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SOCIAL MEDIA BROWSING WHILE DRIVING: EFFECTS ON DRIVER PERFORMANCE AND ATTENTION

by
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AN ABSTRACT OF THE THESIS OF

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Driver distraction is one of the leading causes of road accident fatalities worldwide. Whereas texting while driving is known to lead to performance decrements, it is still unclear whether and to what extent browsing social media while driving also negatively affects driver performance and attention. The prevalence of social media applications on mobile phones means there is a need to determine what guidelines or legislation should be in place. The problem is especially relevant for young and less experienced drivers, who are more at risk for driver distraction-related accidents and also tend to use social media applications more frequently. The aim of this research study is to analyze and model the effects of browsing social media on driver performance and attention. Eye tracking is be used as a means of tracing driver attention. To this end, a driving simulator experiment is carried out with AUB students between the ages of 18 and 26. Participants are asked to drive a given path and either browse social media or send text messages on given a cell phone. Performance measures such as lane keeping, average speed, and time to brake are collected, and an eye tracker traces where participants are looking at all times. The collected data is compared across experiment conditions in order to assess the impact of different phone applications on both performance and attention. This research provides the basis for improved guidelines and legislation for drivers, and ultimately a reduction in the number of accidents that are caused by distracted driving. In addition, the results of this research can help lead to the development of in-vehicle safety systems that detect and prevent driver distraction.

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CHAPTER I

MOTIVATION, BACKGROUND, AND RELATED LITERATURE

A. Distracted driving

Motor vehicle crashes remain the leading cause of death and injury for people aged 5-34, accounting annually for over 3,000 deaths and 100 times as many injuries (LaVoie, Lee, & Parker, 2016). While many factors may play a role in such accidents, the main cause of these fatalities and injuries has been found to be distracted driving (Caird, Johnston, Willness, Asbridge, & Steel, 2014), which has been repeatedly highlighted as a significant threat to the safety of drivers (Ascone, Lindsey, & Varghese, 2009; Ferdinand, 2014; Klauer el al, 2014; Lee, Roberts, Hoffman, & Angell, 2012; Metz, Landau, & Just, 2014; Strayer el al. 2013). The National Highway Traffic Safety Administration (NHTSA) reported in 2010 that 3,092 deaths (9% of all fatal crashes) and an estimated 416,000 individuals were injured in car crashes involving distracted driving that year (NHTSA, 2012). Car crashes resulting from distracted driving are thus a major cause of mortality, as well as financial and societal cost (NHTSA, 2015).

Distracted driving can be defined as the presence of any secondary task that causes decrements in driver performance or diverts the driver's attention from the main driving task (Hancock, Mouloua, & Sanders, 2009). Driver distraction can take on many different forms, including both external distractions and within-vehicle distractions. Distractions from outside the vehicle stem mainly from road advertisements and billboards (Wallace, 2003). As for within-vehicle distractions, these could be due to interactions with phones and portable music players (Salvucci, Markley, Zuber, & Brumby, 2007), infotainment systems (Lee, 2007), or due to conversations with other passengers (Heck & Carlos, 2008; Laberge, Scialfa, White, &

Caird, 2004). Driver distraction can also be classified as visual (a driver's eyes are off the road), cognitive (a driver's mind is not on the driving task), or manual (a driver's hands are not on the wheel; NHTSA, 2016).

B. Cell phones and driver distraction

Despite the varied forms of distraction, the main focus when it comes to distracted driving has consistently been on cell phone use while driving, which over 90% of drivers have reported doing (LaVoie et al., 2016). The concern about the use of a cell phone while driving is that it has been shown to cause visual, cognitive, and manual distraction (Fitch, Grove, Hanowski, & Perez, 2013; Klauer et al., 2014; Hancock, Lesch, & Simmons, 2003; McKnight & McKnight, 1993; Lesch & Hancock, 2004; Papadakaki, Tzamalouka, Gnardellis, Lajunen, & Chliaoutakis 2016; Simmons, Hicks, & Caird, 2016; Strayer & Drew, 2004).

In particular, the emphasis has primarily been on two types of phone use: texting and talking while driving, and how these affect human performance and attention (Bayer & Campbell, 2012; Kahn, Cisneros, Lotfipour, Imani, & Chakravarthy, 2015; Moreno, 2014; Olsen, Shults, & Eaton, 2013). The risks are especially high for novice or inexperienced drivers (Klauer et al., 2014). Drivers under 20 have the largest percentage of distracted drivers and those in their 20s constitute nearly 40% of deaths due to cell phone use while driving (NHTSA, 2015).

When it comes to talking on the phone while driving, studies have shown that this can lead to a decrease in the drivers' reaction time, accuracy, and overall recognition of road hazards (Ishigami & Klein, 2009). Simulation research indicates that talking on a cell phone while driving can be as impairing as having a blood alcohol level of 0.08% weight per volume, which can lead to impaired vision and failure to obey road rules (Strayer, Drews, & Crouch, 2006). In addition, that research study found that drivers using hand-held cell phones were on average 50% slower to respond to hazards than when driving without using a phone.

Furthermore, another study has reported that driving while talking on a cell phone reduces the amount of brain activity associated with driving by 37% (Just, Keller, & Cynkar, 2008), which means that the driver is only capable of performing to two-thirds of her/his normal capabilities. Talking on the phone also reduces self-awareness of performance (Sanbonmatsu et al. 2015); in other words, distracted drivers tend to mistakenly believe that their performance is not degraded by the use of cell phones or other communication devices.

As for texting while driving, this has also been shown to result in significant performance decrements and is often considered more dangerous that talking (Gershowitz, 2012; Olson, Hanowski, Hickman, Bocanegra, 2009). Research has shown that texting while driving decreases drivers' lateral vehicle control and reduces reaction time by 35%, compared to 12% and 21% for alcohol consumption and cannabis consumption, respectively (Reed & Robbins, 2008). In addition, texting can lead to increased stopping distance (Austin, 2009) and can increase the risk of crashing by more than 20 times (Olsen et al., 2009). In comparison, the same study found only a marginal increase in the crash rate when talking on a cell phone. As in all driver distraction-related issues, young and inexperienced drivers were found to be more at risk. One study showed that 3 in 4 college students texted while they drove, and this behavior was linked to both crashes and driving tickets (Cook & Jones, 2011). Also, an experiment involving teenagers showed that texting while driving within a driving simulator led to significantly more lane deviations (Lee et al., 2008).

However, it is still unclear how and to what extent the use of social media applications, such as Facebook and Instagram, contribute to driver distraction, particularly for young drivers. More than 80% of Americans under the age of 30 currently have a Facebook account (Duggan, 2015). In addition, in 2014, around 41% of drivers between the ages of 18 and 29 were estimated to be reading social networks while driving, up from 21% in 2009 (State Farm, 2014). Interestingly, the number of people talking while driving decreased over that period. Moreover, the activities associated with social media applications, such as scrolling news feeds, liking posts, and looking at images are different from those involved in texting, meaning that results may not necessarily extend from one to the other. As such, there is a pressing need to better understand how such cell phone applications affect a person's driving behavior, such as lane-keeping performance and obeying traffic laws. While on paper seemingly less threatening than texting, it may be that browsing social media while driving nonetheless leads to significant performance decrements.

Two studies to date have focused specifically on social media applications while driving. In Basacik, Reed, and Robbins (2012), the use of the Facebook chat messenger application led to increased response time to target presentation, more lane departures, and more time with drivers' eyes off the road. The Facebook text messenger application, however, is very similar to the testing functions available on one's phone. In another recent research study, the focus was more specifically on social media applications, rather than texting. McNabb and Gray (2016) asked participants to follow a lead car in a driving simulator and participants were given specific tasks to do using either Facebook, Snapchat, or Instagram. They also had one drive that included texting and one baseline drive. For the Facebook task, participants had to read text updates from a created Facebook account; for the Instagram task, participants had to do the same for image updates, and in the Instagram task, they had to send pictures from their phone that matched the pictures sent to them by the experimenter. Brake reaction time and time headway variability were measured, and participants were asked to do a recognition task at the end of each drive to determine whether given sentences/images had been presented to them before. Results showed that the difference between brake reaction times and time headway variability between the baseline condition in comparison with Instagram and Snapchat was not as significant as that with Facebook or texting. The Facebook task showed higher brake reaction times and time headway variability compared to texting, suggesting that using Facebook while driving is more distracting and dangerous than texting.

However, one limitation of this study is that the Facebook tasks did not include any images, which might explain the similarity between using Facebook and texting. Moreover, the emphasis in this study was on recalling information following the drive, which may not necessarily be the primary concern of drivers using social media. They may simply want to scroll through and search for images or texts that are of interest. The use of the like button is also something that can happen frequently while driving, with drivers' thinking that does not constitute texting per se. These three aspects – visual search rather than recall, the inclusion of images, and the addition of the like button – are critical differences that will be explored in this research.

In summary, there is a need to understand how the use of social media applications affects driver attention, such as where they look while driving and what aspects of the environment they perceive. While performance can be readily measured using metrics such as lane position and braking time, detecting attention is slightly more involved. For this reason, researchers have typically turned to eye tracking for this purpose.

C. Eye tracking and driver distraction

Eye tracking involves tracing where a user is looking on a screen or area (Poole, Ball, & Phillips, 2005). Eye trackers, which can be worn as a headpiece or placed in front of people, typically use infrared light to detect the focus of a person's gaze. The output from an eye tracker is a series of screen coordinates, or gaze points, that allow researchers to assess when and for how long users were looking at screen elements. The coordinates are used to determine eye *fixations*, or spatially stable gaze points that correspond to looking at an area for a minimum period of time (Munn, Stefano, & Pelz, 2008), and *saccades*, which are jumps between fixations (Findlay, 2004; see Figure 1). Fixations and saccades then form the building blocks for several eye tracking metrics, such as mean fixation duration (Beck et al., 2010), mean saccade length (Goldberg & Kotval, 1999), and cumulative fixation time on a certain area of interest (Josephson & Holmes, 2006).

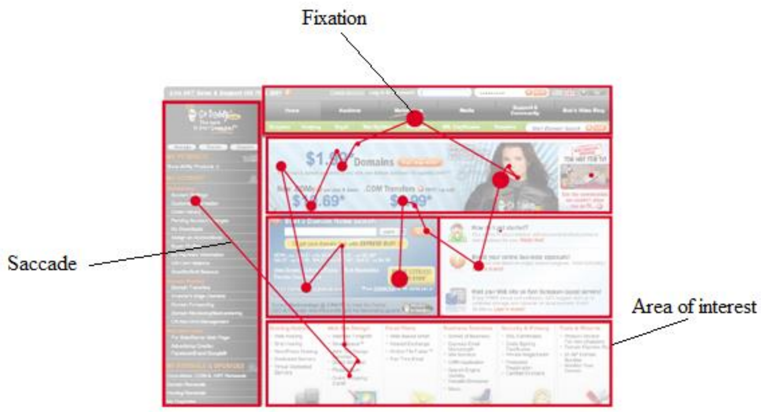


Figure 1:Subramanyam, R., Gollapudi, A., Bonigala, P., Chinnaboina, M., & Amooru, D. G. (2009)

The rationale behind using eye tracking in human factors research is that the position of a person's gaze can be used as an indicator of a person's attention (Zelinksy, 1997). In other words, what a person looks at can be considered the focus of their attention. Moreover, eye tracking is non-invasive, objective, and can serve as a process, rather than performance outcome measure (Ellis, 2009). What this means is that eye tracking makes it possible to trace changing information access strategies in real time at a fine-grained level of analysis. Eye tracking thus provides a unique window into attention that cannot be extracted from other metrics. As a result, eye tracking research has helped human factors professionals identify problems with their displays in fields such as aviation (Sapp, Jessee, Crutcher, King, & Morris, 2012), and website design (Goldberg, 2012). Eye tracking metrics have been developed that help usability researchers detect a number of different problems, such as uncertainty (Bravo & Farid, 2008) and stress (Di Nocera et al., 2006).

Driver distraction is another important construct that can be assessed and explored using eye tracking. Eye tracking serves two important purposes when it comes to driver distraction research. The first is that eye tracking provides more details about how and why distraction occurred. For example, eye tracking has been used to determine how many glances or fixations are devoted to in-vehicle devices such as radio-tuning and navigation (Domeyer, Diptiman, Hamada, Toyoda, & Maynard, 2015; Kaber, Liang, Zhang, Rogers, & Ghankhadenkar, 2012) and the number of fixations on billboards (Dukic, Ahlstrom, Patten, Kettwich, & Kircher, 2013). The threshold for distracted driving is typically considered as more than two seconds with one’s eyes off the road (e.g., Samuel, Pollatsek, & Fisher, 2011). Eye tracking has also been used to assess the delay in noticing an external stimulus when distracted (Hirayam, Mase, & Takeda, 2012). Other studies have focused on identifying distinctive pattern of fixations that characterize distracted driving, such as higher cumulative off-road eye glance duration (Li et al, 2013) or the greater dispersion of fixations (Kountouriotis & Merat, 2015).

The second major advantage of using eye tracking for distracted driving is the fact that eye tracking data can be obtained in real time. In turn, this means that eye tracking can be used to detect distraction as soon as it occurs while driving, and thus form the basis of in-vehicle warning systems (e.g., Ahlstrom, Kircher, & Kircher, 2013). Several such real-time systems have been developed with many different approaches adopted. For example, in some studies, distraction was detected by estimating it as the total amount of time with eyes not looking at the road (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006; Donmez, L. Boyle, & J. Lee, 2008). Another system, called AttenD, estimates distraction uses three types of glances: to the road, to necessary areas such as the mirror, and to other unnecessary areas (Kircher, Kircher, & Ahlstrom, 2009). On the other hand, MDD (Multi Distraction Detection) calculates percentage of fixations to the center of the road and gaze concentration on the center of the road as a measure of distraction (Victor, 2010). Other studies have used machine learning techniques such as Hybrid Bayesian networks to detect distraction (Liang & Lee, 2014).

SPECIFIC AIMS AND EXPECTED CONTRIBUTIONS

The specific aims of this research project are to:

1. Analyze the effects of social media browsing on **performance** while driving, where performance will be measured by metrics such as lane position, driving speed and acceleration, and the time to brake. These effects will be compared to those of texting while driving and to a baseline (no phone) condition.
2. Analyze the effects of social media browsing on **attention** while driving. Decrements in attention will be assessed using an eye tracker mounted in the simulator, from

which we will calculate metrics such as the number of fixations on and off the road, the standard deviation of fixation position, and mean fixation duration. These attentional effects will also be compared to those of texting while driving and to a baseline (no phone) condition.

The specific aims will be realized by means of a driving simulator experiment. This research will contribute to the literature on driver distraction and the effects of in-vehicle hand-held devices on performance and attention. This research can also help suggest guidelines and legislation for drivers and contribute to a reduction in the number of accidents that are linked to distracted driving, particularly for young and inexperienced drivers. In addition, the results of this research can contribute to the development of in-vehicle safety systems that detect driver distraction.

CHAPTER III

METHODS

The main goal of this research is to analyze the effects of using social media on drivers' attention and performance. A driving simulator experiment was conducted to analyze these effects and to collect the desired eye movement data, key performance measures, and subjective data.

A. Participants

Twenty-six students from the American University of Beirut were asked to volunteer in this experiment. In order to recruit participants (after obtaining IRB approval), emails were sent to a random subset of AUB students and flyers were hung on bulletin boards across campus. Students who replied to the emails and indicated their willingness to participate were contacted by a member of the research study and the time and date of the experiment was scheduled. Students were eligible to participate if they were between 18 and 26 years old, had a valid driver's license, had normal or corrected to normal vision, and had an active Facebook account. The age range was chosen as this is a typical range used to classify young drivers (e.g., Hosking et al., 2009; Braitman & McCartt, 2010). These criteria were all mentioned in the recruitment documents and confirmed through a screening interview (see Appendix B) prior to beginning the experiment. Students who did not meet the criteria were not allowed to participate in the experiment.

The average age of all participants was 21 (range: 18 to 25), with 16 males and 10 females. Participants for this experiment spanned three faculties the faculty of engineering and architecture, school of business, and the faculty of arts and sciences with 7 graduate students and 19 undergraduate students. The average driving experience for participants was 3 years with the least experienced participant having one year of experience and the most experienced having seven years of experience.

B. Location and Equipment

The experiment was conducted in the Irany Oxy Engineering Complex, and specifically in the Transportation Research Unit, which contains a DriveSafety DS-600c Research Simulator (see Figure 2). This high-fidelity simulator consists of a full-width Ford Focus automobile with standard driver controls, instrumentation, and some motion cues. A 180° screen displays shows the outside road, allowing for a realistic and immersive driving experience. This driving simulator can represent the path and speed of eight different types of pedestrians and can represent different road artifacts such as crosswalks, sidewalks, etc. The simulator is also equipped with a Fovio eye tracker (www.fovio.com) located above the dashboard that was used to collect eye movements. The eye tracker uses a sampling rate of 60Hz, meaning that the location of the driver's gaze is captured every 17ms. In addition, a scene camera is placed on the roof of the vehicle to capture videos of all the drives.

Figure 2: Driving simulator that was used in this research

C. Experiment Design

The independent variable for this experiment was the phone application (social media, texting, none). The social media application that was investigated is Facebook, given that it is the most popular social media application in use today (Duggan, 2015).

The independent variable was varied within-subjects. Participants were asked to do three drives along a given path, with each drive corresponding to each of the three variable conditions. Each drive, or scenario, contained four events that occur at predetermined locations: a green light turning to orange and then red as the driver approaches the intersection, a red light turning green as soon as the driver approaches the intersection, a pedestrian crossing in front of the car, and a car braking suddenly in front of them. These four events took place at different locations and in a different order in each of the three scenarios (drives). In previous studies the participants were given the search or text tasks before every simulation run is started; therefore, with our current setup with tasks being given throughout the run and detecting in real time the drivers' reaction to the changing scenarios and task requirements, we attempted to explore new data and results. The conditions of the simulator were set such that the mean traffic density and mean traffic speed were equivalent in all three runs for all participants. The sequence of driving runs, which correspond to the three experiment conditions, was counterbalanced across participants.

Figure 3 shows the road the participants had to drive for the control run.

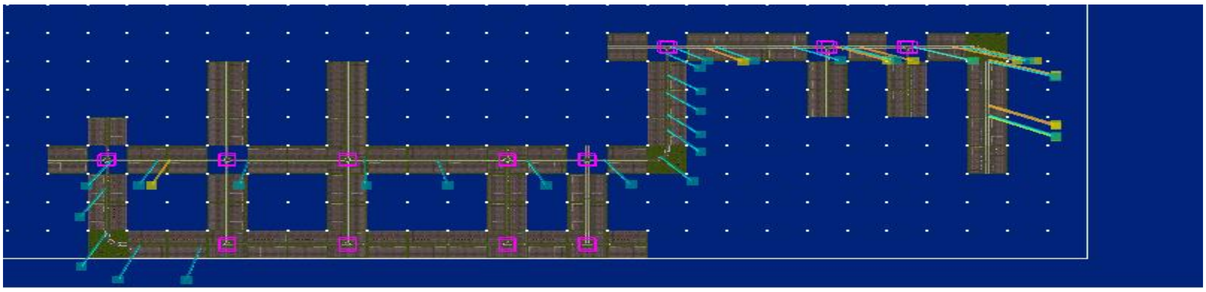


Figure 3: Blue Markers: Route Indicators, Yellow Markers: Triggers (Event, Audio instructions), Purple Squares: Intersections

The dependent variables are a set of performance measures, eye tracking data, and subjective data. The performance measures include both continuous data (i.e., collected across the whole scenario) or event data (at one of the three events). Table 1 includes all performance metrics used in this experiment.

Table 1: Performance Metrics

Metric	Description
Average Speed (Simulator Units/S)	Average driver speed throughout the whole drive
Average Acceleration	Average driver acceleration during times of acceleration only. Note that the value of the acceleration is a fraction out of the maximum value of 1.
Average Deceleration	Average driver deceleration during times of braking only. Note that the value of the deceleration is a fraction out of the

	maximum value of 1.
Average Lane Position (Simulator Units)	Average driver position with respect to the center of the lane with a value of 0.2 corresponding to the center of the lane.
Average Reaction Time (Seconds)	Average reaction time needed for drivers to react to a certain event (Sudden car stopping, Pedestrian crossing, Traffic light change.)
Average Acceleration/Deceleration at Scenarios (Simulator Units/Second)	Average driver acceleration/deceleration at each scenario event (Sudden car stopping, Pedestrian crossing, Traffic light change.)

Moving on to the eye tracking metrics, during the experiment we had one main area of concern and that was the simulator's center screen. The center screen was where the driver viewed the road, sidewalks, traffic lights, and pedestrian crossings. All gaze points collected on the center screen were considered to be gazes on the road. All other gaze points collected were considered to be gazes off the road.

Table 2 includes all the eye tracking metrics used in this experiment and the purpose for using each.

Table 2: Eye Tracking Metrics

Metric	Description
Number of Gaze Points on the Road (Points/Second)	An indication of the extent to which the driver was looking at the road as opposed to at the phone
Number of Gazes on the Road (Gazes/Minute)	A gaze on the road starts with the first gaze point on the road and ends with the first gaze point off the road. This metric can be used to determine the number of transitions from the road to the phone, which, in turn, would be a measure of the amount of distraction caused by the phone.
Convex Hull Area (mm^2)	Minimum convex area which contains the fixation points. This is used to determine how spread out or focused a driver's attention is.
Spatial Density (Percentage)	The number of grid cells containing gaze points divided by the total number of cells. Similar to the convex hull area, spatial density indicates how spread out or focused a driver's attention is.
Mean Fixation Duration on the Road (Seconds)	The mean of all the fixation durations is used as a measure of how much visual processing occurs.
Average Gaze Position (X and Y coordinates)	The average of the driver's X and Y gaze position is used to determine the general

	location of the driver's focus throughout the drive

At the completion of each scenario, participants were also asked to fill out a NASA-TLX (Hart & Staveland, 1988) (See Appendix C) survey to assess the experienced workload. At the completion of the experiment, participants were also asked to fill out a debriefing questionnaire in which they assessed their own performance, such as how they believe they performed in each drive and comparing the difficulty of tasks. In addition, they were asked to give some information about themselves as to what type of tasks they usually perform on their phone while driving. The full debriefing questionnaire can be seen in Appendix A.

D. Experiment Procedure

The experiment consisted of four phases. In the first phase, when participants first come to the Transportation Research Unit, they were asked to read and sign the consent form. The experimenter then conducted a short (5-minute) interview with participants to make sure that they have all the necessary qualifications and meet all the conditions of participating in the experiment. Participants who did not meet the criteria were not allowed to continue with the experiment. In the second phase, participants were shown the road that they will be driving and shown how they will have to navigate it. Participants were then allowed to practice driving the path until they are comfortable with all the controls and directions. This training phase took around 10 minutes. The eye tracker was then set up and calibrated before any of the scenarios start, which took around 5 minutes. In the third phase, participants were asked to drive the path three times, the sequence being assigned by the experimenter.

For the two scenarios that consist of using a phone, participants were given a phone other than their own to use. The phone has the Facebook application installed and has an account set up specifically for this experiment. For the social media browsing scenario, before starting the scenario, they were then told orally by the experimenter about the theme they have to look for (e.g., sports, music, etc.). The Facebook application on the given phone was opened by the experimenter and given to the participant before starting the scenario. Participants were then asked to start driving while searching for images or texts that are related to the given theme. When they find one such post, they have to press the “like” button for that post. Participants were told that locating less than 80% of posts related to the specified theme renders the drive null. This was done to motivate participants to not neglect the social media task and to simulate the situation where a driver has strong desire to browse social media. At the same time, participants were told to drive as they normally would and pay attention to pedestrians and driving signs. More than two crashes or incidents with participants renders the drive and results null.

For the texting task, the messaging application is opened for participants and they were told whom they need to write to and what they need to write. During the drive the participant receives a continuous stream of math questions with a thirty second interval in between. Similar to the social media application, the participant was informed that a response rate less than 80% renders the drive null. More than two crashes or incidents with participants also renders the drive and results null. For the scenario with neither social media browsing nor texting, participants were just instructed to drive normally.

The data for 2 participants were discarded for not meeting the requirements.

Each drive took around 6-10 minutes. After completing each scenario, participants were given the NASA-TLX ratings sheet to complete, which took around 2 minutes each time. Finally, after completing all scenarios, participants were asked to complete a debriefing questionnaire, which took around 5 minutes. The full experiment thus took around 60-70 minutes.

CHAPTER IV

RESULTS

The results for 24 out of 26 participants were analyzed in order to understand the effect of each task on the drivers' behavior and attention. The results for 2 participants were discarded due to the fact that they do not meet the requirements mentioned in the Experiment Design section. One participant failed to achieve the 80% response rate for the texting task, and the second had 3 accidents during one of the drives, which exceeds the limit of 2. The normality of the data was checked in SPSS and the data is approximately normal. Bonferroni adjustments were used for all multiple comparisons.

A. Performance Results

1. Average Speed

The average speed throughout the whole drive was 12.81 (standard deviation (*SD*) = 2.01), 11.26 (SD = 1.73), and 12.17 (SD = 2.06) units/sec for the control, Facebook, and texting scenarios, respectively (see Figure 4). There was no significant effect of the scenario on the average speed ($F(1,24) = 5.417$, $p = 0.12$)

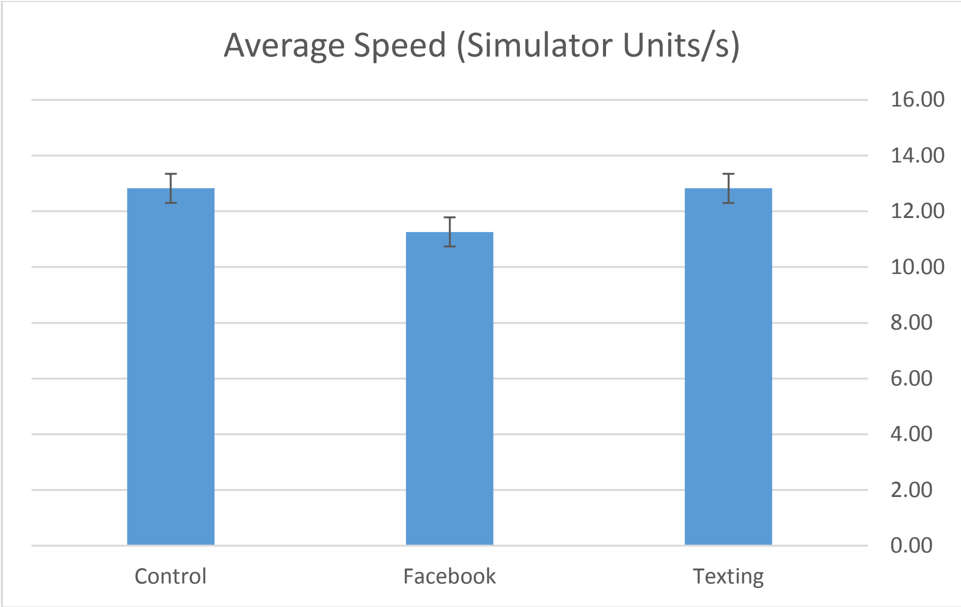


Figure 4: Average Speed

2. Average Acceleration and Deceleration

The average acceleration throughout the times the driver was accelerating was 0.35 (standard deviation (*SD*) =0.09), 0.33 (SD=0.08), and 0.33 (SD=0.07) units for the control, Facebook, and texting scenarios, respectively (See Figure 5). There was no significant effect of the scenario on the average acceleration ($F(1,24)=0.259$, $p=0.774$).

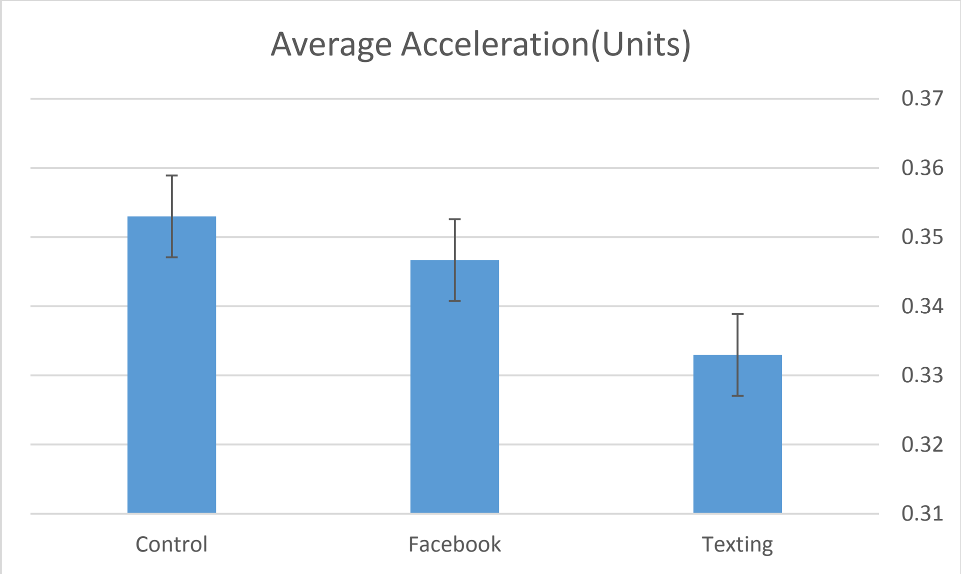


Figure 5: Average Acceleration

Similar to the average acceleration, the average deceleration throughout the times when the drivers were decelerating was 0.13 (SD = 0.024), 0.138 (SD = 0.028), and 0.133 (SD = 0.022) units for the control, Facebook, and texting scenarios, respectively (See Figure 6). There was no significant effect of the scenario on the average deceleration ($F(1,24)$ = 0.77, and p = 0.475)

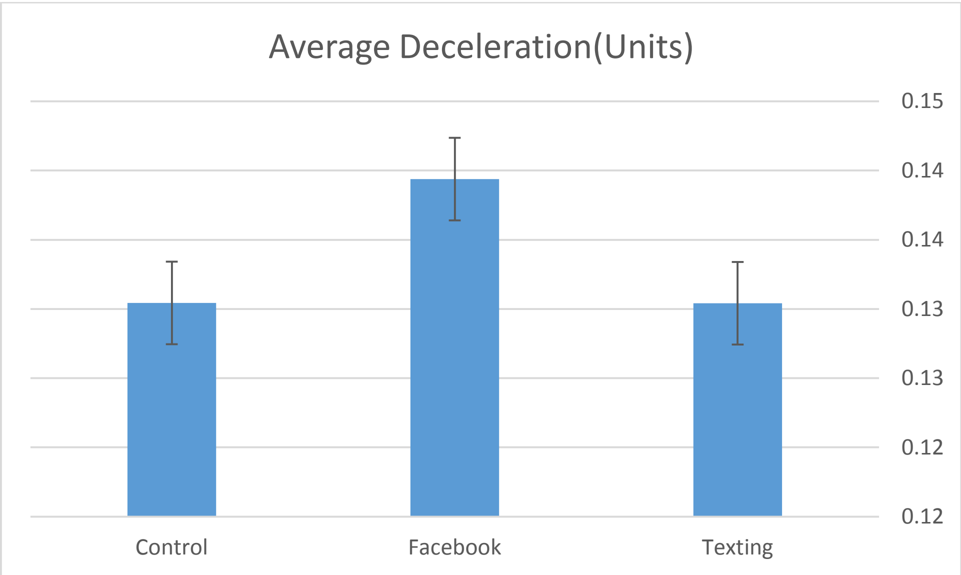


Figure 6: Average Deceleration

3. Average Deceleration at Scenario Events

The average deceleration at the pedestrian crossing was 0.63 (standard deviation (*SD*) =0.03), 0.64 (SD=0.03), and 0.64 (SD=0.04) units for the control, Facebook, and texting scenarios, respectively (See Figure 7). There was no significant effect of the scenario on the average acceleration (*F*(1,24)=0.361, *p*=0.984).

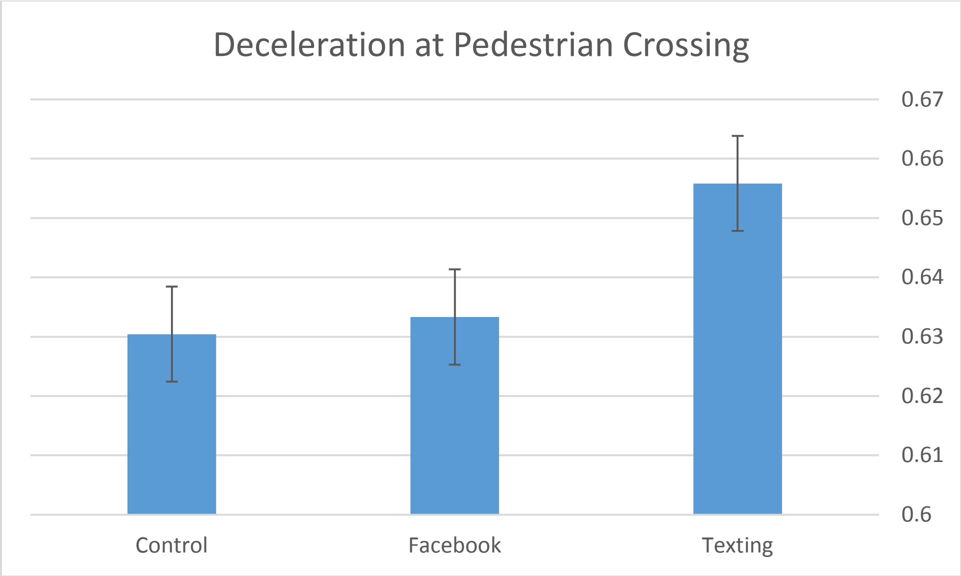


Figure 7: Deceleration at Pedestrian Crossing

The average deceleration at the pedestrian crossing was 0.63 (standard deviation (*SD*) =0.03), 0.64 (SD=0.03), and 0.64 (SD=0.04) units for the control, Facebook, and texting scenarios, respectively (See Figure 8). There was no significant effect of the scenario on the average acceleration (*F*(1,24)=0.421, *p*=0.763).

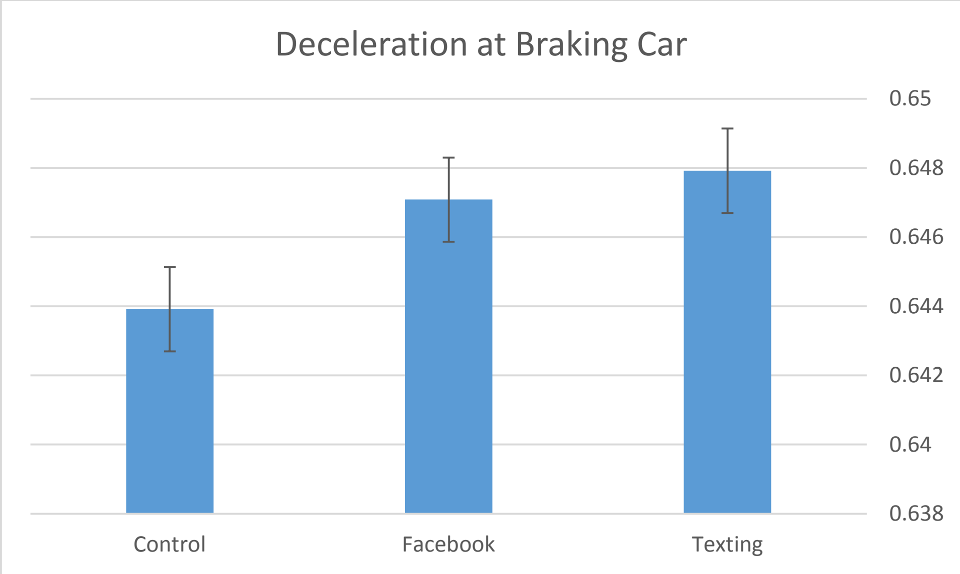
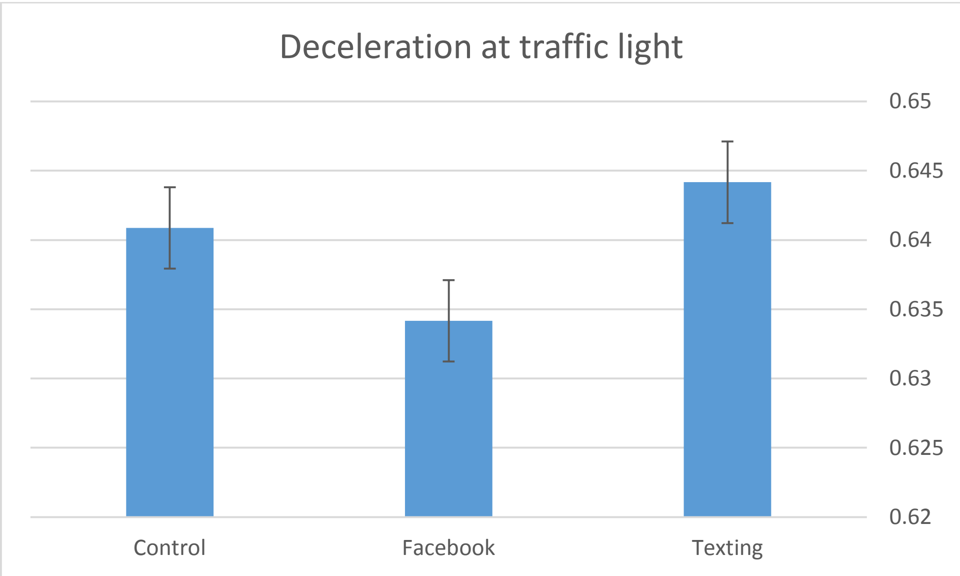


Figure 8: Deceleration at Braking Car

The average deceleration at the traffic light was 0.64 (standard deviation (*SD*) =0.04), 0.63 (SD=0.04), and 0.64 (SD=0.04) units for the control, Facebook, and texting scenarios, respectively (See Figure 9). There was no significant effect of the scenario on the average acceleration ($F(1,24)=0.371$, $p=0.693$).



4. Average Lane Keeping

The average lane position with respect to the center of the road was 0.19 (SD = 0.079), 0.216 (SD = 0.135), and 0.1088 (SD = 0.06117) units for the control, Facebook, and texting scenarios, respectively (See Figure 10). There was a significant effect of the scenario ($F(1,24) = 19.975$, $p<0.001$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the texting condition ($p < 0.001$) and between the Facebook and texting conditions ($p = 0.01$).

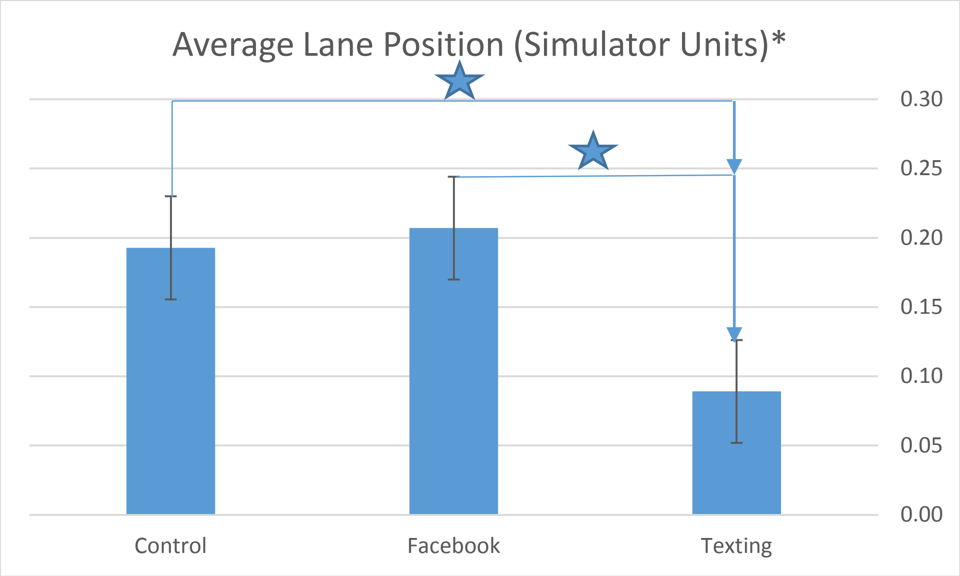


Figure 9: Average Lane Position

5. Brake Reaction Time at Pedestrian Crossing

The average reaction time to respond to the scenario event was calculated resulting in averages of: 1.6 (SD = 0.361), 2.34(SD = 0.409), and 3.04 (SD = 0.548) seconds for the control, Facebook, and texting scenarios, respectively (See Figure 11). There was a significant effect of the scenario ($F(1,24) = 36.579$, $p < 0.001$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition (p < 0.001), between the Facebook and texting (p=0.001) and between the control and texting conditions (p < 0.001).

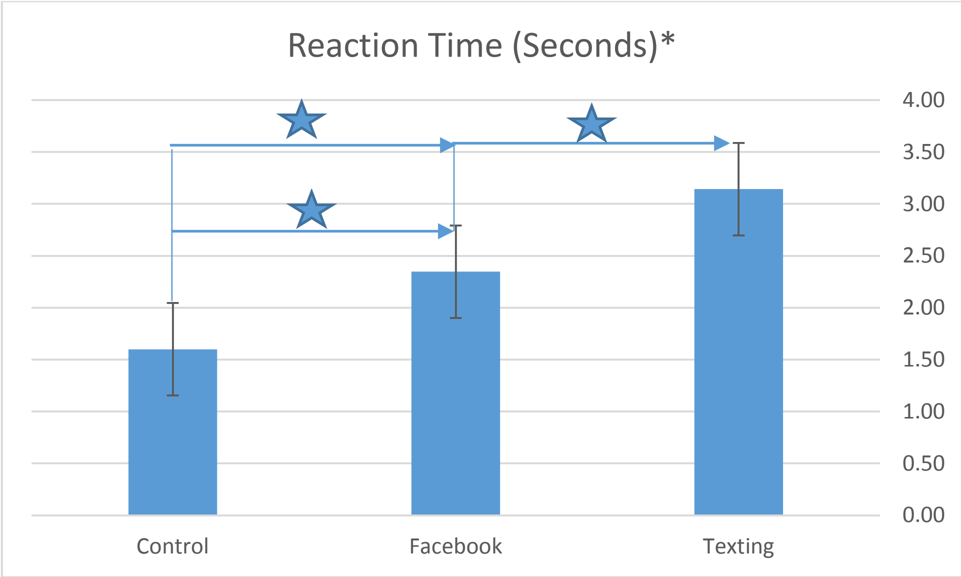
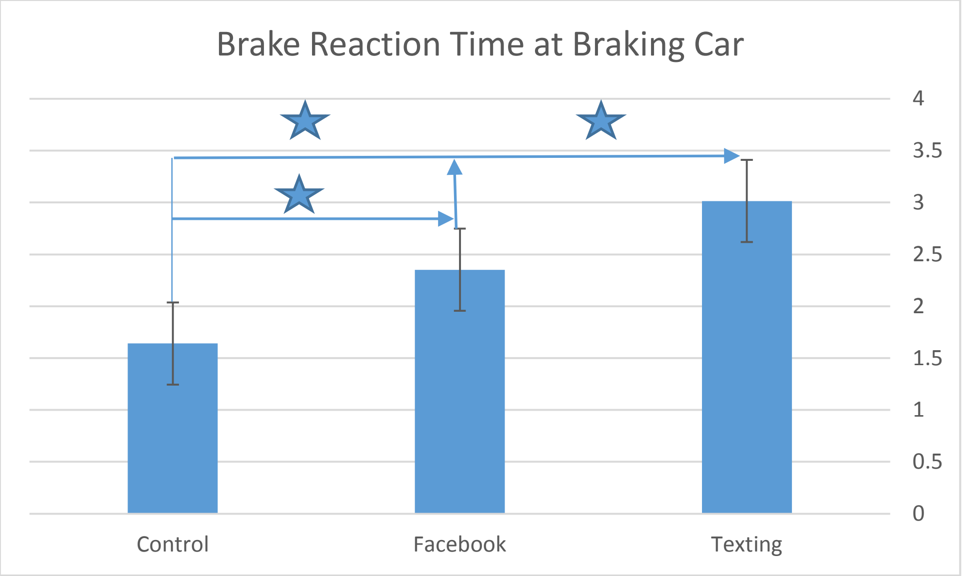


Figure 10: Reaction Time at pedestian crossing

6. Brake Reaction Time at Braking Car

The average reaction time to respond to the scenario event was calculated resulting in averages of: 1.64 (SD = 0.303), 2.35(SD = 0.423), and 3.05 (SD = 0.174) seconds for the control, Facebook, and texting scenarios, respectively (See Figure 12). There was a significant effect of the scenario (F(1,24) = 32.723, p < 0.001). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition (p < 0.001), between the Facebook and texting (p=0.001) and between the control and texting conditions (p < 0.001).



7. Brake Reaction Time at Traffic Light

The average reaction time to respond to the scenario event was calculated resulting in averages of: 1.62 (SD = 0.298), 2.34(SD = 0.393), and 3.03 (SD = 0.196) seconds for the control, Facebook, and texting scenarios, respectively (See Figure 13). There was a significant effect of the scenario ($F(1,24) = 33.195$, $p < 0.001$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition ($p < 0.001$), between the Facebook and texting ($p=0.001$) and between the control and texting conditions ($p < 0.001$).

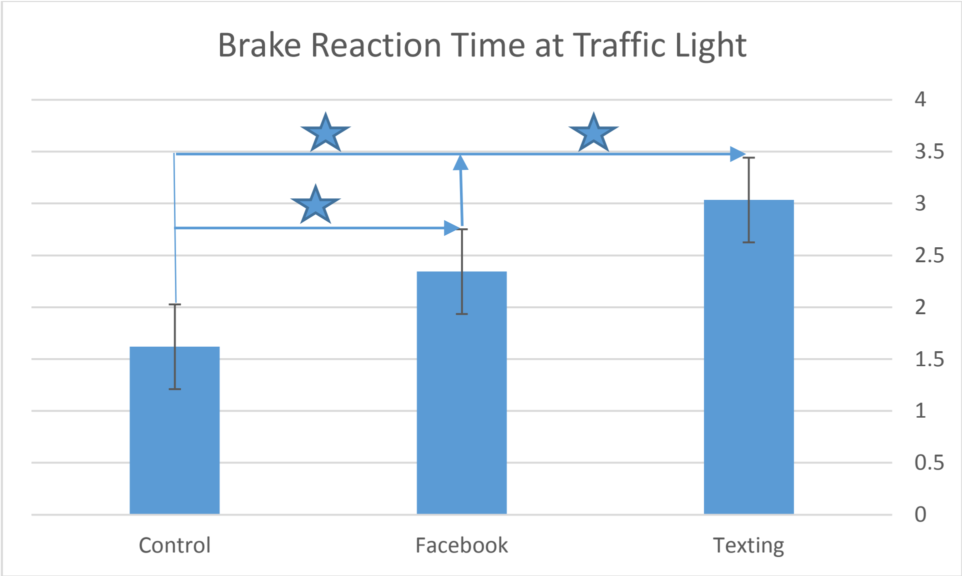


Figure 11: Brake Reaction Time at Traffic Light

B. Eye Tracking Results

8. Gaze points per second on the road

The number of gaze points per second on the road was calculated resulting in averages of: 54.68 (SD = 5.9), 34.76 (SD = 6.10), and 26.84 (SD = 7.35) for the control, Facebook, and texting scenarios, respectively (See Figure 9). There was a significant effect of the scenario ($F(1,24) = 197.802$, $p < 0.001$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition ($p < 0.001$), between the Facebook and texting ($p = 0.001$) and between the control and texting conditions ($p < 0.001$).

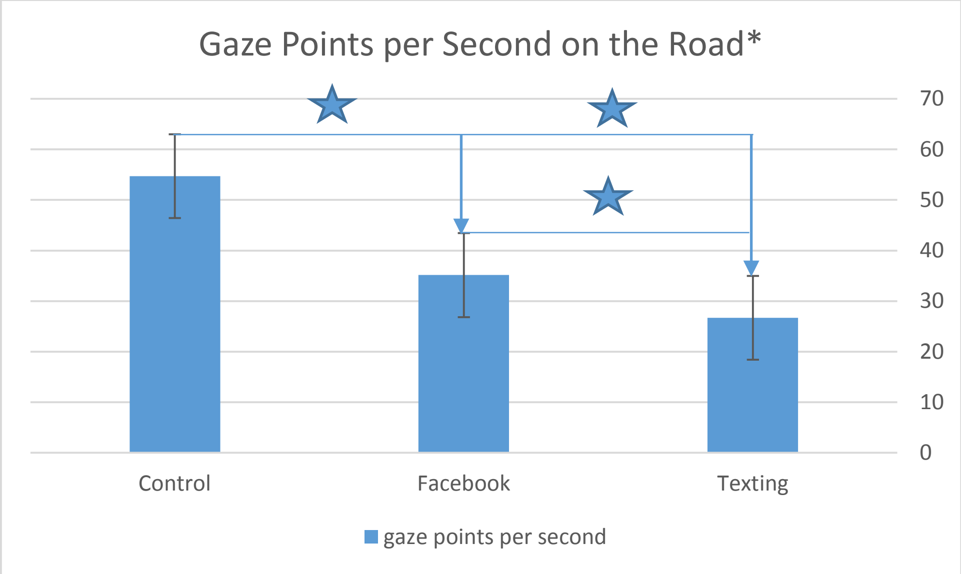


Figure 12: Gaze Points per Second on the Road

9. Fixations per minute on the road

The number of fixations per minute on the road was calculated resulting in averages of: 74.79 (SD = 19.68), 57.10 (SD = 12.83), and 42.57 (SD = 5.71) for the control, Facebook, and texting scenarios, respectively (See Figure 10). There was a significant effect of the scenario ($F(1,24) = 35.623$, $p < 0.001$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition ($p < 0.001$), between the Facebook and texting ($p < 0.001$) and between the control and texting conditions ($p < 0.001$).

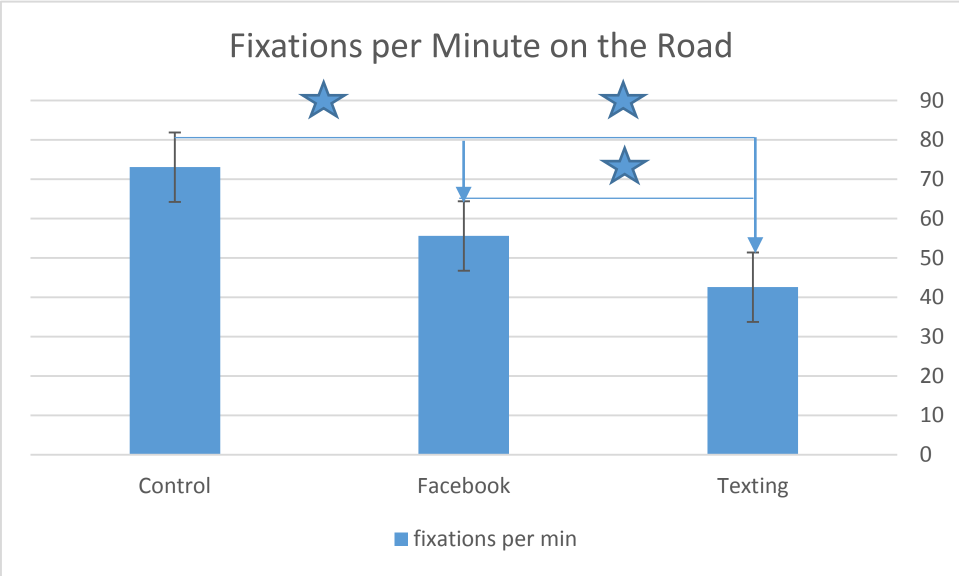


Figure 13: Fixation per Minute on the Road

10. Mean Fixation Duration on the Road

The mean fixation duration on the road was calculated resulting in averages of: 0.61 (SD = 0.206), 0.41 (SD = 0.088), and 0.42 (SD = 0.069) seconds for the control, Facebook, and texting scenarios, respectively (See Figure 11). There was a significant effect of the scenario ($F(1,24) = 10.889$, $p = 0.01$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition ($p < 0.001$), and between the control and texting conditions ($p = 0.01$).

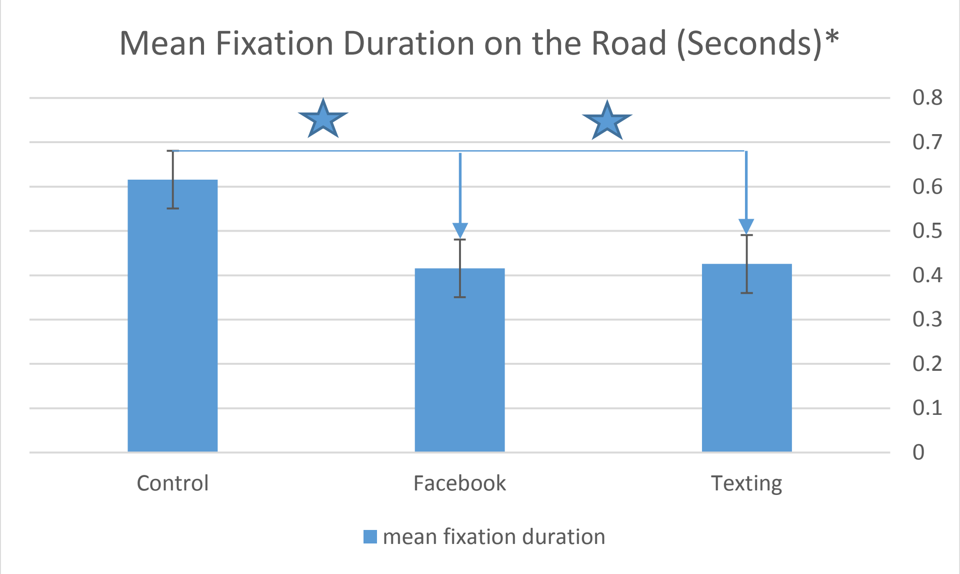


Figure 14: Mean Fixation Duration on the Road

11. Number of Gazes on the Road Per Minute

The number of gazes on the road per minute was calculated resulting in averages of: 0.727 (SD = 0.604), 0.979 (SD = 0.552), and 0.915 (SD = 0.476) for the control, Facebook, and texting scenarios, respectively (See Figure 12). There was no significant effect of the scenario on the number of gazes per minute ($F(1,24) = 1.388$, $p = 0.271$).

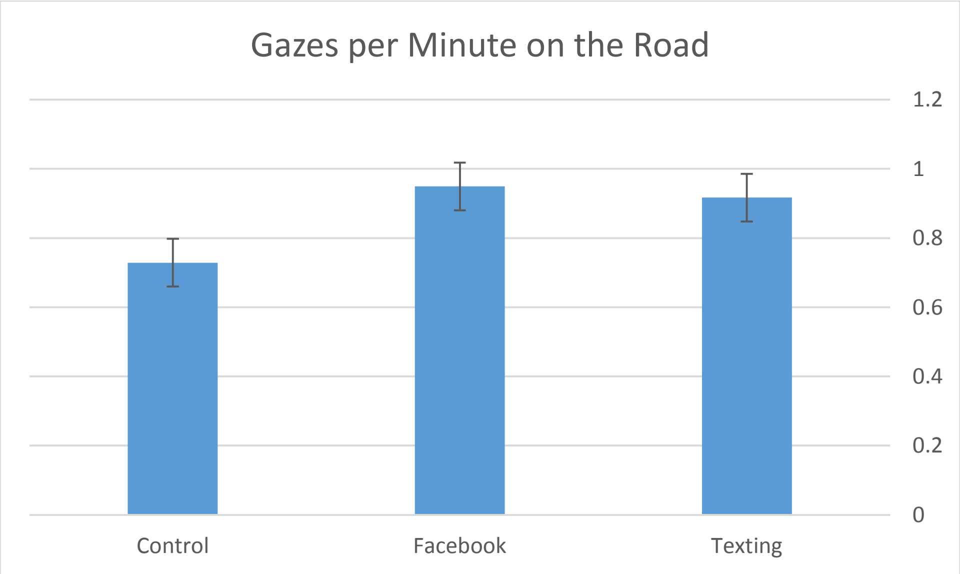


Figure 15: Gazes per Minute on the Road

12. Average X and Y Position of the Drivers' Gaze

The average X coordinate for the drivers' gaze was calculated resulting in averages of: 875.75 (SD = 108.68), 545.09 (SD = 105.56), and 479.61 (SD = 87.42) for the control, Facebook, and texting scenarios, respectively (See Figure 13). There was a significant effect of the scenario ($F(1,24) = 174.892$, and $p = 0.01$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition ($p < 0.001$), and between the control and texting conditions ($p = 0.01$).

Similarly, the Y coordinate for the driver's gaze was calculated resulting in averages of: 531.18 (SD = 112.83), 357.84 (SD = 87.86), and 318.80 (SD = 78.72) for the control, Facebook, and texting scenarios, respectively (See Figure 14). There was a significant effect of the scenario (F(1,24) = 39.798, p = 0.01). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition ($p < 0.001$), and between the control and texting conditions ($p = 0.01$).

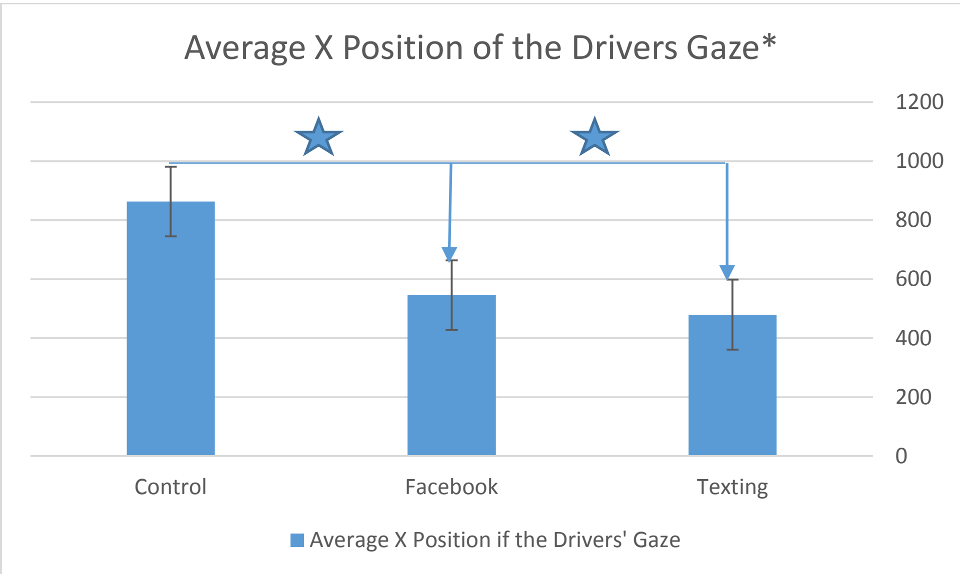


Figure 16: Average X Position of the Drivers' Gaze

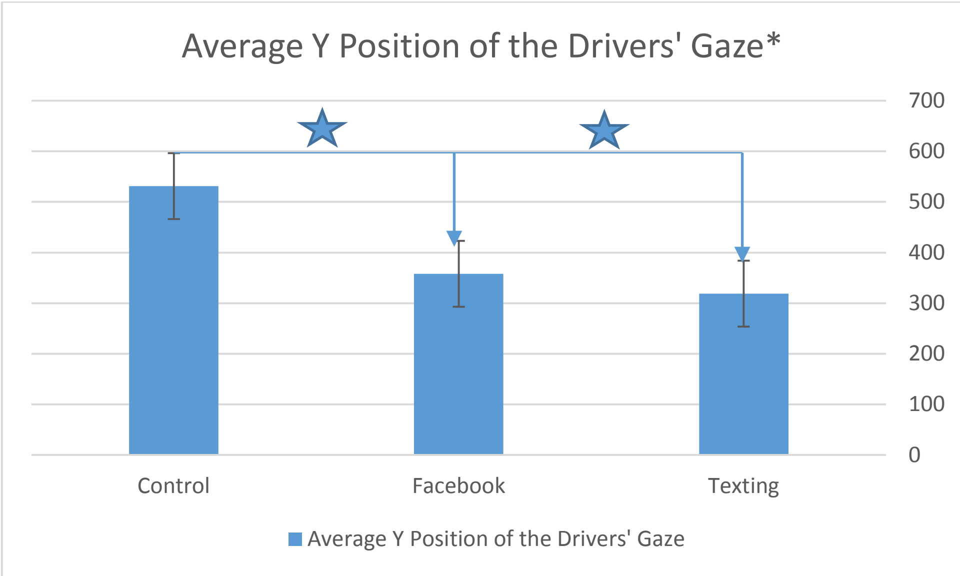


Figure 17: Average Y Position of the Drivers' Gaze

Figure 18: Drivers' View of the Road; Black Circle: Control Scenario, Silver Circle: Facebook Scenario, White Circle: Texting Scenario

1.88
Meters

Shown in Figure 15 is a display representing the drivers' view of the road and the average gaze position throughout each drive.

13. Spatial Density

To further assess the driver's reaction, the center display of the simulator (Road Display) was converted to a grid of 100 equally sized squares. The reason for that is to determine the percentage of the road and surrounding the driver observes and compare between the 3 drives. The spatial density was calculated resulting in averages of: 68.04 (SD = 5.73), 57.33 (SD = 5.96), and 53.95 (SD = 5.88) for the control, Facebook, and texting scenarios, respectively (See Figure 16). There was a significant effect of the scenario ($F(1,24) = 30.885$, $p < 0.001$). Fisher's LSD post-hoc tests showed a significant pairwise difference between the control condition and the Facebook condition ($p < 0.001$), and between the control and texting conditions ($p < 0.001$).

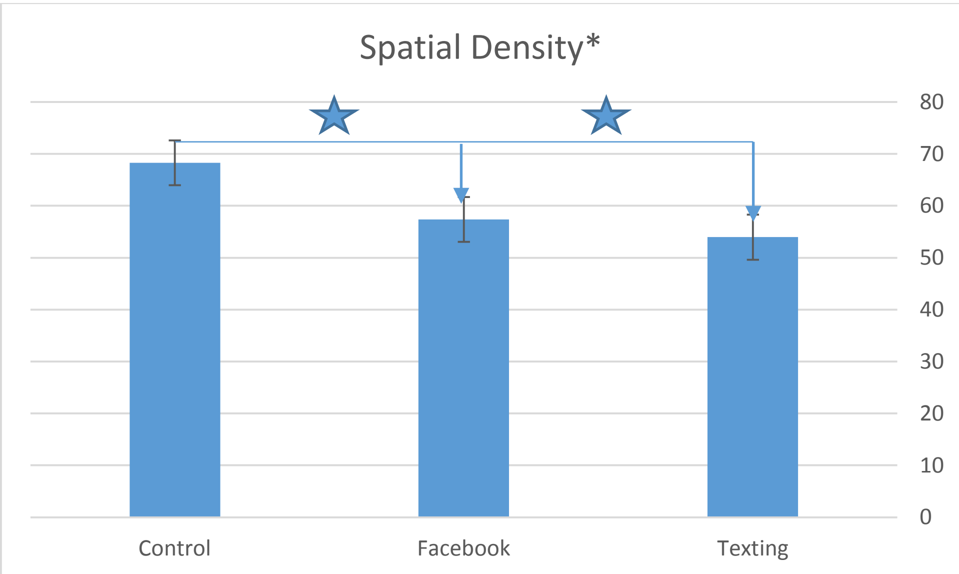


Figure 19: Spatial Density

C. Subjective Results

14. Facebook and Texting Results

Table 3 shows the percentage of posts that were successfully located in the Facebook task, as well as the percentage of questions that were successfully answered in the texting task. On average, 87.7 (*SD* = 6.5) % of participants successfully located the targeted posts, while 92.0 (5.7) % of participants answered questions correctly, meaning that they had the right answer to the arithmetic task.

Table 3: Facebook and Texing Task Results

	Percentage of Posts Successfully Located (%)	**Percentage of Questions Successfully Answered (%)**
Average (*SD*)	87.7 (6.5)	92.0 (5.7)

15. Debriefing Questionnaire

Shown in Table 4 are the responses of the participants when asked about their performance during each scenario. On average participants believed that their best performance was during the control scenario followed by the Facebook scenario with the texting scenario having the worst performance.

Table 4: Participants Percieved Performance

Question	Poor	Fair	Good	Excellent
How was your performance without a phone?	0	0	7	17
How was your performance while browsing Facebook	0	10	11	3
How was your performance while texting?	0	18	6	0

Shown in Table 5 are the number of participants that use social media or text while driving. 79.1% of participants have a tendency to browse social media while driving while 87.5% have a tendency to text while driving.

Table 5: Participants' Phone Use Habits

Question	Never	Sometimes	Often	Always
How often do you browse social media while driving?	5	18	1	0
How often do you text and drive?	3	18	3	0

Although 75% of the participants sometimes browse social media or text while driving it is still important to test for the correlation between decrease in performance and frequency of phone use while driving. The performance metric used to check for any correlations was the reaction time as it is the metric most significantly affected by phone use. The results of the correlation tests showed no significant correlation between the frequency of browsing social media while driving and reaction time (correlation coefficient: 0.228; p=0.283). Similarly, the tests showed no significant correlation between the frequency of texting while driving and reaction time (correlation coefficient: 0.114; p=0.594).

Shown in Table 6 are the participants' perceived effect of browsing social media and texting while driving on their performance and attention. Only 37.5% of the participants believe that browsing Facebook while driving has a significant or very significant effect on their performance and attention compared to 91.66% who believe that texting while driving significantly affects their performance and attention.

Table 6: Significance of Facebook vs Texting on Driving

Question	Not Significant	A little	Significant	Very Significant
Do you believe that browsing social media has a significant effect on your driving?	0	15	8	1
Do you believe that texting has a significant effect on your	0	2	12	10

driving?				

The last question in the debriefing questionnaire asked the participants to compare the dangers of browsing Facebook and texting while driving (see Table 7). Only 16.67% of the participants believed that browsing Facebook may be just as dangerous as or more dangerous than texting while driving whereas the majority of 83.33% believed that browsing Facebook is not as dangerous as texting.

Table 7: Danger of Facebook vs Texting

Question	Not as Dangerous	Just as Dangerous	More Dangerous
Do you believe that browsing social is as dangerous as texting while driving?	19	4	1

Table 8 shows the average NASA-TLX score for all the participants when asked to rate the mental demand, temporal demand, and effort needed throughout each scenario out of 20.

Table 8: NASA-TLX

Question	Control	Facebook	Texting
Mental Demand	3.5	10.54	17.17
Temporal Demand	1.13	8.91	17.75
Effort	1.13	11.65	18.43

Friedman non-parametric test was conducted to check for significant difference for mental demand, temporal demand, and effort required between the 3 testing conditions.

There was a significant effect of the scenario on mental demand, temporal demand, and effort ($p<0.001$). Post hoc test showed significant pairwise difference between the control and Facebook conditions (*p*<0.001), the control and texting conditions (*p*<0.001), and between the Facebook and texting conditions (*p*<0.001) for all 3 categories.

Table 9: Performance Summary

Metric	Facebook	Texting	Results
Average Speed	-	-	Browsing Facebook and texting had no effect
Average Acceleration	-	-	
Average Deceleration	-	-	
Average Lane Keeping	-	↑	Texting while driving leads to a decrease in lane keeping
Average Reaction Time	↑	↑ ↑	Browsing Facebook and texting while driving lead to increased reaction times with Facebook still having significantly better times compared to texting

Table 10 : Eye Tracking Summary

Metric	Facebook	Texting	Results
Gaze Points	↓	↓ ↓	Less attention on the road
Fixations	↓	↓ ↓	
Mean Fixation Duration	↓	↓ ↓	Drivers do not process the environment
Gazes	-	-	Same number of transitions
Spatial Density	↓	↓	Drivers did not sample as many areas of the environment (attentional narrowing)
Average Gaze Position	Significant Difference	Significant Difference	Shift in average gaze position away from the center of the road

CHAPTER V

DISCUSSION AND CONCLUSION

The goal of this research study was to determine the effect of using social media while driving on the drivers' performance and attention. The hypothesis was that browsing Facebook while driving would be just as dangerous as texting, both from a performance and an attentional standpoint.

From a performance standpoint, it appears that browsing Facebook while driving did have a negative effect on performance, but this effect was not as severe as texting while driving, where results confirmed the detrimental effects this behavior has on driving performance (e.g., Basacik, Reed, & Robbins 2012). This was evident, for example, by the average lane position, which showed the driver very close to the edge of the road as compared to both the control and Facebook scenarios. In addition, the reaction time for the driving task was significantly worse than both the Facebook and the control condition. These findings are in contrast to previous experiments on browsing social media while driving. For instance, Basacik et al. (2012) found reduced lane keeping performance whereas McNabb and Gray (2016) found higher reaction times for the Facebook scenario as compared to the control one, strongly suggesting that Facebook browsing is more detrimental to performance than texting. However, the critical difference between this task and the one of McNabb and Gray (2016) is that the Facebook condition in this study required participants to search for a type of post on a social media page, whereas the previous study required participants to remember facts about the page they browsed. The rationale for using a search task is that browsing social media rarely involves recalling information or committing items to memory, so the pure search task was intended to make the scenario more realistic. It appears that the memory load caused by asked participants to recall information was a significant factor in affecting the behavior of participants. Moreover, the fact that there was no significant effect of the scenario on the average speed, average acceleration and average deceleration suggests that drivers do not necessarily slow down significantly when using their cell phones while driving, which was contrary to expectations. This finding is worrisome, as it brings up the question of how drivers are able to compensate for the added mental load of Facebook browsing or texting.

The eye tracking metrics provided further insight into the performance results and helped explain the observed performance effects. The number of gaze points on the road, which are significantly less for texting, followed by Facebook, confirm that participants did not devote enough attention to the road in these two conditions, which resulted in the performance decrements. Spatial density values also follow this pattern, suggesting that participants were not sampling as much of the environment while Facebook browsing or texting. The mean fixation duration for Facebook and texting is also roughly similar, which indicates that they were processing the environment with the same level. However, the results for the average gaze position show significant differences between the values for the control scenario as compared to the values for the Facebook and texting scenarios. These results indicate that although the driver pays more attention to his/her surrounding while browsing Facebook as compared to texting while driving, the focus of the driver is divided and not centered on the road. The average gaze position illustrates that while browsing Facebook, drivers tend to shift their focus from the center of the road to the area just in front of them, which shows constant transitions from looking at the cell phone to looking at the road. From this perspective, Facebook browsing appears to affect attention just as badly as texting does. It could be that different tasks that are more complex than the one in this simulator would see the attentional decrements manifest themselves in more serious performance decrements.

Finally, when it comes to the subjective measures, the most telling result was the fact that 14 out of the 24 participants believed that their performance while browsing Facebook was good or excellent. This suggests that drivers are not aware of the extent of the effects of driving distractions. There is a need for better legislation and better awareness campaigns in order for drivers to be aware of the dangers of using their phone while driving. It is also worth noting that these results were obtained with young, college-age students, who are meant to be very technology and phone-savvy. It may be that with older adults these effects are exacerbated.

The main limitations of this study were related to eye tracking and to the number of participants. The eye tracker could not track participants' gaze on the car dashboard or within the car, meaning that the exact time that participants were looking at the phone could not be calculated. Instead, the amount of time spent on the phone was estimated from the other eye tracking metrics. In addition, the limited number of participants did not allow for modelling of the results. This number of participants will be addressed in future work and will be used to create a model of attention allocation that can be used to predict distraction due to cell phone use in the car.

In conclusion, browsing Facebook while driving can have a significant effect on the drivers' performance and attention in ways comparable to texting while driving. Browsing Facebook while driving leads to reduced lane keeping in addition to increased reaction times to changes in the surrounding (changing traffic light, car suddenly braking, pedestrian crossing, etc..). Similar to texting, browsing Facebook reduces the drivers' focus explained by the decrease in number of fixations and their duration on the road. However, the main problem is that drivers typically believe that browsing social media does not significantly affect their driving performance as much as texting. Therefore, they do not adjust their attention properly as when they are texting and driving because they do not feel the need to. Browsing Facebook while driving can be just as dangerous as or even more dangerous than texting while driving and thus proper awareness is needed.

CHAPTER VI

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Appendix A

Social media browsing while driving: effects on driver performance and attention

Nadine Marie Moacdieh (PI), Maya Abou Zeid (Co-I), Mahmoud Hashash (Co-I)

Debriefing questionnaire

All your answers will remain confidential.

Subject ID [Filled out by experimenter]: ……………
Questionnaire Date and Time [Filled out by experimenter]: ……………

Instructions: please answer each of the following items to the best of your knowledge.

Section I: Performance assessment

1. Overall, to what extent did driving in the simulator feel like real world driving?
   a) Not at all close
   b) Relatively close
   c) Very close

2. To what extent did you feel dizzy while driving the simulator?

   a) Not at all
   b) A little
   c) Very much

3. Do you believe that dizziness or other factors made your driving behavior in the simulator differ from your actual driving behavior on the roads?
   a) Not at all
   b) A little
   c) Very much. If so, please explain:
   ____

4. Overall, how did you feel you performed when driving **without a phone**?
   a) Very poor
   b) Fair
   c) Good
   d) Excellent

5. Overall, how did you feel you performed when driving **while texting**?
   a) Very poor
   b) Fair
   c) Good
   d) Excellent

6. Overall, how did you feel you performed when driving **while browsing through Facebook**?
   a) Very poor
   b) Fair
   c) Good
   d) Excellent

7. How did you adjust your attention and driving behavior while browsing social media? Please explain your approach.
   ____
   ____
   ____

8. How did you adjust your attention and driving behavior while texting? Please explain your approach.

____
____
____

Section II: Social media activity

9. Do you have social media applications installed on your phone?
   a) Yes
   b) No

10. If yes, which applications do you have installed?

____
_____

11. How often do you use social media applications while driving?
   a) Never
   b) Very rarely
   c) Sometimes
   d) Often
   e) Very frequently

12. If you do, which applications do you use while driving?
   ____
   __

13. Do you text while driving?
   a) Never
   b) Very rarely
   c) Sometimes
   d) Often
   e) Very frequently

14. Have you ever had an accident or a near accident (i.e., very close) with an object or person because you were **browsing social media** while driving?
   a) Never
   b) Once or twice
   c) Sometimes
   d) It happens a lot

15. Have you ever had an accident or a near accident (i.e., very close) with an object or person because you were **texting** while driving?
   a) Never
   b) Once or twice
   c) Sometimes
   d) It happens a lot

16. Do you think **browsing social media** while driving negatively affects your driving performance and attention?

a) Not at all
b) A little
c) Very significantly

17. Do you think **texting** while driving negatively affects your driving performance and attention?
    a) Not at all
    b) A little
    c) Very significantly

18. Do you think browsing social media is similar to texting while driving?
    a) It is not as dangerous as texting
    b) It is just as dangerous as texting
    c) It is a lot more dangerous than texting

19. If you have any comments about this survey or the experiment in general, please write them below:

____
____
____

Appendix B

Social media browsing while driving: effects on driver performance and attention

Nadine Marie Moacdieh (PI), Maya Abou Zeid (Co-I), Mahmoud Hashash (Co-I)

Screening Interview

Subject ID [Filled out by experimenter]: ……………………………………………………

<u>Interview Date</u> [Filled out by experimenter]: ………………………………………………

[These questions will all be asked verbally by the experimenter]. We will ask you a few questions to make sure you are eligible to participate in this study.

1. **Do you have a valid driver's license?**
   - ☐ Yes
   - ☐ No

[If "No", interviewer thanks the participant and tells him/her that he/she is not eligible to participate in the study; otherwise, the participant is asked to kindly show his/her driver's license before proceeding to Question 2.]

2. **Do you currently drive?**
   - ☐ Yes
   - ☐ No

[If "Yes", experimenter proceeds to Question 2a; otherwise, If "No", experimenter proceeds to Question 2b.]

2a. For how long have you been driving?
………………………………………………………………………………

2b. How long has it been since you stopped driving?
………………………………………………………………………………

[If answer to Question 2b is 3 years or more, experimenter thanks the participant and tells him/her that he/she is not eligible to participate in the study; otherwise, experimenter proceeds to Question 3.]

3. **Do you have an active Facebook account?**
   - ☐ Yes
   - ☐ No

[If "No", the experimenter thanks the participant and tells him/her that he/she is not eligible to participate in the study; otherwise, experimenter proceeds to Question 4].

4. **Where do you usually drive?**
   - ☐ Lebanon, Greater Beirut
   - ☐ Lebanon, Outside Greater Beirut
   - ☐ Outside Lebanon
     Please Specify: …………………………………

5. **[Health related issues]**
   a) **Are you on medications?**
   - ☐ Yes
   - ☐ No

   b) **Have you ever complained of dizziness?**
   - ☐ Yes

- ☐ No

c) **Do you have any ear or eye problem?**
- ☐ Yes
- ☐ No

d) **Do you have any motion sickness?**
- ☐ Yes
- ☐ No

e) **Have you had any recent sleep deprivations?**
- ☐ Yes
- ☐ No

f) **Do you have any active medical problems such as heart problems, epilepsy, etc.?**
- ☐ Yes
- ☐ No

g) **Do you have any active psychiatric problems such panic disorder, etc.?**
- ☐ Yes
- ☐ No

h) **Do you have Alzheimer's disease?**
- ☐ Yes
- ☐ No

i) **Do you have any mental health condition that would make you feel uncomfortable participating in this experiment?**
- ☐ Yes
- ☐ No

j) **Do you currently feel exhausted?**
- ☐ Yes
- ☐ No

k) **Have you had a main meal shortly before coming to the experiment?**
- ☐ Yes
- ☐ No

[If participant answers "Yes" to any of the above questions, experimenter thanks the participant and tells him/her that he/she is not eligible to participate in the study; otherwise, experimenter proceeds to Question 6.]

6. **[Interviewer notes respondent's gender.]**
- ☐ Male
- ☐ Female

[If participant is female, experimenter proceeds to Question 7; otherwise, experimenter proceeds to Question 8].

7. **Are you pregnant?**
   - ☐ Yes
   - ☐ No

   [If participant is pregnant, experimenter thanks the participant and tells her that she is not eligible to participate in the study]

8. **What is your age?**
   ……………………………………………

   [If age is less than 18 or greater than 24, experimenter thanks the participant and tells him/her that he/she is not eligible to participate in the study]

9. **What are your faculty and major of study?**
   Faculty and major of study:
   ………………………………………………………………………………………………………

10. **What is your current educational status?**
    - ☐ Freshman
    - ☐ Sophomore (first year)
    - ☐ Junior (second year)
    - ☐ Senior (third year or above)
    - ☐ Graduate (Masters or Ph.D student)

11. **What is your nationality?**
    ……

Appendix C

NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High