# Effects of Cell Phone Notification Levels on Driver Performance

by

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# ABSTRACT

Previous literature was reviewed in an effort to further investigate the link between notification levels of a cell phone and their effects on driver distraction. Mind-wandering has been suggested as an explanation for distraction and has been previously operationalized with oculomotor movement. Mind-wandering's definition is debated, but in this research it was defined as off task thoughts that occur due to the task not requiring full cognitive capacity. Drivers were asked to operate a driving simulator and follow audio turn by turn directions while experiencing each of three cell phone notification levels: Control (no texts), Airplane (texts with no notifications), and Ringer (audio notifications). Measures of Brake Reaction Time, Headway Variability, and Average Speed were used to operationalize driver distraction. Drivers experienced higher Brake Reaction Time and Headway Variability with a lower Average Speed in both experimental conditions when compared to the Control Condition. This is consistent with previous research in the field of implying a distracted state. Oculomotor movement was measured as the percent time the participant was looking at the road. There was no significant difference between the conditions in this measure. The results of this research indicate that not, while not interacting with a cell phone, no audio notification is required to induce a state of distraction. This phenomenon was unable to be linked to mind-wandering.

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# CHAPTER 1

# INTRODUCTION AND PREVIOUS RESEARCH

It has been well documented that the usage of cell phones while operating a motor vehicle has an effect on a driver's capabilities (Collet, Guillot, & Petit, 2010.) With use continually increasing as cell phones become more and more ubiquitous, the issue of cell phone notifications in vehicles are becoming an ever pressing issue. According to (Atchley et al., (2011), 92% of college students surveyed responded that they utilized a cell phone while driving, even when aware of the dangers of distracted driving. In response, several cell phone providers have installed software that allows the user to limit their notifications while driving. Given the apparent separation anxiety humans are developing concerning their devices, an important question arises, could limiting notifications during driving still cause a loss of performance and perhaps, what might be the underlying mechanisms?

Stothart, Mitchum, & Yehnert, (2015), did explore the relationship between cell phone users and their devices. The researchers took participant's cellular phone numbers during initial intake and randomly assigned participants into three levels: call, text, and no notification. The participants were then asked to perform a sustained attention to response task (SART) which asked them to press a key when digits 1-9 appeared on the screen. Unbeknownst to the participants, the script also had the researchers call or text those in the two notification groups while they were working on the SART task. Participants were excluded if they did not have their phones on or looked at their phone in response to the notification. The research found that, when notifications were received by the participant, even when they did not interact with the phone, participants had a measurable drop in performance on the SART task. The loss of performance during a distracted condition echoed previous studies which looked at distracted vs. non-distracted conditions. The persistent distraction-like effects even in the absence of direct interaction lays a fundamental framework for how research can look at future interactions between drivers and their devices. Particularly distraction that does not involve direct contact.

While not specific to automotive operation, Ward, Duke, Gneezy, & Bos, (2017), investigated this phenomenon. In the first of two experiments, the researchers asked 520 participants to silence their devices and then place them either in another room, face down on the desk where tests would take place, or in a pocket/bag. These were operationalizing the concept of phone salience. Phone salience refers to a phone's ability to drain cognitive resources. For example, "high salience" would refer to a phone placed directly in the field of view of the participant. Participants were then asked to complete two tasks: the Automated Operation Span task (OSpan) and Raven's Standard Progressive Matrices. Both are intended to measure cognitive capacity. Those who had their cell phone in the other room performed significantly better on available working memory capacity and functional fluid intelligence than those who had their device either in their pocket/bag or on the desk. There was no significant difference between the desk and pocket/bag condition.

The second study took 275 different participants and used a 3 (Phone Location: desk, pocket/bag, other room) x 2 (Phone on or off) between subjects design. The intake procedure was similar to the first experiment except the participants in the, "Desk" condition were asked to leave their phones facing screen up on the desk. The other major difference was that some participants kept their phones on, but in silent mode, while others simply were asked to turn them off. Participants completed both the OSpan test from the previous study and a Go/No-Go task which is intended to measure sustained attention. The researchers found that phone salience had an effect on cognitive capacity with the, “Desk” condition, in which participant’s phones were face-up on the desk, leading to the poorest performance on the tasks. They found no significant relationship between phone salience and sustained attention. Both of these studies provide evidence that even the mere presence of a cell phone can have an effect on the cognition of an individual.

Similar research was conducted by McNabb and Gray (submitted). The study primarily focused on the effects of different methods of receiving and checking notifications and served as the basis for the research. Participants completed several conditions during a simulated drive. The primary conditions were levels of how a cell phone notified the participant during the drive. The notification conditions were further separated into several sub-conditions to which the participants could check their device (only when stopped, any time, or at the end of the drive). In an effort to simulate a participant’s natural desire to check their phone, a riddle task was devised in which participants received clues via their mobile phones at two-minute intervals and were asked to answer the riddle at the end of the experiment. The researchers found that even in notification only conditions in which the participants were notified, but did not immediately answer the texts, the anticipation of answering the riddle and knowing they are receiving notifications was enough to cause a change in driver performance measures of brake reaction time, time headway and average speed. This was theorized to be attributed to mind-wandering, as thoughts not related to driving could be stimulated by the phone notifications.

Mind wandering is a phenomenon that is not exclusive to motor vehicle operation. It is a state that occurs when an individual is performing a primary task which is not cognitively demanding enough to warrant a person's complete attention. The brain then, looking for novel stimulation, begins to wander (Galéra et al., 2012). There is some precedence for mind wandering being considered an influence in distracted driving. Galéra et al., (2012) interviewed 955 participants who had been recently (within 72 hours), admitted to a hospital following an automobile accident. It was found that half of participants admitted to having wandering thoughts before the accident. It was also found that those who reported having a high degree of mind wandering before the accident, were significantly more likely to be at fault than those who didn't. It is important to note however, that this significance was only achieved once other confounding variables were balanced for. This study, though-survey based, lends some credence to the idea that mind wandering, though not an external distraction, can be a significant contributor to poor driving behavior.

Oulasvirta, Rattenbury, Ma, & Raita, (2012) decided to look at the motivations that might cause a user to look at a cell phone even when they know they should not. The main area of interest was the influence of habits in cell phone usage. The main habit evidence was provided for was a, "checking habit", wherein users investigate their phones repeatedly often for short periods of time or where several actions are performed in rapid succession (ex. Checking the time or scanning for app notifications). The researchers found these behaviors accounted for approximately 18% of all cell phone usage. The frequency of quick, repeated interaction lends credence to the idea that smartphone usage may be, in part, automatic and habitual. Checking habits, the researchers explain, are frequently performed simply to look at the notifications screen to check for any incoming and more importantly, novel stimuli. Checking habits were found to have three main motivators: entertainment (looking to be entertained), killing time (searching for novel stimuli) and, awareness (ensuring one is, "on top of" incoming information ex. e-mail). Oulasvirta et al. (2012), also found some evidence to suggest that checking habits can be, "gateway habits" to other applications, as more frequent checking habits was correlated with an increase in overall usage of the device. They also suggested that these checking habits can be greatly influenced by situational cues including the very presence of a mobile phone. However, the effect a noticeable, but not interacted with cell phone was not investigated directly.

He, Becic, Lee, & McCarley, (2011), attempted to study the frequency of mind wandering specifically while behind the wheel. Seventeen participants were assigned a driving simulator task in which they were asked to maintain an equal distance between a car in front of them and behind them which randomly varied in speed from forty to fifty miles per hour. The participants also had to contend with a high lateral wind condition, in which they would be drifted off course and were expected to correct to maintain center lane position. The course was made intentionally dull in an effort to induce mind wandering. Participants were then asked to press a button to indicate whenever they found themselves mind wandering, defined as any thoughts that weren't task relevant. It was found that when participants were in the more cognitively demanding, high wind condition, less mind wandering was reported. The clearest connection between mind wandering and the measures of driving ability were between mind wandering and horizontal gaze, which was reduced in scope during periods of mind wandering. This suggests that mind wandering may cause an individual to stop scanning their environment for changes or threats. The researchers suggest that due to this change in behavior, mind wandering can potentially negatively affect driving capabilities in a manner similar to secondary-task distraction (performing another task while driving). The researchers also went on to mention that due to the nature of the self-reporting method of tracking mind wandering, it was impossible to know how participants might have reacted to critical events while mind wandering. This research is, however, invaluable in laying some groundwork for baselines of driver behavior, and oculomotor changes while mind wandering behind the wheel.

Baldwin, Roberts, Barragan, Lee, Lerner and Higgins (2017), investigated more closely how to detect and quantify mind wandering during simulated driving. Nine participants drove twice per session. Both drives included no turns and contained no traffic and only light scenery. The only difference being that the second drive was a reverse of the first drive, starting at the previous end point and returning to the first starting lot. In-between the two drives, participants performed a SART task in an effort to drain the participants of cognitive resources that may help them stay on task. During both the driving and SART sessions, participants were prompted with tones to probe participants to report whether they were mind wandering or not. The probe style method of detecting mind wandering was used here as spontaneous self-reporting requires the participant to be both, having off-task thoughts, and aware they are having off-task thoughts. If the participant reported that they were mind wandering, they were also asked to report whether they were aware they were mind wandering before they were probed. Participants reported mind wandering to an average of 70.10% of probes. Participants were more likely to report that mind-wandering during the second task, after the SART task likely drained some cognitive resources. The researchers also found that lane deviation and speed variability decreased during periods of mind wandering. Though this might sound positive, it may continue to suggest that mind wandering causes individuals to, “space out” and fall into an, “autopilot” state where they could be less likely to identify and respond to potential critical events.

Yanko & Spalek, (2014), performed two experiments which investigated mind wandering and critical events. To assess mind wandering, probing the participant was also used. When the tone prompted the participant, they were instructed to press the button if they were mind wandering, but to withhold a response if their mind was on task. In the first experiment, seventeen subjects drove around a circular track behind a pace car. The pace car was programmed to always lead by thirty meters, speeding up or slowing down as necessary to maintain a constant headway from the participant’s vehicle. However, participants were instructed to attempt to maintain a twenty meters per second speed at all times except for braking events. The pace car would brake intermittently (slowing down to 9.2 meters per second), averaging thirty seconds between braking events with no less than ten seconds between events. When these events occurred, the simulator would record the time it took for the participant to apply the brakes. At which point, the pace car would resume the normal pace required to have thirty meters of headway. The researchers found that braking reaction time was significantly longer when participants reported they were mind wandering.

The second experiment had thirty-two participants and was relatively similar in design. However, the lead vehicle was now allowed to vary the headway distance between itself and the participant's vehicle. Also, female pedestrians were programmed alongside the road in two hundred-meter intervals. A random, twenty percent of these pedestrians would walk towards the road when the participant was fifty meters away. Participants were also instructed to press a different button when they noticed a pedestrian beginning to walk towards to the road. Similar to the first study, braking response times were found to be significantly longer when participants were mind wandering. They also found that participants followed the lead vehicle more closely in a state of mind wandering. Finally, it was discovered that participants took significantly longer to respond to the women walking towards the road in their peripheral vision while having off-task thoughts. While the probing style of operationalizing mind-wandering has been shown to be relatively valid, a better method would be one that prevented the participant from reporting falsely. A biological measure which would indicate to researchers that a participant was engaging in internally directed thoughts as opposed to engaging in a task.

Benedek, Stoiser, Walcher, & Körner, (2017), attempted to correlate eye behavior with internal and external cognition. In the research, forty-six participants performed anagram and sentence generation tasks. In the anagram task, meaningful four-letter words were displayed, and participants were asked to rearrange them into another meaningful word. In the sentence generation task, participants were asked to create a meaningful sentence using the prompt letters as the beginning letters of each word in the new, generated sentence, in order. Both tasks were further subdivided into external, and internal attention conditions. In the external condition, the words associated with the tasks remained on screen throughout the task whereas in the internal condition, the words were masked after a time. The change in availability of information forced the participant to continue to envision and work through the problem internally, during which the participant's pupil dilation, fixation count and duration, saccade count and amplitude, and blink duration were measured. The researchers found that during the internal attention condition, participants showed a decreased rate of both fixations and saccades. However, the duration of the fixations and the amplitude of the saccades did increase. In effect, the participants in the internal attention condition moved their eyes less while formulating an answer. The researchers posit that this is evidence for the perceptual decoupling hypothesis, which suggests that internally directed cognition decouples and takes resources away from external sensory processing. The relevance of the research suggests if driver's eyes are found to be fixating for longer periods of time, this can be taken as some evidence that internally directed cognition is occurring. In a scenario in which a person is actively driving a vehicle, this internally directed cognition while observing active stimuli could be a measure of mind-wandering.

Savage, Potter, & Tatler, (2013), investigated the potential effect a recent cell phone conversation could have on attentional processing. In the study, 17 participants were hooked up to an eye tracker with an EEG reader. In the experimental condition, a high cognitive load was induced by asking the participant a riddle to be solved whereas in the control condition, the participant heard only a neutral statement. The participant was then shown a Hazard Perception Clip of vehicle footage and was asked to press a button to indicate the moment they perceived a hazard. Participants in the high cognitive load condition were significantly slower in responding to hazards and they reported false hazards 30% more. It was also found that, in the high cognitive load condition, saccades were smaller than in the control. The researchers conclude that eye movements including saccade and fixation measures provide a measure of driver distraction that is unobtrusive to the participant.

Underwood, (2007), compared the visual scanning fields of novice and experienced drivers. Looking at previous research in the field, it was determined that experienced drivers tended to have wider scanning range than novice drivers. One potential explanation the researchers suggest is that novice drivers are overloaded with information and begin to fixate for longer to avoid the overtaxing of cognitive resources with new data. When hazardous situations were present (ex. a nearby cyclist appears, necessitating braking from the participant), both experienced and novel drivers attended to it at comparable levels. However, more experienced drivers returned more rapidly to a default scanning state after a hazardous situation, allowing them to continue scanning the environment for new potential threats faster than novel drivers. Assuming an experienced driver is the baseline for good driving behavior, a driver's oculomotor movements may be able to discern whether or not a driver is being cognitively overtaxed in the way novel drivers are.

The previous research demonstrates driver behavior while using a cell phone as well as oculomotor behavior when driving, and when under a high cognitive load. Ward, Duke, Gneezy, and Maarten (2017) and McNabb and Gray (submitted), found that even when a cell phone was not directly being used, its mere presence was enough to cause measurable differences in cognitive performance. Several studies suggest that oculomotor movements can be a valid indicator of increased distraction.  When individuals are experiencing off-task thoughts, their oculomotor behaviors begin to include longer fixations, fewer overall saccades as well as a smaller horizontal scanning range, and are more likely to miss or react slower to threats appearing in the periphery (Savage, Potter, Tatler 2012, Underwood 2007, Benedek, Stoiser, Walcher and Körner 2017, He, Becic, Lee and McCarley 2001, Yanko and Spalek 2014).

However, oculomotor measures of distraction have not been measured alongside driving ability when distracted by a cell phone.  Measuring mind wandering as an explanation for the purposes of this research is difficult as its definition is nebulous at best.  As such, the current work will instead focus on correlating traditional measures of driving performance (average speed, headway variability, brake reaction time) with a measure of mind wandering.  Mind wandering will be quantified with data from a camera located in a simulated vehicle's rearview mirror.

CHAPTER 2

# METHODS

The following methods were adapted from McNabb and Gray (submitted)

## Participants

13 participants were gathered through personal contacts and advertising in Arizona State University Polytechnic's SIM building. All participants were required to be native English speakers with normal or corrected-to-normal vision with a valid driver's license and be smart phone users. This was a within-subjects design with each participant experiencing each of the three conditions, (No Notifications, Airplane, and Ringer modes) in a block randomized order. Two participants were eliminated from the final analysis due to simulator sickness causing an inability to complete the tasks.

## Apparatus

A DS-600c Advanced Research Simulator by DriveSafety™ was used. This simulator is comprised of a 300 deg wraparound display, a full-width automobile cab (a Ford Focus) and a motion platform. Tactile and proprioceptive feedback cues will be provided via dynamic torque feedback from the steering wheel and vibration transducers mounted under the driver's seat. The motion platform provided coordinated inertial cues for the onset of longitudinal acceleration and deceleration.

To track oculomotor movement, an internal camera data located in the rearview mirror of the vehicle was used.

## Procedure

### Driving Task

Participants were asked to drive through a simulated city environment and to drive as they would normally while following auditory turn instructions from a navigational system. Each drive lasted roughly ten minutes with drivers receiving a five-minute practice session to increase familiarity with the simulator, test for simulator sickness, and reduce any novelty biases. Between each of the three conditions (Control, Ringer, Airplane), the participant was allowed a five-minute break to reduce fatigue and delay the onset of simulator sickness. The course was intentionally designed to lack stimulation to encourage the participant to think off-task thoughts unrelated to the driving task.

**Conditions and Questions**

Drivers were instructed that they will be receiving several texts throughout some of the conditions. If the condition included texts, the participants were then asked to answer them at the end of the drive. Questions were delivered throughout the driving task via text message at two-minute intervals. None of the participants were allowed to check their devices during the drive, but all had their phones screens face-down but physically visible in the passenger seat. Participants completed three conditions in a block randomized order:

1. *Control* – Participants have their phone turned off during the drive. The participants did not receive or answer texts. However, the presence of the phone in the simulator will reduce the influence of phone presence as a confounding variable and instead will emphasize notification salience. It is important to note that during this condition, the participant is aware that they

will not be receiving any texts and will focus entirely on driving through the simulation.

2. *Notifications Only Mode* – Participants will drive with their phone in an audible ringtone mode.
3. *Airplane Mode* – Participants will complete the course on airplane mode, receiving no visual or audio indicators of incoming messages. In this condition the key is the participant will be aware that they are receiving texts throughout the drive, regardless of no immediate notification.

The specific block of questions used for each condition and for each driver were randomly assigned. Upon completion of the course, drivers were allotted one minute to check their phone and answer the questions. Questions consisted of general, "small talk" style questions ex. "What was the last film you saw?", "What make/model car do you drive?".

Driving ability will be operationalized by three measures:

1. *Brake Reaction Time* – The time between the time to collision with the lead vehicle falling below two seconds and the brake reaching half its maximum force.
2. *Headway Variability* – The standard deviation of the distance between the participant and the vehicle ahead of them measured in a ten second window.
3. *Average Speed* – Average speed of the participant

Measures of distraction will be operationalized through the camera located in the rearview mirror of the driving simulator. It is hypothesized by the researchers that due to the internally motivated distraction caused by a desire to check a cell phone notification, when participants are most distracted (in the ringer and airplane modes) they will experience a longer brake reaction time, a higher headway variability, and a higher average speed.

CHAPTER 3

RESULTS

**Brake Reaction Time**

Figures 1-4 shows the mean and standard deviation for each condition as it pertains to each dependent measure. A repeated measures ANOVA for Brake Reaction Time was performed and suggested that there is a significant mean difference between the conditions $F(2, 9)=8.539$, $p=0.002$, $\eta_p^2 = 0.461$. Mauchly's test, $\chi^2(2) = 0.865$, p=0.649 did not indicate a violation of sphericity. Post-hoc Bonferroni tests suggested differences between conditions which were followed up by paired samples t-tests. The t-test suggested that the control condition was significantly faster than the ringer and airplane conditions: $t(10)=-3.694$, $p=0.004$, $d=-1.499$ and $t(10)=-3.827$, $p=0.003$, $d=-1.765$ respectively. This suggests that participants take longer to react to a braking event when in ringer and airplane conditions. However, when compared to each other, these non-control conditions are statistically very similar.

**Headway Variability**

Time Headway Variability measured a significant mean difference of $F(2, 9)=16.404$, $p=0.000$, $\eta_p^2 =0.621$. Mauchly's test, $\chi^2(2) = 0.958$, p=0.619 did not indicate a violation of sphericity. The post-hoc paired samples t-test suggested a difference as well with the Control having a larger amount of headway variability from both the Ringer condition, $t(10)= -4.875$, $p=0.001$, $d=-1.972$, and the Airplane mode condition, $t(10)= -4.855$, $p=0.001$, $d=-2.378$. This measure suggests that participants were less in control of their ability to regulate distance between themselves and the object in front of them when in experimental conditions.

## Average Speed

An Average Speed repeated measures ANOVA suggested a significant difference as well $F(2, 9)=10.762$, $p=.001$, $\eta_p^2=0.518$. Mauchly's test, $\chi^2(2) = 5.299$, p=0.071 did not indicate a violation of sphericity. The follow up t-tests followed the trend, with a Control-Ringer t-test resulting in $t(10)= 2.990$, $p=0.014$, $d=1.243$ and, Control-Airplane $t(10)= 6.335$, $p=0.000$, $d=1.955$. Unlike the other two measures, average speed was significantly faster in the control condition as opposed to the airplane and ringer conditions.

## Percent Time Looking at the Road

The repeated measures ANOVA for percent time looking at road did not achieve similar results to the other variables. It suggested that there was no difference between the control and experimental conditions $F(2, 9)=0.360$,$p=0.702$, $\eta_p^2=0.035$. Mauchly's test, $\chi^2(2) = 0.327$, p=0.849 did not indicate a violation of sphericity.

Figure 1 (included standard deviation bars)

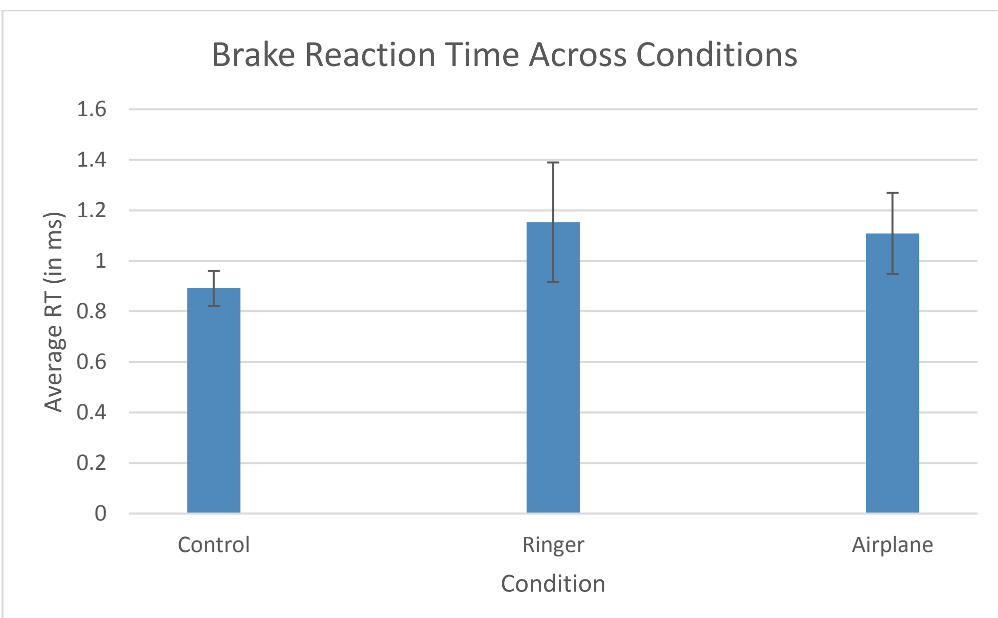


Figure 2 (included standard deviation bars)

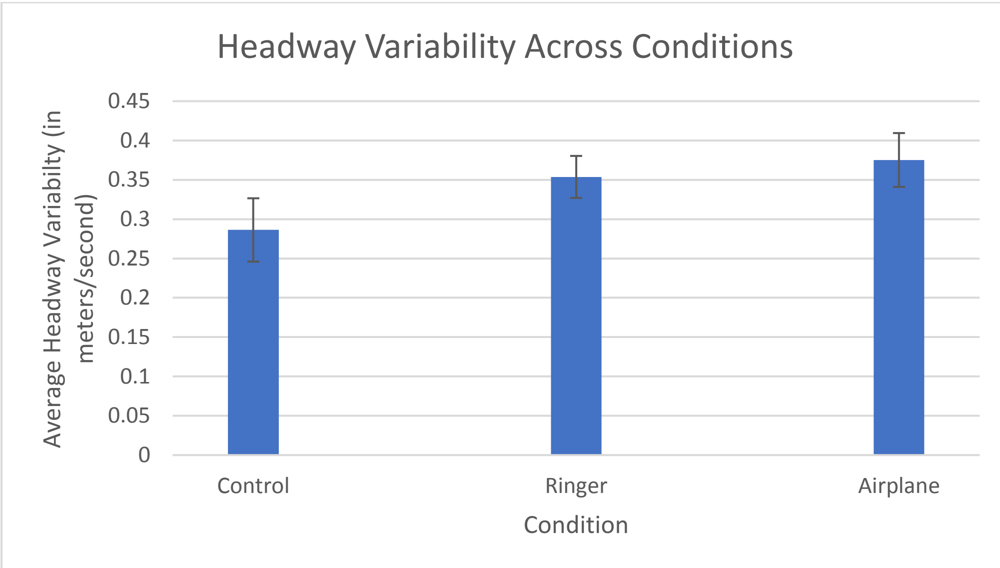



Figure 3 (included standard deviation bars)

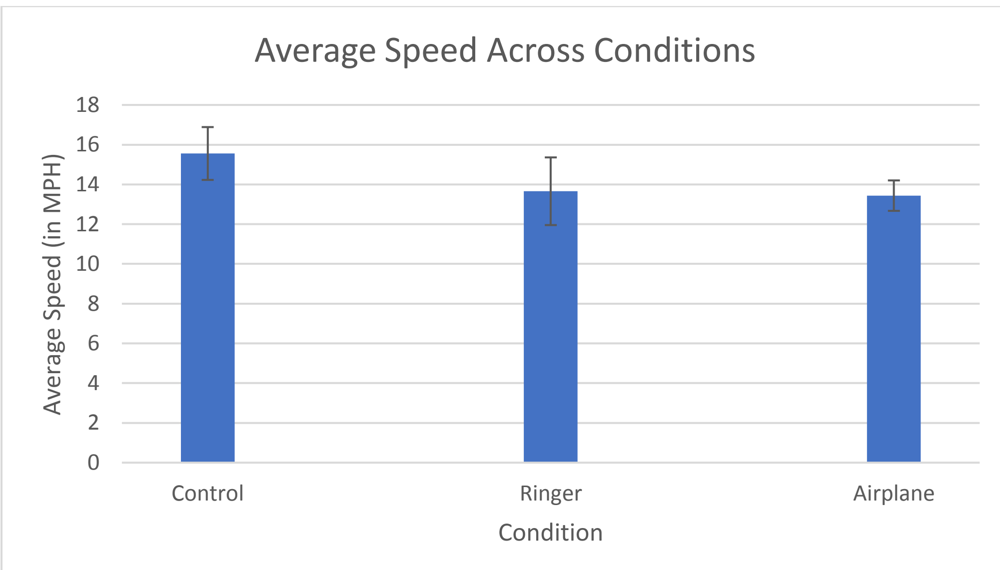
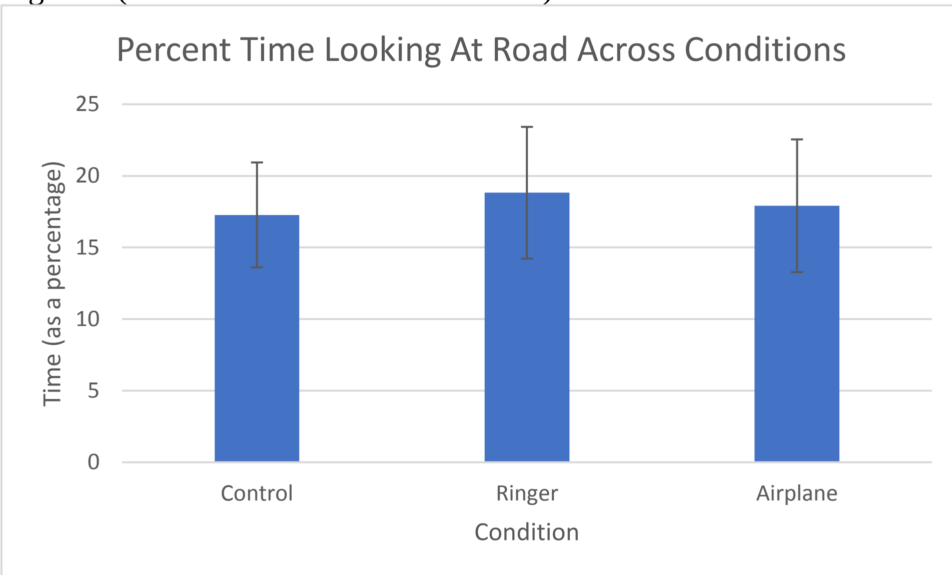


Figure 4 (included standard deviation bars)



# CHAPTER 4

## DISCUSSION

In an effort to reduce cell phone distractions in vehicles, various modes and apps have been developed to try and reduce how distracting they are. However, it seems that merely muting notifications isn't enough. The results of the present research suggests that having the phone on an airplane while driving can have a similar distracting effect to having an audible notification. Both of which, suffer when compared to the control condition. This mirrors previous research by Ward et al., (2017), which seemed to show a sort of threshold effect in that performance measured was decreased in experimental conditions where the participant's cell phone was available but otherwise did not interact with it. The researcher attributes this to the anticipation of notification having a measurable effect on driver behavior. With the anticipation potentially causing a delay in braking time and higher headway variability, while also causing a measurable decrease in average driver speed.

This assumption however, is based entirely on past research correlating poorer driving performance with increased off task mind wandering. Consistent with previous research into driver behavior, the results here align with a state of distraction in the participants. As with McNabb and Gray (submitted), participants who were under experimental conditions had a higher brake reaction time and time headway variability while also experiencing a slower average driving speed. This also falls in line with previous research (Caird, Johnston, Willness, Asbridge, & Steel, 2014), which suggested that these measures can be reliable indicators for distracted driving, particularly texting and driving. Given that the phone was present, but not interacted with, in all three conditions, this suggests that the issue is not the salience of the phone itself, but the anticipation of notification. This is substantiated by Stothart, Mitchum & Yehnert, (2015), whose results suggested that having a phone available, even when not interacting with it, can result in a decrease in performance on an attention task.

This research, however, was unable to clearly identify a role for mind-wandering in these effects. Operationalized in this study as, percent time looking at road, it is important to note that there is no evidence for percent time looking at road as a valid indicator of mind wandering. Previous studies used the more valid methods of saccade and fixation measures. As such, there was no quantifiable method of determining if off task thoughts caused the driver's loss in performance. This measure and previous research into oculomotor movements were included to add to the body of literature.

**Limitations**

This study contained several limitations. Firstly, the simulated environment of this study contained programming glitches including cars that would only become visible on partial displays. This could have affected the participant's mindset as it likely decreased the overall fidelity of the simulation. This also led to several incidents in which participants felt confused and as to how they should react to impossible situations.

For example, during the drive participants experience a traffic light which displays yellow when the participant approaches. Many participants would stop at this light unknowing that the simulation would never change to red and continue the traffic cycle. To continue the tests, the experimenter instructed participants as minimally as possible to get them through a programming error. In this example, participants were instructed to continue driving through the intersection as normal. Some, but not all participants spontaneously self-reported experiencing simulator sickness post-test but not to a degree enough to halt the experiment. This could have also distracted them in a way which was unrelated to the cell phone notification level. No data was collected on sensitivity to simulator sickness.

Pertaining to the oculomotor data, a potential measure sensitivity issue could be to blame. Underwood's (2007), research focused on saccade and fixation length and frequency to help determine mind wandering. The eye tracking software capabilities of the simulator were not sensitive enough to gather data on these measures.

**Implications and Direction for Future Research**

The statistically significant effects here may hold clues to help direct future laws. Though Arizona, where this research is being performed, is one of three states in the United States to not have a state-wide distracted driving law, individual cities seem to be passing legislation as quickly as they can. But a blanket, "No cell phones and driving" law is too open to interpretation and as this research suggests, is partially ineffective. As the anticipation of notification is an internally driven process, that is something beyond regulatory power. As such, this issue is likely not going to be resolved easily or quickly. This researcher suggests future scientists investigate if hands-free devices share a similar distraction, potentially allowing a method of communication with the least amount of distraction. It would also benefit future research greatly to use more precise oculomotor methods of determining mind wandering to give better confidence in pinning down what is causing the observed effects.

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