simulators to place participants in realistic yet safe experiments. Driving simulators are able to prompt participants with multiple distractions in an unlimited number of environments, without exposing participants to actual dangerous situations. Works involving driver simulators proved the viability of using simulators as a tool to view risky behaviour among participants [Gre1, Fis1, Pra1, Cha1, Mut1].

# 3. Methods

The research team conducted the project with 27 Commercial Motor Vehicle (CMV) operators as our participants. All participants were required to have their Commercial Driver's License (CDL) a minimum of two years. Unexpectedly, the participants on average had their CDL's for twenty years. Subsequently, the participants had over a combined 500 years of driving experience. The participants had an average age over 35 years old, consisted primarily of male drivers, and employed by a variety of companies in the greater Central Florida area.

# 4. Measures

The researchers used five measures to analyse the participants driving performance. The driving performance measures were: hazardous speed, dangerous braking, collisions, lane deviations, and off road. Each occurrence of the aforementioned measures counted as one performance error point. Tabulating each type of five measures separately, researchers summed the five measures into a total performance error for each scenario per participant. The measures were dictated by the legal definitions found in the 2012 Florida Drivers Handbook [Fla1].

Researchers also included a demographic and study experience survey to catalogue participants' reaction to the simulation.

# 5. Equipment

## 5.1. Driving Simulator

Since the participants in this experiment were highly trained and experienced professionals, the research team decided to use a high fidelity driving simulator to provide realistic feedback. The driving simulator used was the L-3 Mark III, which features a motion platform with six degrees of freedom, two LCD side mirrors, and three projectors creating life size images in front of the fully functional truck cabin. The simulator's high fidelity combined with the safety procedures allowed for a low rate of simulation sickness among this group of experienced professionals.

## 5.2. Hand-Held Devices

All participants used the same touchscreen Mp3 player, which researchers provided. To mitigate any confounds that might arise from varying touchscreen Mp3 players; the researchers preloaded an iPod Touch. This touchscreen Mp3 player was loaded with a variety of song tracks and organized them into specific playlists. In scenarios 3 and 7, participants followed embedded instructions from the songs, which told the participants various tasks to perform on the Mp3 player. In scenarios 4 and 8, participants selected from a set of songs to have playing during the experiment. The demographic survey asked a several questions, which allowed researchers to determine each participant's familiarity. In the results section, the researchers discuss the effect of iPod ownership within the sample.

This study also required the use of a cell phone and since participants were already learning to manipulate the touchscreen Mp3 player, researchers allowed them to use their personal cell phone. All of the participants used only the phone function of the cell phone in this research. Researchers did not allow participants to use "hands free" devices, Bluetooth, or phone accessories in this research. Participants made phone calls to the researchers, and other times the participants received phone calls from the research team at predetermined positions.

## 5.3. EEG/ECG

To assist in further study of the experimental scenarios, the research team used a ten channel dual machine "B-Alert" Electroencephalogram (EEG) and Electrocardiography (ECG) made by ABM. The data and findings from this equipment will be addressed in another paper.

## 5.4. Video Recordings

To capture the driving performance of the participants the research team recorded several videos for each scenario. The cameras recorded a video of the participants inside truck cabin and a video of the room surrounding the simulator while driving. Additionally, the research team recorded a helicopter view of the participant's truck inside

the computer simulation. The researchers used these videos to obtain the participants performance error scores.

The researchers digitally recorded videos of the experiment to a secure drive to promote green and sustainable research. The videos were all simultaneously recorded in real-time and saved between scenarios. This allowed the research team to see and hear the participants during the entire experiment. To communicate with the participants the research team used a strategically placed hand radio to give instructions. The cameras and radio functioned as an intercom system, which also increased the study's safety protocol for the drivers. A team member was standing by at the back of the room to render immediate assistance as added safety.

## 6. Design

The research team developed computer simulations in L-3 Scenario Builder for the experimental scenarios. Each of the eight scenarios simulates the same stretch of a highway with additional traffic present but none entering or exiting the roadway. To minimize fatigue, each scenario contained only two distraction areas. Researchers would implement the variables only within these three separate areas on the highway. The external distractions included common aspects of work zones with different looking traffic. The participants began by merging onto the highway, which was always in the same direction to preserve the same level of task complexity. To keep the effect of the external scenes balanced the number of stationary vehicles, moving vehicles, lights, and pedestrians were equal in both kinds of work zones. The work zones used features observed from real scenes that follow in accordance with Florida State law. The MPH was displayed on screen, and collisions resulted in a temporary text notification on the screen and driving continued.

**Table 1: Scenario Configuration**

| | Distraction Area 1 | Distraction Area 2 |
|---|---|---|
| **Scenario 1 (Control)** | ➢ No external distractors<br>➢ No internal distractors | ➢ No external distractors<br>➢ No internal distractors |
| | | |
| **Scenario 2** | ➢ No external distractors<br>➢ Received Phone Call | ➢ No external distractors<br>➢ Returned Phone Call |
| | | |
| **Scenario 3** | ➢ No external distractors<br>➢ Active Mp3 use only | ➢ No external distractors<br>➢ Active Mp3 use only |
| | | |
| **Scenario 4** | ➢ No external distractors<br>1. Silenced Mp3 music<br>2. Received Phone Call<br>3. Resumed Mp3 music | ➢ No external distractors<br>1. Silenced Mp3 music<br>2. Received Phone Call<br>3. Resumed Mp3 music |
| | | |
| **Scenario 5** | ➢ Work Zone (construction )2<br>➢ No internal distractors | ➢ Work Zone (vehicle accident)1L<br>➢ No internal distractors |
| | | |
| **Scenario 6** | ➢ Work Zone (construction )1R<br>➢ Received Phone Call | ➢ Work Zone (vehicle accident)1L<br>➢ Returned Phone Call |
| | | |
| **Scenario 7** | ➢ Work Zone (construction) 1L<br>➢ Active Mp3 use only | ➢ Work Zone (construction )2<br>➢ Active Mp3 use only |
| | | |
| **Scenario 8** | ➢ Work Zone (construction )1R<br>1. Silenced Mp3 music<br>2. Received Phone Call<br>3. Resumed Mp3 music | ➢ Work Zone (construction)1L<br>1. Silenced Mp3 music<br>2. Returned Phone Call<br>3. Resumed Mp3 music |

## 7. Results

The data summary includes an analysis of the survey data and driving performance error data. Participants filled out a demographic survey at the beginning of the experiment. The demographic survey gathers relevant characteristics about the participants. This includes driving experience and experience with the internal distraction devices. Additionally, researchers administered a repeated Participant Assessment Survey to obtain feedback about the experiment.

These surveys showed that participants enjoyed the experience and felt immersed in

the simulation due to the fidelity of the experiment.

Previous studies, like Chisholm and Horrey's works, show that touchscreen Mp3 players and cell phones [Chi1, Hor1, Hor2] are detrimental to driver performance and attention. In this study, researchers expressed decreases in participants' performance as increases in performance errors.

*Hypothesis-1*: Distractions will, on average, cause a significantly higher number of driving errors than when no distractions are present.

*Hypothesis-2*: Multiple distractions will cause significantly more errors on average.

*Hypothesis-3*: Internal distractors such as the cell phone and Mp3 player will cause significantly more driving errors than external distractions such as work zones.

## 8. Data Analysis

To guard against practice effects, learning curve, or fatigue, the researchers randomized the sequence of the scenarios for each participant in order to counterbalance the study. The research team established a naming convention of "Run number" that represents the order of the scenarios. Each participant started the experiment on Run 1 and ended on Run 8, although to the research team each run was a different scenario. To keep track of which scenario was happening and in what order, the team created a table style list for each participant. These tables listed the run numbers sequentially and aligned them with the corresponding scenarios.

Multiple t-tests compared the chronological sequence of the scenarios. Researchers wanted to see if there is any significant difference, increase, or decrease in the average of errors between run 1 through run 8. For instance, the tests results show that there is no sufficient evidence to conclude that the total average of errors in run 1 and run 8 are statistically different (t-value=-1.17, p-value=0.249), neither increased from run 1 to run 8 (t-value= -1.17, p-value=0.124) nor decreased from run 1 to run 8 (t-value= -1.17, p-value=0.876). The results delineate the availability of a significant fatigue bias or a learning factor. The average number of errors per run is shown in FIGURE 1.

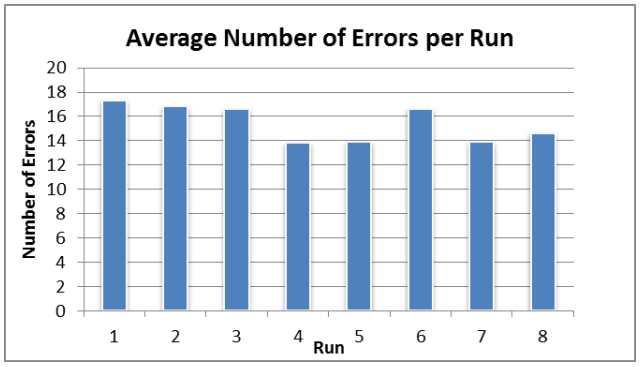


**Figure 1: Average Number of Errors per Run**

Scenarios 2-8 contained the three distracting factors (cell phone, touchscreen Mp3 player, and an external events) and their combinations. FIGURE 2 is a bar graph of the average of the total number of driving errors per scenario and variance.

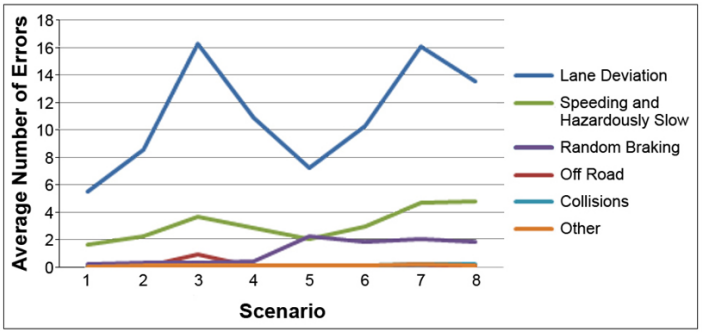


**Figure 2: Average Total Errors per Scenario**

Before comparing the scenarios, a review of the residuals showed the data after a natural logarithm transformation follows a normal distribution. A multiple one way within subject ANOVA tested for the existence of a significant difference between the eight scenarios. The ANOVA results revealed that at least one scenario was significantly different from the rest of the scenarios (F-value=25.23, p-value=0.000).

Knowing there are some statistical differences within the data set, several comparisons of the eight scenarios were conducted for significances. To account for the overall probability of type I error, multiple Tukey's test comparisons were employed on a 95% confidence level, the results were as follows:

*Hypothesis-1* is supported by comparisons one through eight, which means every distractor, internal and external, caused a significantly higher average number of driving errors than driving without a distractor.

*Hypothesis-2* is inconclusively supported by comparisons nine, ten, and eleven, meaning

the presence of multiple distractors does not always result in more distraction.

*Hypothesis-3* is inconclusively supported by comparisons twelve, thirteen, and fourteen, meaning internal distractors are not always higher than internal distractors.

## 9. Discussion

Compared to scenario 1, all distractors including the combination of distractors (scenarios 2-8) resulted in significantly more errors during the driving task. This suggests that compared to having no distractors, driving errors will increase with the addition of a cell phone, Mp3 player, external event, or any combination of the three. Moreover, in scenario 3 and 7, participants were required to interact actively with an Mp3 player, as opposed to simply listening or turning the volume up and down. The sustained use of an Mp3 player showed the highest error rates. Researchers have attributed these deficits in driving performance to the prolonged glances away from the road required to manipulate an Mp3 player [Chi1, Din1]. Additionally, this finding is congruous with previous research that more complex Mp3 player tasks decrease driver performance when compared to less complex Mp3 player tasks [Chi1].

This study was not without complications and challenges. One such limitation was the inability to garner a larger sample size of commercial motor vehicle operators. Expert drivers in the field are limited in number and their time is expensive. Additionally, representatives from the Florida Trucking Association expressed concern over possibility of negative consequences to the industry participation associated with academic studies. Though a few participants had only two years of driving experience, the average years of experience across participants was twenty years. Despite the variance, results from the control scenario (scenario 1) were similar, validating that the expertise of the sample group was homogenous. In addition, this effort was proposed as a two year effort but due to contract issues, it was only granted 13 months, resulting in limited outreach and follow up effects of driver awareness.

## 10. Conclusion

It should be noted that many studies have questioned the viability of using simulators when the topic concerned driver training, distracted driving, and other topics. Chan et al., noted. "Simulators measure driving performance, what the driver can do. However, safety is determined primarily by driver behaviour of what a driver chooses to do. It is exceedingly unlikely that a driving simulator can provide useful information on a driver's tendency to speed, drive while intoxicated, run red lights, pay attention to non-driving distractions or not fasten a seat belt [Cha1]."

Although this study measured the CMV operator's performance, there is a high correlation between what drivers can do versus what they choose to do [Cha1]. This study focused on what professional drivers can do while behind the wheel of a motor vehicle. To influence and change behaviours' of a driving community, the authors believe that distracted driving studies should be accompanied by awareness campaigns that include outreach to influence not just CMV operator behaviour but the general public as well. This study showed that very experienced drivers are clearly distracted by such behaviours/events, even though many people believe they can do these things and NOT be distracted adversely.

The experiment was conducted in a safe, controlled environment, which compared the effect of being distracted to the non-distracted scenario. The team found that manipulating a touchscreen Mp3 player device is approximately three times more distracting among CMV operators. In addition, the team found that engaging with multiple tasks while driving is approximately two to three times more distracting than non-distracted driving among CMV operators.

The results of this investigation have shown that the use of a cell phone, the use of a touchscreen Mp3 player, the presence of external distraction, or any combination of the three causes increases in driving performance errors. Performance measures suggested the largest performance deficiencies come from actively using a touchscreen Mp3 player. This study combined aspects of previous experiments expressed in the literature review and focused on a key demographic. The combined aspects of the previous research were the most relevant to the studied demographic, which ensured that the project would be as realistic and useful as possible. The challenge of distracted driving continues to be a concern for overall traffic safety. As such, additional research is strongly encouraged.

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