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DRIVING PERFORMANCE ADAPTATION THROUGH PRACTICE WITH AND WITHOUT DISTRACTERS IN A SIMULATED ENVIRONMENT

by

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ABSTRACT

A preponderance of research points to the detrimental effects of distraction on driving performance. An interesting question is whether practice can improve distracted driving. The results from the few longitudinal simulator-based research studies conducted on driving distraction have been inconclusive. This may be because practice effects could be confounded with participants adapting to driving in the simulator. Therefore, participants in the current studies were trained until performance reached a steady state prior to introducing the distracters.

In this dissertation, two single-subject design studies were used to investigate the effects of training on distracted driving. The first study included two participants who experienced several different types of distracters. In the second study distracters were introduced before and after the training phase. The two distracters selected for Study 2 included conversing on a handheld phone and texting on a touchscreen phone continuously while driving in a city scenario. Previous research has not compared texting to phone, has had relatively little examination of texting and driving alone, and has primarily focused on hands-free phones and on highway settings. Participants drove on a city route which they had previously memorized to add realism to the driving task. Measures collected included speed maintenance, lane deviations/position errors, stop errors, and turn errors in both studies. In Study 2, subjective workload and reaction time were also collected.

Findings indicated that training improved performance substantially for all participants in both studies compared to the initial baseline. Participants who experienced six and even nine sessions of the initial baseline did not necessarily improve more than those who only had three sessions. Performance for some participants did not improve in the initial baseline. The lower error levels in training remained fairly stable in subsequent baselines showing that actual learning did occur. Texting had higher error levels than phone both pre and post-training. There were no practice effects noticed for the distracters post-training for any of the participants, and in fact errors increased across sessions for phone and especially texting in Study 2. Training helped improve performance during the phone distraction more so than texting overall, although this varied for different dependent measures. Although errors were reduced after training in the distracter phases, the data actually showed that the performance difference between the baselines and the distracters pre-training was smaller than the differences post-training. Based on these findings, it is recommended that researchers conducting driving simulation research systematically train their participants on driving the simulator before they begin data collection.

I dedicate this dissertation to all my loved ones for their support and encouragement. Without you all I would not have been able to achieve this monumental milestone.

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LIST OF ACRONYMS/ABBREVIATIONS

DEQ	Driving Experience Questionnaire
DHQ	Driving Habits Questionnaire
CPEQ	Cell Phone Experience Questionnaire
IRB	Institutional Review Board
NASA-TLX	National Aeronautics and Space Administration Task Load Index
PRP	Psychological Refractory Period
SSQ	Simulator Sickness Questionnaire

CHAPTER 1: INTRODUCTION

Driving is a complex task individuals perform frequently (Hole, 2007). The human factor is still the most important part of safe driving as about 90% of traffic crashes involve human error (Cai, Lin, & Mourant, 2007). With the driving task, a driver must sense and perceive an environmental stimulus, understand the stimulus and what it means to the driver, decide how to respond to the stimulus, and then finally make the actual response.

Driving a vehicle in light traffic and good weather may not be overwhelming for most drivers. However, driving in conditions such as heavy traffic, in poor weather, at high speed, or in complex situations can surpass many drivers' abilities (Rinalducci et al., 1993). Attention is required in every phase of the driving task. Although driving can be thought of as a manual task (e.g. turning the steering wheel), a visual task, and somewhat an auditory task, it is also a cognitive task. For instance, improvement over time in driving performance through experience is due to the gradual changes in obtaining and processing of information (Shinar, Tractinsky, & Compton, 2005).

As individuals gain experience driving, the task becomes more automated than controlled (Reisberg, 2006). With tasks becoming more automated, drivers should be able to handle other tasks better, as they should be able to allocate more cognitive resources to the secondary tasks. However, automaticity can cause errors by creating "mental reflexes" to various road events since the tasks are not well controlled (Reisberg, 2006).

Driving and distraction

Driver distraction has been a concern for many decades. Regan, Lee, and Young (2009) defined driver distraction as “a diversion of attention away from activities crucial for safe driving toward a competing activity” (p. 34). Olson, Dewar, and Farber (2007) defined it as “a mismatch between the attention demanded by the driving task and the attention devoted to it” (p. 472). Researchers have also distinguished between the concepts of distraction and inattention. Distraction is thought of as something external to the driver and compelling like a cell phone or radio, whereas inattention is more internal and not compelling, like daydreaming (Treat, 1980; Caird & Dewar, 2007, Olson, Dewar, & Farber, 2007).

Olson, Dewar, and Farber (2007) more specifically stated that the types of distraction are “visual distraction (looking away from the roadway), auditory distraction (e.g. responding to a ringing cell phone), biomechanical distraction (e.g. adjusting the radio volume), and cognitive distraction (e.g. being lost in thought)” (p. 473). Cognitive distraction occurs when drivers shift their attention away from the primary task of driving to focus on a secondary task (Giguere, 2003), which can cause drivers to miss potential hazards (Alm & Nilsson, 1994; Strayer & Drews, 2008, Tornros & Bolling, 2006).

Miles and Vincent (1934) claimed that when drivers are distracted, they tend to have reaction time increases because their attention is diverted to something else. Driver distraction contributes anywhere from 20 to 30 percent to all crashes (Giguere, 2003), and more recently the National Highway Traffic Safety Administration reported that 20% of driver injuries in automobile crashes were due to distraction in 2009 (NHTSA, 2010). Another study showed that attention failures caused 78% of 69 car crashes and 65% of another 761 car crashes (Lee, 2009).

The negative effects of distracted driving may go completely unnoticed by a driver unless they experience a near-miss or crash. Research on distraction and visual scanning indicated that, in general, distracted participants tend to make fewer peripheral scans and more scans in the central field of view, thus less overall scanning of the visual scene area (Atchley & Dressel, 2004; Beede & Kass, 2006; Barkana, Zadok, Morad, & Avni, 2004; Harbluk, Noy, Trobovich, & Eizenman, 2007; Victor, Harbluk, & Engstrom, 2005).

Harbluk, Noy, and Eizenman (2002) differentiated between “eyes off the road” and “mind off the road”. If an individual was looking at a text message or dialing a phone, this would most likely require “eyes off the road”. Conversing on the phone while driving would be a form of cognitive distraction and would represent “mind off the road”. In this sense, an individual may not be visibly blind but cognitively blind when conversing on a cell phone. This could be just as dangerous if it leads to a failure in perceiving an important hazard and could result in what some researchers refer to as “looked but failed to see” crashes (Olson, Dewar, Farber, 2007).

Because cell phone use can serve as a biomechanical, visual, auditory, and cognitive distraction, it is not surprising that it can cause severe detriments in driving performance. For instance, in 2002, the Harvard Center for Risk Analysis roughly estimated that driver cell phone use is responsible for more than 2,500 deaths and greater than 500,000 minor-to-critical injuries in the U.S. each year. Drivers even admit that cell phone use while driving increases the chances of crashing (Giguere, 2003). Strayer and Drews (2004) found that when individuals conversed on the phone while driving, their reaction time declined 18%, it took them 17% longer time to get back to the speed that they were at before they started slowing down, their headway (distance between their vehicle and the vehicle ahead) increased by 12%, and they also had twice as many rear-end collisions. Other research has found that when conversing on a phone and driving concurrently, performance decrements could be as serious as when driving intoxicated (Strayer, Drews, & Crouch, 2006).

Texting (reading and writing messages) while driving may be more detrimental to driving performance than simply talking on a cell-phone because of the constant visual and manual demands that texting involves (Hosking, Young, & Regan, 2009). Because of the increased demands, it is likely that those who text will look off-road for longer periods than those talking on the phone. This is critical given that the duration of off-road glances longer than two seconds more than doubles crash risk (Klauer et al., 2006). Although good theoretical reasons suggest that texting is a very serious distraction, surprisingly little empirical research exists regarding its effects on driving performance (Hosking et al., 2009). One population that may have greater risk for driving while distracted in general could be older individuals, given the many cognitive and perceptual deficits that come with aging include a decreased ability to allocate attention adequately (e.g. Kramer, Larish, & Strayer, 1995). Since driving requires cognitive and perceptual abilities, deficiencies in these abilities due to aging are likely to cause a decrease in driving performance.

Novice drivers

Although older drivers in general are more prone to car crashes, novice drivers also have very high crash rates (Olson & Farber, 2003). Even though teens are 14% of the licensed drivers, they actually count for 26% of the drivers having a deadly crash (Seo & Torabi, 2004). Curry, Hafetz, Kallan, Winston, and Durbin (2011) pointed out that the leading cause of death for teens is motor vehicle crashes based on almost 5500 major crashes from mid-2005 to the end of 2007, with almost all of the blame being placed on driver error. Of the crashes considered to be driver error, the researches noticed that a teen was responsible for the error about 3 out of 4 times. Teen Driver (2006) reported that 60% of the teens killed annually are drivers and about 450,000 teens are injured in car crashes annually.

Novice drivers may have more crashes partly because they lack driving experience. Initially, for novice drivers, many of the driving tasks increase cognitive load as compared to those taken up by an expert driver. The driving task is not automatic for novices, and thus they are less prepared to deal with secondary tasks or more complex driving situations such as adverse weather. McKnight and McKnight (2003) pointed out that teen car crashes not resulting in a fatality were the result of attention lapses, inadequate scanning/searching, failure to adapt driving to the current road conditions, lower ability to detect hazards, and lower ability to handle an emergency situation. They also found that lack of experience is a larger factor than risky behavior for teen drivers. Underwood (2007) explained that novice drivers scan less compared to experienced drivers, particularly when road demands increase. Underwood (2007) suggested that experience and training can help improve visual scanning through developing greater task understanding by novice drivers.

The risk of having a crash decreases substantially in just the first couple of months after obtaining a license as a product of learning, practice, and gaining important experience (Mayhew, Simpson, & Pak, 2003; Sagberg & Bjornskau, 2006). What these researchers showed is that experience and practice are quite important for the novice driver’s safety, and that the gains in safety are substantial in little time. This gives support for the use of graduated driver license programs, where teens are allowed various driving privileges (e.g. nighttime, teen passengers) gradually over time so they drive in certain situations when they have built enough experience to do so safely. Certain aspects of graduated driver's license programs are associated with reduced teen crashes (Masten & Hagge, 2004; McKnight & Peck, 2002; Ulmer, Preusser, Williams, Ferguson, & Farmer, 2000).

Seo and Torabi (2004) expressed their concern with novices using cell phones while driving and stated that such use is increasing rapidly. According to Seo and Torabi (2004), the vast majority of the college students who were drivers not only owned a cell phone (87%), but also claimed to at least sometimes talk on the cell phone and drive (86%). Further, upwards of 58% of young drivers have texted while driving (Telstra, 2004), and about 30% more teens text while driving as compared to more experienced drivers (McEvoy, Stevenson, & Woodward, 2006). It is possible that practice and experience driving in these dual-task conditions may also improve driving performance under these conditions (Chisholm, Caird, & Lockhart, 2008; Cooper & Strayer, 2008; Shinar et al., 2005).

Practice effects on task performance

The human brain needs to adapt to change so that it can cope with variations that occur in the environment (Goldstein, 2010). Although "practice makes perfect" may be difficult to achieve, practice typically can improve performance within limits. The questions then are when practice improves task performance, which task aspects improve, how much improvement there is, which mechanisms are involved, and whether enhanced performance continues over time. Improvements with practice are of particular importance for the complex and potentially dangerous task of driving.

A practiced task requires fewer cognitive resources given that workload is reduced and the spare resources can be allocated to a secondary or emergency task if necessary (Reisburg, 2006). In the beginning, driving necessitates a step-by-step procedure to learn and follow (check the mirrors, press the brake, put the car in drive, check mirrors again, etc.). Each step taken taxes mental processing capacity to the point where there is little to no extra processing capacity for an out of the ordinary and unexpected situation, such as a car pulling out in front of the novice driver's vehicle (Reisberg, 2006).

Moreover, it is very difficult to combine all the tasks together for the novice (Reisberg, 2006). Because of automation, after practice, the steps are not as demanding cognitively, thus more steps can be dealt with at a given time and more capacity is freed up to deal with new steps if necessary (Resiberg, 2006). After substantial driving practice over time, the driver begins to be able to handle the driving task much better, and rather than going through serial processing of all the individual tasks, parallel processing begins to dominate, where the driver combines these steps. With practice, tasks begin to become automatic as opposed to being controlled (Reisberg, 2006), the latter taking more resources, and thus making dual-task performance difficult. Automatic tasks do not require as much cognitive capacity because they are typically familiar to the individual due to practice, and therefore are easier to conduct concurrently with other tasks.

Practice can help improve performance while driving through trial-and-error as well as memorization (Reisberg, 2006). Drivers learn through past experiences that they have had driving or as passengers. They learn what works well and does not work well for them, and in a way adapt their skills to the task at hand. Memorizing the routine, the route, the way to shift gears, etc., is another way that practice can help improve driving performance partly by reducing the need for executive control. Practice over time allows for this memorization to occur and should make the task easier by making it more automatic.

Once driving is mastered with enough practice over time, an individual still has more learning to do. The “expert” driver still has to conquer new routes, different traffic patterns, and various types of weather. For example, driving in the snow takes practice that will add to the cognitive demand of the driver, thus a novice driver who has little to no spare cognitive capacity because it is entirely consumed by the ordinary driving task probably would be wise not to drive in such weather conditions. Even the well-practiced driver can find driving in complex conditions such as adverse weather to be too much to handle.

For the novice driver, a distracter task can be easily overwhelming due to not having the spare cognitive capacity. Research has shown that even expert drivers suffer driving performance decrements while distracted (e.g. Caird, Willness, Steel, & Scialfa, 2008). It may not be a major problem if the expert driver is having a simple conversation and is not in a complex driving situation. However, the driver may suffer major driving performance decrements if the distracter becomes more complex and thus requires more resources and/or drives in a more complex driving environment. A major question is whether practice can improve dual-task performance while driving, much like practice can improve ordinary driving performance and driving under adverse conditions. If practice can reduce the effects of dual-task interference, it is likely to vary for individuals and certain variables (e.g. age).

Most simulator-based driver distraction studies have participants come in for only one session. Given the vast amount of individual differences, distraction studies would benefit from analyzing participants longitudinally to assess their adaptability and performance changes rather than group participants together by a variable such as age and not observe their reactions to distraction and simulator driving over time. Even within participants there can be differences longitudinally in the method of conducting a task with training and practice (Woodrow, 1939).

As some road studies observe participants over time (Brookhuis, de Vries, & de Waard, 1991), there is also reason to obtain a more reliable and valid picture of various measures of performance longitudinally using simulation. The strategy of the current study is to examine a few participants longitudinally with many data points as opposed to testing as many participants as possible cross-sectionally. In this way, the experimental design allows for more freedom for participants to show learning effects at their own pace, which would not be visible in a typical cross-sectional study.

Novices usually start out driving (before and after obtaining a license) in simple conditions (e.g. little traffic, straight road) rather than attempt to learn to drive in complex driving environments or while distracted so as not to overload mental processing. Inexperienced drivers gain experience through a step-by-step process, gradually increasing complexity and difficulty as the individual successfully handles the previous less difficult step. Thus, beginners could first practice driving in a new environment (i.e. simulator), then practice in gradually more complex situations. Drivers may have to allocate more mental processing initially to driving in a simulated environment than previously believed. If participants practice first on the simulator before engaging in a more complex driving task or dual-task situation, they may have enough resources spared for the secondary task.

CHAPTER 2: LITERATURE REVIEW

Cognitive and perceptual foundations of driving

Visual attention in driving.

One definition of attention is that it is the "central capacity to support information processing" (Atkinson & Shiffrin, 1968, p. 461). Alternatively, Reisberg (2006) stated that attention is not really a capacity but rather "an achievement of performing multiple activities simultaneously, or an achievement of successfully avoiding distraction when you wish to focus on a single task" (p. 136). If an adequate amount of attention is focused on the incoming sensory information from the environment, it is encoded and processed for meaning. There are certain objects at any given moment that need deeper processing and more visibility. Some individuals have a better ability to focus their attention on any given task, and some individuals are better than others at multi-tasking, or splitting their attention on several tasks simultaneously (Reisberg, 2006).

Researchers have investigated the importance of visual attention in driving. A test of visual attention administered via computer was the best predictor of on-road driving performance (Baldock, Mathias, Mclean, & Berndt, 2007). Richardson and Marottoli (2003) found that visual attention was critical for assuring a safe gap between other vehicles and other hazards such as pedestrians, which partly involves determining distances to objects, turning, and merging (Richarson & Marottoli, 2003). As shown in other studies (e.g. Reimer & Sodhi, 2006), scanning can reveal the amount and location of driver's attention, ways of drivers obtaining information from the environment, and driver information processing. Underwood, Chapman, Brocklehurst, Underwood, and Crundall (2003) as well as Becic, Kramer, and Boot (2007) found individual differences in scanning strategies.

Metz, Schomig, and Kruger (2011) found that when distracted, individuals produced more focused scanning or in other words less spread out scanning and longer fixation durations of the road environment. They also determined that having a crash was positively correlated with inefficient or insufficient scanning and therefore attention lapses to the environment while driving and distracted. Edquist, Horberry, Hosking, and Johnston (2011) found that having external-to-vehicle distracters altered participants' visual scanning patterns, thus changing their focus of attention while driving and slowing their reaction. Participants tend to perform better on a visual attention task when not distracted by passengers or cell phones (Golden, Golden, & Schneider, 2003).

Selective vs. divided attention. Selective attention is where an individual narrows their focus on a particular task or object (Goldstein, 2010; Sanders & McCormick, 1993). This is needed to absorb as much information as accurately as possible by parsing out distracters such as other tasks or objects that are competing for attention. Attention can be processed in the periphery, but visual acuity declines rapidly beyond the focus point (Goldstein, 2010). Experience can play a role in selective attention. Experience in the environment, in particular the driving environment, made a difference in the detection of traffic signs and their locations (Shinoda, Hayhoe, & Shrivastava, 2001). The participants' fixations on the stop signs were typically at the ones located at intersections rather than other locations because participants' past experience suggested where to look for stop signs, and thus they were more likely to detect stop signs when they were at intersections (Shinoda et al., 2001). Divided attention occurs when an individual focuses on more than one object or task simultaneously (Goldstein, 2010) and is essential for everyday tasks such as driving. Certain tasks can be done concurrently with divided attention rather easily, for example, walking, waving, and verbally greeting someone. However, listening to someone in the room talk and listening to the television concurrently may be very difficult.

Researchers are interested in determining which tasks can be difficult to multitask and why. There are limits on how much individuals can divide their attention. Tasks that are similar to each other can cause enough interference to lead to errors (e.g. Allport, Antonis, & Reynolds, 1972, Hirst & Kalmar, 1987). Divided attention is of major interest with driving distraction. Research clearly shows that distractions such as conversing on a phone while driving can lead to driving errors (e.g. Horrey & Wickens, 2006). If there isn’t enough capacity available to adequately attend to both tasks simultaneously, errors can occur in one or both tasks.

There are times when a lack of attention on an object can lead to a failure of perceptual detection, even if the object of interest is close to the center of focus. This phenomenon is called inattentional blindness, or basically the inability to perceive an object even if it is right in front of the observer’s gaze due to a lack of focused attention on the object (Goldstein, 2010). The concept of inattentional blindness is crucial to driving. For instance, a driver who is glancing straight ahead at the road but cognitively distracted could miss a potential hazard such as a pedestrian crossing the road. If drivers are distracted and their attention is not focused on the object, they may fail to detect the object’s motion, and thus fail to detect the change in the object (Goldstein, 2010).

Strayer, Drews, Albert, and Johnston (2001) revealed that participants had a two times greater chance in failing to detect traffic signals when conversing on the phone even though the signals were at the fixation center, which is evidence of inattentional blindness. The participants, however, did not have trouble perceiving traffic signals when listening to the radio or to an audio book. Similarly, Strayer, Drews, and Johnston (2003) showed that talking on cell phones and driving concurrently were detrimental to implicit perceptual memory of targets at the fixation center. Also, talking on a hands-free phone limited explicit recognition memory when asked to recall certain billboards that were placed on the side of the road. Apparently the memory impairment was because of participants paying less attention to targets presented in the fovea.

Lee, Lee, and Boyle (2007) either had intermittent blanks appear in the scene (representing an attention lapse or look away from road) or increased participants cognitive load. Although the intermittent blanks caused more errors in detecting the changes than cognitive load, both cognitive load and brief blanks that simulate an attention lapse increased the chances of not detecting a potential hazard. The participants in McCarley et al.'s (2004) study who were distracted had more difficulty detecting the change and an increased chance of missing a hazard. A listening task distracter did not have the same detrimental effects on attention.

Dual-task interference.

Failures of attention, leading to such phenomenon as inattentional blindness, can be particularly common when performing two tasks simultaneously, also called dual-task conditions. In these situations, less spare cognitive capacity is available and thus there is a lower ability to focus attention adequately on the necessary elements. Dual-task performance is the performance while attempting to multi-task and involves both divided and selective attention.

Part of what determines whether conducting simultaneously two or more tasks will be difficult is from which type of cognitive resources the tasks are pulling. This is the basic idea of Multiple Resources Theory (Wickens & Hollands, 2000). Based on this theory, individuals may be able to conduct two tasks concurrently provided that certain stimuli or response channels are not overloaded by being used at the same time. For example, reading while watching television would likely overtax the visual resource capacity and therefore be very difficult to succeed at.

Based on Multiple Resource Theory, it would be logical to conclude that driving and conversing on the cell phone, because they generally pool from different perceptual resources (driving-visual/manual and phone-auditory/verbal), should not conflict with each other. One could argue, however, that even a phone conversation requires individuals to visualize the conversation and/or the individual they are talking to. With further analysis, both driving and conversing on a phone can be considered a cognitive task. There may be an overall attentional capacity that both tasks borrow from, to the point where there is little to no capacity left to handle both tasks successfully. This could be thought of as possibly the central executive or central processing (Baddley, 1992).

There are other theories of how dual-task interference could be caused. Broadbent (1958) conceived the idea of the central processing bottleneck. Like a bottleneck which is narrow compared to the rest of the bottle, there is only so much that can fit through at a time. For example, assume that an individual was involved in a visual-manual primary task, followed by an auditory-verbal secondary task. If these tasks are separated with enough time, then there should not be any dual-task interference. But as the two tasks get closer to each other temporally, interference increases. The interval between when the first stimulus is revealed to when the second is revealed is called the stimulus onset asynchrony (SOA) (Wickens & Hollands, 2006).

When participants are given a short SOA, the reaction time for the secondary task usually slows. This delay in reaction time for the secondary response is like a domino effect caused by the primary task's reaction selection process. This delay is also called the psychology refractory period--PRP (Wickens & Hollands, 2006). The key is that the individual cannot focus their attention on how to react to the secondary task until they respond to the primary task. There is not enough mental capacity theoretically to handle the response selection of both tasks at the same time, like a narrow bottleneck that has room for only so much at a time.

Pashler (1994) as well as Ulrich et al. (2006) suggested that the PRP and bottleneck were caused by not only action/response selection, but also other factors such as retrieving information from memory and response execution. When Ulrich et al. (2006) altered the temporal demand of executing the response for the primary task, thus increasing reaction and processing time for executing the first task, the reaction time for the completion of the secondary task was prolonged.

Hazeltine and Ruthruff (2006) conducted one of several studies on dual-task interference and the PRP that varied the modality pairings between stimulus and response. For instance, rather than having a visual-manual pairing, having a pairing of visual-verbal. Changing around the modality pairings had little impact on reaction times for single-task conditions but did play a major role during dual-task conditions. They concluded that the central bottleneck was responsible for the slower reaction times in the dual-task conditions.

Research on driving distraction

The ability to focus attention adequately and have spare cognitive capacity to handle one or both tasks concurrently during a dual-task condition is challenged when driving while distracted. Driving by itself is a complex task, and adding a secondary task places even more strain on mental processing. Driving while distracted is problematic and common. Stutts et al. (2005) had cameras installed in vehicles of volunteer drivers over a one week time period. Distraction in general was common to everyday driving, with eating and drinking as the most common distractions. Others included various in-vehicle distraction such as manipulating vehicle controls and unknown external distractions. They also noticed that distracted drivers' gaze seemingly focused more on the inside as opposed to outside the vehicle and they also had more lane deviations.

McEvoy et al (2007) surveyed drivers that were in the hospital due to a vehicle crash. More than 30% of these drivers stated that they were involved in at least one activity considered distracting to them at the time they crashed. Distracted driving caused 13.6% of all crashes in their study. Of the different types of distractions, some of the most common were passenger (11.3%), lack of concentration (10.8%) and outside factors (8.9%). Drivers with less driving experience had a greater chance of having a crash involving distraction.

In the United States in the past decade, conversing on cell phones while driving has become quite popular. Eby, Vivoda, and St. Louis (2006) conducted an archival study in Michigan, reporting over a four year period on a total of 13 statewide surveys. Experimenters examined only hand-held cell phone use during daylight hours because they collected the data through observational means when vehicles were stopped at intersections and exit ramps of highways. Hand-held cell phone use had more than doubled between 2001 and 2005. In 2005, at any given hour during the day, about 36,550 drivers were talking on the cell phone while driving in Michigan. Seo and Torabi (2004) reported that approximately 20% of the reported crashes or near-crashes occurred while talking on a cell phone. The number of times the driver talked on the cell phone while driving was correlated with crashes or near-crashes.

White, Eiser, and Harris (2004) stated that roughly half of cellphone owners surveyed claimed they used them while driving. Furthermore, participants felt that they themselves had less risk of a crash when conversing on the phone and driving than other individuals who were doing the same thing. Wogalter and Mayhorn (2005) revealed that almost three quarters of the individuals surveyed owned a cell phone. About 80% of those surveyed claimed to have used a phone while driving. Just as with White et al. (2004), Wogalter and Mayhorn (2005) found that those who used cell phones while driving felt more strongly that they themselves driving and talking on a cell phone were less dangerous than other individuals doing the same thing.

Auditory and verbal distracters.

When Strayer and Johnston (2001) compared several common types of everyday distracters such as listening to a radio or a book on tape, no significant decline in performance was noted. However, when the cognitive workload increased in the secondary task, such as word generation and unconstrained conversations, there was a significant decline in ability to detect simulated traffic signals as well as slower reaction times to those signals. When a language comprehension task was combined with a driving task, even with hands-free phones, it caused a decline in driving performance and was suggested to take away mental resources from the driving task (Just, Keller, & Cynkar, 2008).

Barkana, Zadok, Morad, and Avni (2004) found that when using a phone task as the auditory/cognitive distracter in a search paradigm, participants failed to detect certain targets and had an increased reaction time in detecting targets. The authors pointed out that the individual differences should be considered in any legislation on driving and phone use, that individual testing on dual-task interference might be fairer as opposed to banning everyone from talking on the phone and driving.

Kubose et al. (2006) compared simulator driver performance in single task conditions to conditions where participants either spoke, listened to speech, or both concurrently. Driver performance suffered in these dual-task conditions. Speaking and listening yielded similar results, with the exception of lane deviation where speaking led to improved lane control, however listening did not have much effect on that dependent variable. Recarte and Nunes (2003) also compared a verbal acquisition task to a verbal production task. Contrary to Kubose et al. (2006), the production task was more detrimental to performance, revealing that especially in-depth conversations can be hazardous for driving, regardless of whether they takes place on the phone or in-person.

With participants subjected to an auditory distracter, Richard et al. (2002) examined the effects of distraction by having participants search for certain targets in a driving scene, some of which were essential to driving such as traffic lights and some that were not, such as a mailbox. When participants were distracted by conducting an auditory task at the same time as searching for these elements, their reaction times increased, particularly to the unrelated targets.

Several researchers have varied the type or difficulty of the conversation that the drivers partake in with an auditory/verbal distracter. Lin and Chen (2006) used a driving simulator and hands-free type phone varying the type of distracter as either a math task or a causal conversation. Driving performance degraded when talking on the phone particularly with the mathematical tasks. Patten, Kircher, Ostlund, and Nilsson (2004) used a peripheral detection task (PDT) to assess drivers' mental workload while conversing on a hands-free or hand-held phone or not conversing at all while driving, as well as manipulating simple versus complex conversation type. Increased reaction times existed while conversing on either type phone and while driving under different types of roads. However, unlike the findings of another study (Rakauskas, Gugerty, & Ward, 2004), Patten et al. (2004) actually noticed that the level of complexity of the phone conversation was the most important variable on the effects of workload than which type of phone used. Attention and workload suffered more when participants engaged in more complex conversations.

Visual distracters.

When examining a visual distracter, Reyes and Lee (2008) found that participants working with an in-vehicle information system (IVIS) had a more difficult time detecting a bicyclist, interestingly sometimes even after they were done working with the IVIS. Also of interest are the effects of spatial tasks on driving. Hurts (2011) gave participants oral questions while driving and asked them either to reason spatially about the questions or just remember and repeat spoken words. The spatial reasoning task was more distracting than simply remembering and repeating words spoken.

Patrick and Elias (2009) analyzed how a spatial task affected the reaction time and accuracy of vehicle depth/proximity judgments. The authors included a non-spatial task that they labeled a semantic task, as well as a control condition which did not have a distracter task. Much like the findings of Hurts (2011), a conversation that included a spatial distraction had the most detrimental effects on the dependent variables. Recarte and Nunes (2000) examined distraction effects based on different distracter tasks. They revealed that the spatial-imagery task was the most taxing on driving performance and visual scanning. Participants experienced a limited functional field of view omnidirectionally and longer duration of fixations when distracted with the spatial-imagery task. Furthermore, participants did not look at the mirrors or speedometer as much when distracted, which could lead the driver to miss hazards.

With the advent of cell phones being used for texting, a new complication arose for driving distraction. When texting, the individual will likely look inside the car and away from the driving environment more often, but may be more likely to put the phone down in busy situations compared to when having a conversation on the phone for etiquette reasons. When participants were texting while driving on a simulator, they had slower reaction time to braking lights of a car ahead, had decrements in headway as well as lane control, and had more crashes (Drews, Yazdani, Godfrey, Cooper, & Strayer, 2009).

Libby and Chaparro (2009) conducted an experiment in which participants driving in a simulator had the secondary task of categorizing terms on billboards as either the name of a US state, a fruit, or a drink. Participants either texted their response, called on a cell phone, or just said aloud the answer. The participants who texted their answer were significantly slower to react to target letters that were presented in their periphery, had a slower driving speed, greater lane deviation variance, and looked inside the vehicle more often than in the other conditions.

Hosking, Young, and Regan (2009) corroborated other researchers who believe that novice drivers are more at risk when driving while distracted. The authors analyzed novice drivers' visual scanning while texting and found that drivers looked at the road up to 400% less than those not texting, lane deviations increased by 50%, missed lane changes swelled to 140%, and headway variability enlarged to 150%.

Visual combined with other distracter.

Researchers have also scrutinized the difference between the effects of a visual distracter and another type of distracter (e.g. auditory) on driving performance. Analyzing the effects of a visual and a cognitive distracter, Lamble, Kauranen, Laakso, and Summala (1999) examined how drivers react in a car following task. Participants either conducted a dialing task or were involved in a task involving memory and addition that did not require them to take their eyes off the road. Both tasks were detrimental to participants' ability to detect the lead car's deceleration for brake reaction time and time-to-collision. However, there was little difference between the two distracter tasks on participants' reaction to the car ahead decelerating. Ranney, Harbluk, and Ian (2005) tested participants on a track and varied the type of distraction as an auditory or visual distraction. Overall, regardless of distracter, participants increased following distance and exhibited less vehicle control and target detection ability. Nevertheless, contrary to the results of the Lamble et al. (1999) study, the auditory distraction was not as detrimental to driving performance as the visual distraction for vehicle control and target detection ability.

Other research examined the differences between a visual distracter and another type of distracter on visual scanning. For instance, Victor, Harbluk, and Engstrom (2005) noted that their participants did not look as often at the road ahead when engaging in the visual distraction task, and instead glanced at the system's display more frequently, for a greater amount of time, and with more fluctuations in amount of time as the difficulty of the visual task increased. On the other hand, the authors examined an auditory task as a distracter and found that drivers increased the amount of focus on the road ahead as a type of tunnel vision effect. Also, drivers increased their focus to the road ahead of them as the difficulty of the auditory task amplified.

Examining the effects of a visual and a cognitive distracter on visual scanning, Sodhi, Reimer, and Llamazares (2002) noticed that drivers fixated for more time on areas not on the road when tuning a radio and a task involving checking the rearview mirror. Interestingly, this effect was not found when participants were engaged in a task checking the odometer. When participants conducted a task involving calculations of dates, the variability of the locations of their fixations were smaller than when driving without distraction. Engstrom, Johansson, and Ostlund (2005) also varied the distracter task to be either visually or cognitively distracting. For the visual task, participants drove slower and lane deviation increased. On the contrary, the cognitive task did not lead to driving slower and actually caused decreased lane deviation; however, as other researchers have found, the cognitive task did cause participants to focus more in the center of the road.

Assessing the difference between a manual dialing (visual distracter) and a voice-activated (auditory/cognitive distracter) phone, Jenness, Lattanzio, O'Toole, Taylor, and Pax (2002) had participants drive in a simulator. The participants who were in the voice activated condition had fewer lane deviations by 22% and fewer scans away from the road by 56%. Whether participants were using voice activated or the traditional dialing method, drivers took longer to drive the course than when not distracted at all, most likely to compensate for the distraction.

Types of cell phones.

Patten et al. (2004) is one of many studies to compare two main types of cell phones used while driving. Handheld is the standard phone whereas hands-free (e.g. Bluetooth) can be used without holding the phone. Given the wide use today of cell phones while driving and increasing use of hands-free phones, researchers such as Patten et al. (2004) have been interested in examining the effects of the newer hands-free technology. Treffner and Barrett (2004) examined reaction time and force of braking when conversing on a hands-free phone. When in the dual-task condition, driver's braking reaction time approaching a corner increased and force of braking decreased. The authors suggested that when drivers converse on a cell phone, even hands-free, they might be less aware of the road environment and thus less prepared for potential hazards or future steps in the driving process.

Some feel that hands-free type phones are a safer alternative because they can keep their hands on the steering wheel. In a survey assessing risk of various types of distracters while driving, participants felt that driving while conversing on a handheld was one of the riskiest distracters, whereas using hands-free phones while driving was perceived to have a relatively minor risk (White et al., 2004). Most research on the effects of both types of phones however shows that contrary to individuals' beliefs, hands-free phones are distracting.

Some research findings confirm that using hands-free phones negatively affects participants' visual scanning while driving (Harbluk & Trbovich, 2005). Harbluk, Noy, Trobovich, and Eizenman (2007) found a tunnel vision effect when drivers used a hands-free phone while scanning outside of the car. There was also less scanning inside the car at important instruments and mirrors, and some participants failed to scan these essential in-vehicle targets at all. When the participants came towards and drove through intersections and were simultaneously distracted, they did not scan as much for important traffic signals and visually searched less to their right side as well compared to when they were not distracted.

Many studies have shown that hands-free and handheld phones have similar negative effects of distraction (e.g., Strayer & Johnston, 2001). For instance, Kass, Cole, and Legan (2008) emphasized how hands-free cell phones are just as distracting as hand-held phones. They suggested that talking on either type of phone disrupts drivers' situational awareness and that it is the visual and cognitive distraction that is the major problem as compared to the physical distraction of not having both hands free. Hendrick and Switzer (2007) examined the use of hand-held and hands-free phones while measuring reaction time. They included a simulation task mimicking a situation where participants were moving their foot from the accelerator to the brake pedal in response to a visual signal that represented brake lights. Reaction times were slower regardless of the type of phone used compared to the control, suggesting that hands-free devices are really not any better than hand-held.

Consiglio, Driscoll, Witte, and Berg (2003) measured braking reaction time for young participants between age 18 and 27. Participants were assigned to either a control condition with no distraction, driving while listening to the radio, talking with a passenger seated next to them, talking on a hands-free phone, or talking on a hand-held phone. Listening to a radio did not seem to be a detriment to driving performance. On the other hand, participants had increased reaction time when driving with a passenger, talking on a hand-held phone, or talking on a hands-free phone. The three distracter types were fairly equally threatening to driving safety. Strayer, Drews, Albert, and Johnston (2001) found similar detriments whether participants were conversing on a hands-free or hand-held phone in terms of detecting stimuli.

Some researchers, however, have noticed some similarities as well as important differences between using the two types of phones. Tornros and Bolling (2005) found that drivers had an increase in workload regardless of the type of phone, whether in the dialing or the conversation phase. Driving performance when participants where in the dialing phase of the phone task showed similar increases on lane deviation for both types of phones. While conversing on the phone, participants tended to have fewer lane deviations, indicating better performance, regardless of the type of phone. Conversing also caused a reduction in speed but only when using the hand-held phone.

Haigney, Taylor, and Westerman (2000) observed that hand-held phones led to worse driving performance when compared to hands-free phones when driving on a simulator. Both types of phones however led to increases in workload and slower driving speeds. Like Patten et al. (2004), Tornros and Bolling (2006) used the PDT as a measure of cognitive workload and found that the performance on the PDT was negatively affected by conversing on the phone. Speed was reduced when using hand-held phones in all environments, but only in the rural environment with a speed limit of 90 km/h and the complex urban environment when using the hands-free phone.

Meta-analyses of driving distraction studies.

Horrey and Wickens (2006). Two key meta-analyses were recently conducted on distracted driving. Horrey and Wickens (2006) included a total of 23 studies, examining such variables as hand-held versus hands-free phones, distracter tasks involving a conversation or more of an information processing task (e.g. math), passenger compared to phone conversations, and simulator versus field studies. The authors assessed lane deviations and reaction time as dependent measures of driving performance. Across the studies, distracted driving based on the distracters they examined had a larger negative impact on reaction time (effect size = .50) compared to lane deviations (effect size = .23).

When comparing the differences between handheld and hands-free phones on reaction time and lane deviation, Horrey and Wickens found similar effect sizes, suggesting that one type of phone is no better or worse than the other. The conversation task had a larger impact on reaction time (effect size = .66) than did an information processing task (effect size = .42). Although passengers (effect size = .58) were a greater detriment on reaction time than cell phones (effect size = .48), the difference was not significant. Simulator studies (effect size = .42) had less of an influence on reaction time than field studies (effect size = .66).

Caird et al. (2008). The authors analyzed 33 studies and looked at several independent variables, including the research setting (lab, simulator, on-road), passenger versus cell phone conversations, cognitive versus naturalistic conversation task, and hands-free versus hands-held type phones. The dependent measures examined across the studies were reaction time, speed, lateral positioning, and headway. There were only four studies that specifically compared younger and older drivers on reaction time, with the mean age being 64 to 69.

Reaction time was significantly slower when talking on either a hands-free or handheld device compared to the control no-distraction condition. As found by Horrey and Wickens (2006), there was not a significant difference between the two types of phones (effect size difference = .063) for the three specific studies that compared the two types. Handheld phones

(.21s) increased reaction time about the same amount as with hands-free phones (.18s). The older participants had slower reaction times when distracted than younger participants.

Those using a hands-free phone made more lane deviations than in the control condition (effect size = -.152), and had greater headway (effect size = .176). Effects on lane deviation with handheld phones could not be examined as there were not enough studies analyzing the relationship. Using either a hands-free or handheld device caused participants to drive slower compared to the control condition, although the slower speeds were with handheld (effect size = .394) rather than hands-free (effect size = .23) phones.

The authors did not find any significant differences on reaction time across the studies between talking with a passenger versus talking on a cell phone or cognitive versus naturalistic tasks. Greater decreases in speed existed when using a hands-free phone during simulation studies than field studies. However, the authors were not confident in this finding because they pointed out that speed perception is different in a simulator than in the real world. The younger and older drivers saw an increase in reaction time when distracted, however it was much greater for older participants (.46s vs. .19s).

Caird et al. (2008) pointed out two main areas that need more research. A substantial amount of the distracted driving research has focused on hands-free devices, which is logical given that many individuals have the idea that these are safer than handheld phones (e.g. White et al., 2004). However, there is still good reason to examine handheld devices, particularly with visual scanning. Holding a cell phone to one side of the head may alter (e.g. limit) visual scanning and thus possibly limit detection on the side of the visual field on which the person is holding the phone. Further, Caird et al. (2008) suggested that more research is needed on the effects of cell phones on novice drivers.

Comparison of the two meta-analyses. Both found little difference between hands-free and handheld phones, and both found that conversing with a passenger had about the same effects on reaction time as talking on a cell phone. They also both agree that distraction affects reaction time to a greater extent than lane deviation. One key difference between the two studies is that Horrey and Wickens (2006) found conversation was more impactful on driving than information processing, however Caird et al (2008) did not find significant differences.

The Caird et al. (2008) meta-analysis revealed that older drivers were more affected by distraction than younger participants. However, the analysis included a relative few number of studies that explored age differences and the ones that were included had a limited range of ages. One key issue to be discussed is whether the performance drop between the control condition and the distracter condition is steeper for older drivers than younger drivers. Moreover, for a young or middle-aged driver, a related issue is whether their driving performance when distracted drops to a level similar to older drivers who are not distracted.

Novice/Young drivers and distraction

Hosking et al. (2009) suggested that a major reason for young drivers being especially vulnerable to distraction is because they have to use most of their cognitive capacity to drive, which leaves less to handle a secondary task such as talking on a phone. It may take years for this capacity to fully develop through experience (Hosking et al., 2009). One study reveals that when using a handheld phone, 55% of novice drivers did not detect the hazard at all, whereas only 15% of middle aged drivers did not detect a potential hazard (Giguere, 2003).

Neyens and Boyle (2007) in their analysis of teen crashes showed that the effects of distraction on their chances of a crash depended on the type of distracter. Intersection driving when distracted by passengers or a cognitive task was particularly dangerous for teens as evidenced by increasing their chances of rear-end crashes and crashes occurring at an angle. Interacting with some device inside the vehicle led to increased chances of striking a fixed object. Interacting specifically with a cell phone caused more rear-end crashes.

Novice drivers when distracted have been shown to take long gazes away from the road (greater than 3 sec.) more frequently than more experienced drivers when dealing with an in-car distracter, which can cause decreased hazard perception and lane performance (Wikman, Nieminen, & Summala, 1998). Lee (2007) stated that several in-vehicle devices such as cell phones were particularly problematic for novice drivers due to their absence of having spare cognitive capacity to drive safely, such as maintaining control and detecting and handling hazards. This was especially alarming given that novice drivers are the ones that use devices like cell phones and MP3 players more often than older drivers. Moreover, novice drivers were impacted greater in terms of lower driving performance and situational awareness when using hands-free cell phones compared to more experienced drivers (Kass, Cole, & Stanny, 2007). Williams, Ferguson, and McCartt (2007) claimed that the reason for passengers being problematic particularly for teen drivers is because they lack the experience and thus attentional capacity to handle driving and being distracted by another person.

Practice and training

Dual-task interference and practice.

Cooper and Strayer (2008) suggested that in terms of dual-task interference, greater amounts typically occur when the tasks have the same mental demands or have a non-preferred stimulus-response modality pairing. Practice in the single or dual-task condition may open up spare cognitive capacity to handle the dual-task condition (Cooper & Strayer, 2008). Practice should reduce the unpredictability in one or both tasks, which then should free up cognitive capacity as the task becomes more automatic as opposed to controlled and thus decrease the dual-task interference (Cooper & Strayer, 2008). It is possible that performance on tasks requiring divided attention can be improved with substantial amounts of practice, which is thought to reduce attentional demands, even for older adults (Kramer, Larish, & Strayer, 1995). This may be true even with driving and conversing on a cell phone (Horrey & Wickens, 2003).

However, even a simple, highly practiced task from day to day driving may still not be exempt from dual-task interference. Levy, Pashler, and Boer (2006) had participants press the brake as soon as they perceived the car in front of them slow down. The secondary task consisted of participants having to decide how to respond manually or vocally based on the frequency of a visual or auditory stimulus. Even after practice of tasks that do not compete for resources, the performance when conducting both tasks at the same time tends to be not as quick as performing either task by itself. Further, the limits to practice may be found when predictability disappears in an unfamiliar driving situation for example, as the cognitive demand would increase. The effects of practice can be quite variable, and may affect some aspects of the task but not others. For example, some research has found that practice of tasks does not enhance the individual's accuracy, but does lead to quicker performance across time (Kedzior, Kochhar, Eich, Rajput, & Martin-Iverson, 2011).

Liepelt, Strobach, Frensch, and Schubert (2011) examined whether practice of dual-task conditions can enhance inter-task coordination skill, as well as whether the training would transfer to other dual-task conditions. Participants were trained on a visual-manual task and an auditory-vocal task, and were assigned to either a practice group that focused on single tasks or a hybrid practice group that included practice on the single tasks as well as dual-tasks. When participants were tested in the single and dual-task situations, the hybrid practice group performed better compared to the single-task practice group, although advantages in dual-task performance was reliably seen only for the auditory task.

Other studies have focused on practice or training of dual-task conditions with older adults. Hiyamizu, Morioka, Shomoto, and Shimada (2011) had one physical/motor task combined with a Stroop test as the cognitive task. The older individuals were all over 65 years of age and their training was two times weekly for about 12 weeks. The three months of dual-task practice of the balance and the Stroop task led to better Stroop task performance, showing not only improved cognitive ability but improved ability in dual-task conditions.

Voelcker-Rehage and Alberts (2007), like Hiyamizu et al. (2011) were interested in how motor practice affects dual-task interference with one task that is motor and one that is cognitive with older individuals. They gave younger (19-28) and older (67-75) participants a pretest and a posttest with a total of 100 practice sessions in between. The motor practice led to improved performance on the motor task in both single and dual-task conditions for the older and younger participants, and better cognitive performance when in dual-task situations. Nevertheless, older individuals still had worse motor performance as they went from the single to dual-task condition, even after the practice.

Practice effects on the psychology refractory period and bottleneck.

Hazeltine, Teague, and Ivry (2002) found that a bottleneck may not exist at all after sufficient amounts of practice of the dual-task condition. They modeled their study after one conducted by Schumacher, Seymour, Glass, Kieras, and Meyer (2001), which found that the interference from dual-task conditions was significantly reduced after practice if participants placed equivalent importance on both tasks. Van Selst, Ruthruff, and Johnston (1999) argued that studies not finding significant PRP reductions after practice may be due to using tasks that require both manual responses, which enhance the difficulty to perform the tasks in parallel. In the study by Van Selst et al. (1999), trials included a verbal response to a tone (verbal-auditory) and a manual key-press to a visual character (manual-visual). Although the PRP effect disappeared for one of the participants, the other participants had small but statistically significant PRP effects. The authors noticed there were individual differences but argued that eventually all participants should obtain some non-zero asymptote for the PRP effect. Therefore, even though there are situations where one can eliminate dual-task interference completely with practice, there are times when there is still some interference present after practice (Ruthruff, Hazeltine, & Remington, 2006).

Sangals, Wilwer, and Sommer (2007) examined how practice can affect the processing in dual-task situations and determined to what point two tasks could be processed in parallel. The design consisted of five sessions under dual-task conditions varying the stimulus onset asynchronies (SOAs), and placing an emphasis on the first task. When the participants practiced the dual-task situations, their reaction times decreased as the dual-task interference seemed to be less of a factor. Although there could be several explanations for these findings, the authors argued that it was due to a decrease in the temporal demands during the central bottleneck, even though complete elimination of the bottleneck did not occur. They claimed that a late motoric bottleneck may not be affected much if at all by practice.

Ruthruff et al. (2006) varied the type of stimulus-response modality pairings, putting together some that were not harmonious such as auditory-manual, and showed that there was still interference present even after practice. In fact this interference effect was quite significant with the non-harmonious pairings. Liepelt, Fischer, Frensch, and Schubert (2011) also cited the Schumacher et al. (2001) study, stating that the caveat with their findings was that they only used a visual-manual (VM) task and an auditory-verbal (AV) task. Using the modality pairings that Schumacher et al. (2001) used, there was reduced dual-task interference after practice. However, when combining visual-manual and auditory-pedal (press with foot) (AP) tasks simultaneously, the dual-task interference was still quite high even after as many as 12 practice sessions.

Driver practice and training.

Gregersen (1996) examined the effects of two types of training on novice drivers. One group was placed into a training to improve driving skill, whereas the other group was trained on understanding their limitations in driving. With one half hour training session the prior week, the novice drivers were then tested. Although the author did not find a difference in driving performance between the two types of training, the group that was trained in actual driving skills overestimated their performance. This suggested that training driving skills can have an unintended negative effect of overconfidence.

On the other hand, some research has found improvements in driving performance due to practice. Berthon-Donk, Grosjean, Rinkenauer (2011) conducted research on the lane change task, which has been used to examine the effects of distracted driving. Specifically they focused on how feedback on the individual's performance on the lane change task can affect their future performance on the task. They emphasized the importance of feedback on concentrating attention on driving and to enhance learning by motivating the individual. Feedback and practice led to fewer lane deviations.

Okonkwo, Wadley, Crowe, Roenker, and Ball (2007) discussed the potential of training interventions for older individuals with cognitive and visual deficits to be aware of their capabilities and adapt in the most beneficial way to reduce risk. Marottoli et al. (2007) also showed how training centered on common problems older drivers have can improve driving performance in older adults. Ball, Edwards, Ross, and McGwin Jr. (2010) found that the older participants who practiced speed of processing and reasoning tasks had fewer crashes that were deemed their fault by about 50% (for each individual per mile) within a six year period. Romoser and Fisher (2009) found that training involving driving simulation and extensive feedback resulted in older drivers scanning for potential hazards more when turning by about 100% when driving in a simulator and in the real world. On the other hand, training involving just classroom instruction did not show an improvement in scanning.

It may be possible therefore that dual-task training while actually driving could improve capability to handle dual-task conditions and drive safer as a result. Just as it has shown to be useful to train older adults to be aware of their capabilities and learn common problem areas in driving, it may also help novice drivers as well beyond simply teaching novice drivers the basics of how to drive. Pollatsek, Narayanaan, Pradhan, and Fisher (2006) revealed that training novice drivers caused them to increase their fixations on locations where there are likely to be increased risk or potential hazards and on signs warning drivers of potential hazards.

Practice and driving distraction.

Only a few studies have focused on longitudinal studies of distracted driving, examining how practicing the dual-task condition affects driving performance over time. It may not be that practice increases the number of resources available to an individual, but that fewer resources would be needed (Green et al., 2008). Brookhuis et al. (1991) conducted a study with participants of all ages who did not have previous experience driving and talking on a cell phone concurrently. Participants drove a car in the real world for one hour every day for roughly two weeks. Certain variables were susceptible to practice such as heart rate variability (indicative of lower workload) and fewer number of math errors on the secondary task. Nonetheless, the participants did not show significant improvement on driving performance when in dual-task conditions.

Chisholm et al. (2008) tested if practicing using an iPod (visual, biomechanical, and cognitive distracter) while driving would help alleviate the demands on the driver and improve driving performance. Drivers ranged from age 18 to 22 and engaged in seven sessions using a simulator. While driving, the authors presented certain hazards to participants such as pedestrians crossing the road, other vehicles pulling out into the road, and a vehicle ahead slowing down. Participants interacting with the difficult iPod task had increased reaction times and number of collisions compared to the control condition and easier iPod tasks. Moreover, the participants scanned significantly more in the vehicle and thus less on the road when in the difficult iPod condition. Nevertheless, in all levels of iPod task difficulty, participants driving performance improved with dual-task practice, including improved reaction time to potential hazards. However, there was still a performance decrement compared to having no iPod interactions after the practice sessions.

Shinar et al. (2005). These authors also wanted to determine whether practicing being distracted while driving can improve driver performance, citing that practice and feedback can improve performance as the task becomes more automated, leaving spare capacity for the secondary tasks. They suggested that practice can lead an individual to improve at time-sharing of tasks when distracted while driving. Ten young drivers with less than six months driving experience, 10 drivers ranging in age from 30-33, and 10 drivers aged 60-71 participated in the study. The environment was a simulated straight 2-lane highway having a low level of traffic.

Participants used a hands-free phone device and either engaged in a math task or an emotionally-involving conversation. The design included five sessions over two weeks with at least 1-4 days between sessions. The only practice participants had driving the simulator alone before the practice driving with distracters commenced was a four minute practice session. The participants drove for three minutes during each distracter task, as well as three minutes for the control condition of no distraction. Therefore each experimental session included three 9 minute blocks of driving.

Driver’s speed increased across the five sessions when driving in the 65 mph condition across the age groups, and drivers of all age groups drove faster across the training sessions for the two distracter conditions as well as for the control condition. This showed an improvement in handling the single and dual-task condition as distraction typically leads drivers to drive at a slower speed to compensate for the distraction (e.g. Haigney, Taylor, & Westerman; 2000; Liu & Lee, 2006). All age groups experienced less speed variability across sessions, particularly for the oldest group of participants. Speed variability decreased for the two distracter conditions across the sessions, although it decreased mostly for the control condition. Participants made fewer steering wheel deviations across sessions particularly for the oldest group and when conducting the math task. The results for the speed and steering wheel deviations indicate less dual-task interference. There was not a significant main effect of practice on the average lane position, which is not surprising given lane deviation seems not to be as sensitive of a measure to distraction (Caird et al, 2008, Horrey & Wickens, 2006).

As expected, the distracter effects in general were greatest on the first day of training. Practice also significantly decreased the reaction time to peripheral signals. Reaction time appears to be quite sensitive to distraction (Caird et al, 2008, Horrey & Wickens, 2006). Although participants' ratings of subjective workload decreased across sessions, and older as well as younger drivers felt that their driving performance improved over the sessions, the middle aged group actually felt that their driving performance declined across sessions. The most significant finding with the older individuals is that even though their overall driving performance was worse than the middle aged and younger participants, the older individuals showed the most improvement across sessions, sometimes even reaching the same performance level as their younger counterparts.

Cooper and Strayer (2008). These authors conceptually replicated the findings of Shinar et al (2005). The study consisted of 60 participants who reported driving greater than 41 min. per day, talking on their cell phone either less than 5% or greater than 41% of the time. They had highway as well as city scenarios that lasted approximately 18 minutes each. On the highway, participants followed a pace car that periodically braked, whereas in the city scenario participants followed directional arrows inserted in the scenario, which also included various embedded hazards.

All participants practiced driving the simulator without distracters for a standard 20 minutes. Practice was on days 1-4, with day 1 and 4 having single and dual-task driving. On the other hand, days 2 and 3 included dual-task driving only. The distracter was a naturalistic conversation using a hands-free cell phone. After participants practiced on either a highway or city scenario for the four sessions, they would transfer to the scenario they had not practiced on the final day, which the authors termed the transfer condition. They wanted to determine whether the practice effects, if there are any, transfer to a novel driving environment.

Cooper and Strayer (2008) observed that the number of crashes decreased with practice, although it was still greater with dual-task compared to single-task at the end of the training on day 4. The transfer condition to another type of road actually led to increases in crashes. Brake reaction time saw an increase for both single and dual-task conditions across sessions, and was the longest in the transfer condition, with the longer reaction times still for the dual-task. There was a small change in headway across sessions, and even an increased distance in the transfer condition compared to the first day of training. Increased headway typically suggests more dual-task interference as individuals are compensating for the distraction. There was little difference in speed compliance on the first training day for both single and dual-task. However, the authors observed a large difference between single and dual-task between day 4 and transfer, with single task showing better speed compliance than in dual-task conditions. Further, the differences in real-world cell phone use among participants did not show a significant difference in driving performance in dual-task conditions. The authors concluded that the dual-task was never fully automated.

Comparison between Shinar et al (2005) and Cooper and Strayer (2008). Although the results from the Cooper and Strayer (2008) article were almost opposite of what was found by Shinar et al. (2005), Cooper and Strayer (2008) did discuss why they may have found such differences. First, there were differences in some of the dependent measures used, as well as the type of scenarios and the way participants navigated the scenarios. Cooper and Strayer (2008) alluded to the idea that the practice effects in dual-task shown by Shinar et al. (2005) may have been due to learning how to drive the simulator. In other words, the participants in the Shinar et al. (2005) study might have "learned to better regulate the primary task of driving to accommodate the added demands of the phone conversation" (Cooper & Strayer, 2008, p. 900). A different interpretation of Shinar et al.'s (2005) "…could be that they indicate learning associated with simulated driving or perhaps reduced inhibition associated with increased familiarity with the research procedures" (Cooper & Strayer, 2008, p. 901).

Cooper and Strayer (2008) also stressed that they may not have found practice effects because the participants simply needed more practice to see an effect, even though they did have them practice 198 minutes of dual-task compared to Shinar et al. (2005) who only had 96 minutes of practice. Cooper and Strayer (2008) claimed that this is not enough practice to acquire a complex skill. Nevertheless, Cooper and Stayer (2008) stated that no matter how much dual-task practice participants are subjected to, driving while conversing on a phone may be too unpredictable for practice to make an effect.

Critique of Shinar et al (2005) and Cooper and Strayer (2008): Although Cooper and Strayer (2008) argued that the research by Shinar et al. (2005) may have found practice effects because of such factors as participants learning how to drive in the simulator, it is also possible that some flaws in the research conducted by Cooper and Strayer (2008) could have led them to not find practice effects. Most research has shown that practice will improve dual-task performance for most tasks at least to some extent. The Cooper and Strayer (2008) results also are contrary to the findings of Chisolm et al. (2008). If the Shinar et al. (2005) findings were actually due to the learning of driving in the simulator, then one would expect a similar confound in the Cooper and Strayer (2008) study.

The finding in the Cooper and Strayer (2008) study that participants did not improve on the transfer environment is not surprising especially given that they did not find practice effects in the environment participants actually trained in. Nevertheless, even if they had found practice improved driving in the scenario participants trained in, the training would not likely have transferred since participants likely need time to practice driving a new scenario before they are given a dual-task situation. This relates to the research by Sahami and colleagues (2009; 2010; 2013) stating that the cognitive demand of learning the new type of driving or driving environment may inflate driving performance errors in the dual-task condition.

As Cooper and Strayer (2008) pointed out, the types of performance measures used in the study is crucial. In the city scene the authors employed in their research, only speed compliance and crashes were recorded, probably because of the difficulty of measuring other variables in that type of scenario. Neither the Cooper and Strayer (2008) nor the Shinar et al. (2005) studies examined using a hand-held phone or a texting task.

Simulator adaptation

Differences between simulator and real-world driving.

It is important to evaluate the validity of driving simulators as being representative of real-world driving if the results of simulator studies are to be generalizable to that setting. Although clearly the two environments have differences, the issue is whether the advantages of driving on a simulator outweigh these differences. Some research has been supportive of the validity of driving simulators. For instance, drivers who demonstrated slower reaction times in a driving simulator correlated with performance decrements when driving in the real world (Makishita & Matsunaga, 2008).

Mayhew, Simpson, Wood, Lonero, Clinton, and Johnson (2011) found mixed results when having novices drive both in a simulator and on an actual road. The number of driving errors on the actual road and in the simulator was acceptably similar. Also the number of errors for novices was significantly greater in both types of driving than for the more experienced drivers. However, the types of errors between the types of driving were not similar, thus limiting validity simulator studies at least to some extent. Merat, Anttila, and Luoma (2005) also noted some variation in the results between simulator and real-world driving.

Levy and Pashler (2008) also remarked on the limitations of driving on a simulator compared to real-world driving. According to the authors, participants may think that driving in a simulator and the distracting task have the same importance, and in fact the distracting task may even have greater importance. This could be because there is no threat of vehicle damage or bodily harm driving in a simulator. Therefore Levy and Pashler (2008) found that even if they told participants to place much more importance on the driving task when driving in the simulator, the secondary task often took precedence over the driving task when driving in the simulator.

Participants’ speed and distance perception in simulators is typically misinterpreted because of the difference between real-world and simulator driving (Sahami & Sayed, 2013). Drivers use kinesthetic and vestibular cues in terms of forwards, backwards, and sideways acceleration to help navigate the road, particularly when turning, and for judging speed accurately (Sahami & Sayad, 2013). Sahami (2011) suggested that there is extant research that has assessed the relationship between the results of simulator studies to real-world studies; however, most researchers do not thoroughly examine the differences found, such as why they occurred. This stresses the need to determine how one could reduce the effects of the differences between real-world and simulator driving as much as possible.

Simulator driving practice.

Some of these inherent limitations to simulator driving cannot be changed. But there are limits of simulator driving that can be dealt with. For instance, practicing driving the simulator is necessary because of the differences between simulator and real-world driving and because driving the simulator is new to participants initially. Studies on distracted driving commonly have a practice session. However Sahami and colleagues over the past few years have discussed why most practice sessions in research are flawed and how practice is a much more important element in driving simulator studies than realized (2009; 2010; 2011; 2013).

Researchers often have participants practice before the main task; however, there is usually no true measure of how adapted they are to the simulator and this process does not account for individual differences. Further, there is a lot of variability in how the practice scenarios are created. For example, some researchers typically have all participants practice for a set amount of time (e.g. Lee, McGehee, Brown, & Marshall, 2006), or have them drive for a certain distance (e.g. Upchurch, Fisher, & Waraich, 2005), usually on a simulated highway, or let the participants drive until they self-report that they have sufficiently practiced (Fisher, Pradhan, Pollatsek, & Knodler, 2007; Pradhan, Fisher, & Pollatsek, 2006). The third option at least factors in individual differences, but still is a threat to the accuracy of the results as it relies on the participants' own assessment. Sahami and Sayed (2013) found in their study that no relationship existed between actual adaptation and self-assessment of adaptation. None of these methods can really determine adaptation.

Simulator adaptation.

Sahami and Sayed (2010) stressed that participants need time to take their real-world driving skills and apply them to simulator driving. Adaptation to the simulator is essential for the results of a simulator study to be valid (Sahami & Sayed, 2013). Participants need to use what Sahami and Sayed (2013) termed "trial-and-error" and "fine-tuning" to adapt to the simulator and its controls and handling. Initially participants are unlikely to respond as quickly and accurately to the simulator. Once the basics of adapting to the simulator are achieved, the participant can move on to more complicated scenarios and situations (Sahami & Sayed, 2013). Sahami, Jenkins, and Sayed (2009) stated that ideally researchers would be able to determine if participants were in fact fully adapted to the simulator.

Sahami and Sayed (2013) defined adaptation as lasting "until the person knows how the simulator responds to their input and driving becomes automatic" (p. 42). More specifically adaptation was when there was no improvement in the measures in the last few trials, where performance was at a “converged to a constant or oscillatory value” (p. 43). When the improvement in performance peaked, the authors claimed this meant that driving the simulator has become automatic and that the performance could not improve any more.

Not only can responses be different initially before adaptation and thus affect validity, the process of getting used to the simulator adds extra mental load on the participant, which can confound the results in a complex driving situation or a dual-task condition (Sahami & Sayed, 2013). Sahami and colleagues argue that adapting to the simulator puts more cognitive demand on the participants and thus making driving more difficult and therefore lead to lower driving performance initially. In this sense, the adaptation process becomes another distraction that may confound results and limit validity. If participants are not adapted to the simulator, their performance may not validly represent real-world driving performance. Other research has concurred that the learning process of driving in the simulator, such as learning control and handling, does add to the mental load (Speelman & Kirsner, 2005), which can serve as an added distraction to driving.

Sahami and Sayed (2013) emphasized that practice scenarios conducted by other researchers which have participants drive on a straight highway or scenario with straight roads at the same speed are not adequate for true adaptation. Nevertheless, the practice scenario should include the same general task over time so that the researchers can monitor changes in performance and thus learning under the same conditions (Sahami & Sayed, 2013).

Critique of Sahami and colleagues’ work.

Variables and driving tasks used. Sahami and Sayed (2013) measured lateral movement of the vehicle on the curves but not on the straight portions of the road. Although participants may have a harder time with lateral movement during cornering, stability is also needed on the straight roads for safety. Participants starting out driving on the simulator may have trouble with lateral movement on straight roads due to their inexperience with the sensitivity and handling of the steering wheel. It would have also been interesting to determine whether learning occurred on lateral movement for the straight roads.

The lack of generalizability and ecological validity of Sahami and Sayed’s (2013) scenarios limit the usefulness of the dependent variables. Participants in the Sahami and Sayeed (2013) study were instructed to drive through the corners as quickly as they could while attempting to drive in the center of the lane. Learning occurred if their speed increased to the maximum it could on their own through practice. However in real-world driving, one would not encounter having to go as fast as possible around turns, nor would doing so necessarily demonstrate driving proficiency. It is not clear as to why learning would necessarily mean increased driving speed. Rather, it would be expected that the participants would employ a trial and error method to see how fast they needed to go without losing control of the vehicle or deviating lanes. It would be more likely that they would sometimes drive faster and sometimes slower to achieve their ideal speed.

Adaptation definition. The authors claimed that adaptation was a “learning process” lasting until the individual reaches a relatively consistent level of performance, where the participant has become adapted to the simulator. However, they added that being adapted was “an indication that the automaticity phase has been reached and no further improvement is possible” (p. 43). What is not agreed on is that when the individual becomes adapted to the simulator, driving necessarily becomes an automatic process. Becoming adapted does not necessarily imply that performance has reached the highest level it can for that task, nor does it necessarily mean that performance has even improved at all from the start of driving the simulator. It is possible that the authors meant that no further improvement could be made by the participants on their own, without further training. However, given the connection they made between being adapted and automaticity, it is possible that they were implying that once participants are adapted, there cannot be any performance improvements.

Importance of training on the simulator. The effects of distracted driving could be impacted by how well the participant drives the simulator without distracters. Given the distracters are supposed to increase mental load, making driving more difficult and thus creating more errors, it would be interesting to determine how participants drive when distracted if they are trained as well as possible on the driving task by itself before the distraction condition. With this method, performance decrements in the distraction condition would not be due to lack of skill and ability driving in the simulator, and would be less likely to be due to the added mental load of handling the simulator. How the "expert" simulator driver does when distracted is never explored in the literature.

In addition to learning how to manage the speed, handling, control, etc. of the simulator, there are also cognitive skills and strategies of driving the simulator that need to be acquired. These cognitive skills require more than simply visual or physical feedback from the simulator to be learned. For instance, with speed maintenance, the participant lacks the kinetic cues to determine speed. These cues can never be acquired with a simulator that does not include realistic motion. Therefore, the only way that participants can achieve a high level of speed maintenance is if they frequently monitor the speedometer. The problem arises given that the participants are simply not accustomed to driving and glancing at the speedometer often in the real-world because they can get a feel for their speed through kinetic cues. Further, participants are unlikely to attain this skill on their own because it is unnatural for them to frequently glance at the speedometer. Incorporating verbal feedback/instruction, even simply by reminding the participants while they drive could aid in developing the cognitive skill needed for speed maintenance in the simulator (becoming more aware of the need to glance at the speedometer).

Although the authors did incorporate some visual feedback for lane deviations, verbal feedback may be helpful with developing this skill. Visual feedback on the simulator can be misleading, confusing, distracting, and may be missed if attention is not paid towards them (as admitted by Sahami & Sayed, 2013). Verbal feedback from an instructor/experienced driver is what occurs in the real-world when learning to drive. Training could take place that would be similar to driving instruction in the real-world to reduce errors to a point considered sufficient. This would possibly reduce performance variability across subjects as well.

Single subject designs

Sidman (1960) published one of the major texts on single-subject design in which he described why researchers should turn to using single-subject designs, as well as why traditional group designs that include many participants, used heavily in psychology, are flawed (Jackson, 2012). A major rift between the philosophies of researchers who stress single-subject design and those who stress group-designs is based on the definition of behavior. Johnson and Pennypacker (2009) define behavior as “that portion of an organism’s interaction with its environment that involves movement of some part of the organism” (p. 31). They added that only at the individual level does behavior exist.

Based on the ideas of Sidman (1960), rather than having one experiment comparing the results across groups, single-subject designs are created so that each participant serves as a separate experiment (Johnson & Pennypacker, 2009). In this sense, replicability and internal validity is demonstrated by repeatedly giving the manipulation, removing it, and then reintroducing it to an individual. Sidman (1960) criticized group designs for not being able to demonstrate replicability of results sufficiently (Jackson, 2012).

Sidman (1960) argued that because of the tight experimental control in single-subject designs, only one participant is actually necessary to determine an effect of the independent variable. This seems counterintuitive to group designs that employ inferential statistical analyses. One problem with having a single participant is that the one participant tested may not be representative of other individuals, even within the same general demographic category. Nevertheless, as Johnson and Pennypacker (2009) pointed out, this does not change the efficacy of the results for that one individual in terms of internal validity. Including more participants, they added, does not improve accuracy regarding the effects of the independent variable.

One critical feature that distinguishes single subject designs from group designs is the ongoing measurement of the individual. The advantages of this method include: to get a better picture of the true effects of the independent variable on the individual's behavior, to get a good baseline of behavior before introducing the manipulation, to get a good determination of the independent variable's effects on behavior long-term (which could differ from its effects short-term given the effects may not be completely developed), and to give the researcher more flexibility and control to modify the conditions based on the results (Johnson & Pennypacker, 2009; Perone, 1999). Effects based on each alteration to the design made by the researchers can then be determined (Johnson & Pennypacker, 2009). This is in comparison to group designs that are analyzed at the end of the experiment when all data collection has been completed. Unlike group designs, single-subject designs allow for closer, long-term, constant interaction between the researcher and each individual participant, which aids in experimental control (Perone, 1999).

Analyzing the group versus the individual.

As mentioned, a large difference between single-subject and group designs stems from analyzing the individual as opposed to the group. If the goal is to understand behavior as defined by Johnson and Pennypacker (2009), then a group design is not ideal. With group designs, data is averaged across many individuals, which therefore hide individual exceptions (Baron, 1999; Perone, 1999). Some participants may experience the same effect, an enhanced effect, or an opposite effect. This was evident, for example, with the study conducted by Thompson et al. (2011), where some of the participants actually performed better in the distraction condition, even though on average the participants fared worse when distracted. The group average performance may not reflect the performance of all or even any of the participants in that group. Therefore internal validity regarding individual behavior may be obscured when using group designs (Shull, 1999).

In a group design, individual difference effects are factored into error. Having many participants in group designs therefore enhances error variance, which might create difficulty in establishing the true relationship between variables (Jackson, 2012). With single subject designs on the other hand, the effect differences across individuals are not merged into error variance, but rather are a sign that control needs to be improved (Perone, 1999). Johnson and Pennypacker

(2009) discouraged making conclusions about individual behavior when averaging individual performance across groups. There is, however, some good logic to make conclusions on individual behavior when using group designs given the groups are composed of individuals (Jackson, 2012). Nevertheless, Shull (1999) stated that it is better to “see the relevance to individual organisms demonstrated directly instead of indirectly by inference from group-based data” (p. 118). Moreover, Branch (1999) claimed that the researcher infers about the population rather than the individual from the group average, which means that the inference is not about behavior.

Several researchers have stressed the importance of analyzing individual differences in driving research (e.g. Barkana, Zadok, Morad, & Avni, 2004). This is especially true for a conversation distracter, such as with a passenger or on a cell phone. Even if standardized conversation questions were used, every conversation would be unique and tailored to the participants. Shinar et al. (2005) stated that cell phone conversations and their effects are complex, changing, and contain a lot of variability considering the diverse types of conversations or phone tasks, the individuals talking on both ends, and the driving conditions and tasks.

The use of inferential statistics.

In addition to the criticisms against using group designs as opposed to single-subject designs when studying behavior as defined by Johnson and Pennypacker (2009), there are general criticisms of inferential statistics, which are typically used in group designs. Sidman (1960) expressed his view that inferential statistics were not needed and should not be used with single-subject designs centering on individual steady-state behavior (Baron, 1999). Other researchers have agreed that inferential statistics are not required to determine the true effects of the manipulation in single-subject designs (Ator, 1999; Crosbie, 1999; Perone, 1999), particularly with a long-term duration of measurements with steady-state performance reached before the manipulations and with good experimental control. The idea with single-subject designs is to create large and constant effects with individual behavior so that the internal validity is clear (Shull, 1999). Some research has criticized the use of inferential statistics for increasing the sample size to enhance the chances of statistical significance and by hiding the individual difference effects (Davison, 1999).

On the other hand, some have criticized using visual analysis as a means to determine the results rather than inferential statistics, stating that visual analysis is not objective and is not based on hard set rules (Kazdin, 1982). It must be realized, however, that visual analysis is not something done at the end of the study to examine the results. Rather, visual analysis is a continuous process throughout the experiment, surrounded by high level of control, long term observation of an individual, and the achievement of steady-states in all phases (Perone, 1999).

Despite the challenges and criticisms cited regarding using inferential statistics in single-subject research, researchers have pointed out that using inferential statistics such as nonparametric statistics can be helpful sometimes as a supplement to visual analysis and an additional corroboration. (Ator, 1999; Crosbie, 1999; Davison, 1999; Shull, 1999). Whether using a single-subject or group design, it is never guaranteed that there will be perfect agreement across researchers what the outcome is, nor is there a guarantee that the outcome, even if it is agreed upon, is the correct one (Perone, 1999).

Conclusions on single-subject design.

A single subject or small-n design may be a better method for assessing practice effects of dual-task performance in individuals, determining what is the true cause of the performance level, and whether the individual adapted to the driving simulator. Unlike traditional group research designs, single subject designs allow for the participant to reach a visible steady-state in performance before moving to the next phase. Traditional group designs do not usually include as much flexibility or give the amount of time needed for all participants to reach a steady-state on all dependent measures due to the participant commonly showing up for one session only.

As individual behavior is the focus, a single subject design is ideal. Reliability can be assessed through the single subject design, and generalizability can be assessed by having several participants. The individual differences due to such factors as age, experience, and information processing capabilities are not averaged and explained away as error in a single subject design. Simulator driving skill and ability to handle distracters are different for each participant, and information would be lost if participants were grouped together by condition or age for instance.

Current study

Before participants are introduced to the distracters in the present study, they will adapt to the simulator. If the added mental load from learning to drive the simulator is existent when in the dual-task condition, the validity of the results when driving in the dual-task condition would be threatened. Without having adaptation (where error levels become relatively steady after a period of driving the simulator without any training) to the driving simulator first, any practice effects evident in the dual-task condition could be due to just learning to drive the simulator. If adapted first, practice effects in dual-task condition will not be due to adapting to driving the simulator. Previous studies do not measure performance during practice, thus it is not really known whether the participant has adapted and at which level, and whether improvement if any occurred.

Another issue that needs to be investigated revolves around the number of errors that exist when at a steady-state. Although it is important for error levels to reach a steady-state as mentioned before, the error levels could still be steadily quite high for the dependent measures. Having participants attain the lowest error rate possible via training for the dependent measures creates as close to "expert" drivers on the simulator as possible.

Main research questions and relevant hypotheses.

1. How will performance in the initial baseline compare to training? How quickly will performance improve in the training condition?
    - ***Hypothesis 1:*** Training should lower overall error rate substantially from the baseline and distracter phases, and should lower it immediately in the first session of training.
2. How will the initial baseline performance compare to the phone and texting distracter pre-training?
    - ***Hypothesis 2***: Because of the added mental demand of both distracter tasks and evidence from previous research, it is expected that performance will be lower in both distracter conditions pre-training than in the initial baseline.
3. How will phone compare to text pre and post-training?

  - ***Hypothesis 3***: Due to the visual demands encountered with continuous texting, it is expected that the number of errors will be higher in the continuous texting compared to the hand-held phone conversation both pre and post-training. Performance should be more stable for the cell phone conversation phase compared to the continuous texting condition. Practice effects may be less evident in the texting task due to its added difficulty.

4. Will the effects of training last in subsequent baselines?
   - ***Hypothesis 4***: It is expected that the reduction in errors in the training phase will be due to learning and thus will continue in subsequent baselines.
5. How will baselines post-training compare to phone and texting post-training? What will be the comparison between the initial baseline and initial distracter performance to the baselines post-training and the distracters post-training? How will distracter performance compare before training to after training?
   - ***Hypothesis 5***: A similar difference in performance is expected between the baselines and the distracters pre and post-training. Training should reduce errors in baseline phases as well as in the distracter phases given the participant should be a better driver overall and thus better equipped to handle the distracter. Distracter performance before training should be worse than after training.
6. Will there be practice effects in any of the conditions for overall errors?
   - ***Hypothesis 6***: Some decline in errors are expected in the initial baseline phase as participants are practicing driving on their own, gradually learning how to control the simulator. There will be some practice effects evident in the distracter phases

pre-training as they are first introduced as the distracters, but not in post-training. It is expected that there will be practice effects for some of the individual dependent measures pre-training, particularly lane deviations based on pilot data.

7. Will training have a bigger impact on phone or texting on overall errors?
    - ***Hypothesis 7***: Given the expected added difficulty of texting, it is suggested that training will have a larger impact on texting.
8. How will reaction time task performance be affected by the distracters pre and post-training?
    - ***Hypothesis 8***: Based on previous research, reaction time should significantly increase in both distracters pre and post training. It is not expected that reaction time will improve post-training as reaction time will not be trained.
9. How will subjective workload be affected by the distracters pre and post-training?
    - ***Hypothesis 9***: Subjective workload should be higher in all the distracter phases compared to baseline, but may be lower post-training after participants supposedly gain skills and confidence in driving the simulator.

CHAPTER 3: STUDY 1

Methods

Participants.

There were a total of two participants in Study 1, both 22 years of age. The two participants were recruited through word-of-mouth. Both participants drove the simulator briefly several weeks before the study began to ensure they would not encounter simulator sickness. The first participant (Participant A) was a young female. Detailed demographic and driving experience information can be found on all participants in Appendix A. The second participant (Participant B) in Study 1 was also a young female at about the same age as Participant A. The participants had some flexibility as to when they could come in to the lab; however, they both averaged three sessions per week for eight weeks.

Participants did not suffer any greater risk in the study than they would have experienced at most amusement park virtual rides. If the participants felt ill at any time, they were always allowed to stop and rest, and if they desired, quit the day's session or even quit the entire study. To be included, the two participants had to have 20/40 vision or better for far and near acuity, a normal range of contrast sensitivity, normal color vision, and normal hearing. The study followed the guidelines set by the APA for the ethical treatment of human participants.

Apparatus.

The study incorporated a GE I-SIM PatrolSim Mark-II+ high fidelity driving simulator. The simulator includes five computers, including one running the simulator, three separate visual channels corresponding with three separate projector screens, and a computer for the simulator operator interface. The simulator's dashboard resembles a 1990's Ford Crown Victoria with automatic transmission, as the simulator was previously used for police training and Crown Victoria's were commonly used police cars. The simulator has a built-in dashboard with standard instruments including a speedometer as well as a fuel and oil gauge that operate realistically. Also included is a steering wheel with horn, driver's seat with seatbelt, areas in the dashboard to place a radio or GPS, and dials for air conditioning. The dashboard also includes a headlight switch and a panel light dimmer. Researchers have found that this driving simulator was reliable and valid as a substitute for real-world driving (Dos Santos, 2007). Images of the simulator can be seen in Figures 1 and 2.

Figure 1. Driving simulator panel

Figure 2. Driving simulator

The simulator includes one screen for central viewing through the simulated windshield and two screens on the left and right of the driver for peripheral viewing. In total, the three screens take up approximately 130 degrees of visual angle horizontally (about 40 degrees for the center screen and 44 degrees for each periphery screen). In addition, there is 45 degrees of visual angle vertically for the center screen and 49 degrees for the peripheral screens. The resolution of the Dell^{TM} 2400MP projectors are 1024 x 768 pixels. The two peripheral screens are placed at a 30° angle relative to the center screen. Each screen measures 122 cm in height x 107 cm in length. The participant is able to adjust the forward and back position of the driver's seat, and thus can be anywhere from 140-160 cms away from the screens. Images of the simulator screens can be seen in Figure 3.

There are buttons connected to the center of the steering wheel that allow the driver to pan on the left and right screens to the left or right respectively. This is similar to the driver looking further to the left or right, such as when needing to change lanes to check for traffic. The simulation screens contain two side mirrors and a rearview mirror just as in ordinary vehicles. The left and right A pillars of the vehicle are depicted on the screens.

Crashes are recorded by the simulator. There are two options as to what occurs in the event of a crash. The simulation can come to an abrupt stop and the simulation must be restarted, or the simulation can continue after the crash occurs. The option chosen was for the simulation to continue. If the participant crashes, the center screen depicts a shattering of the windshield with the word "collision" in red. This image is flashed for about a second, and then the drive continues normally.

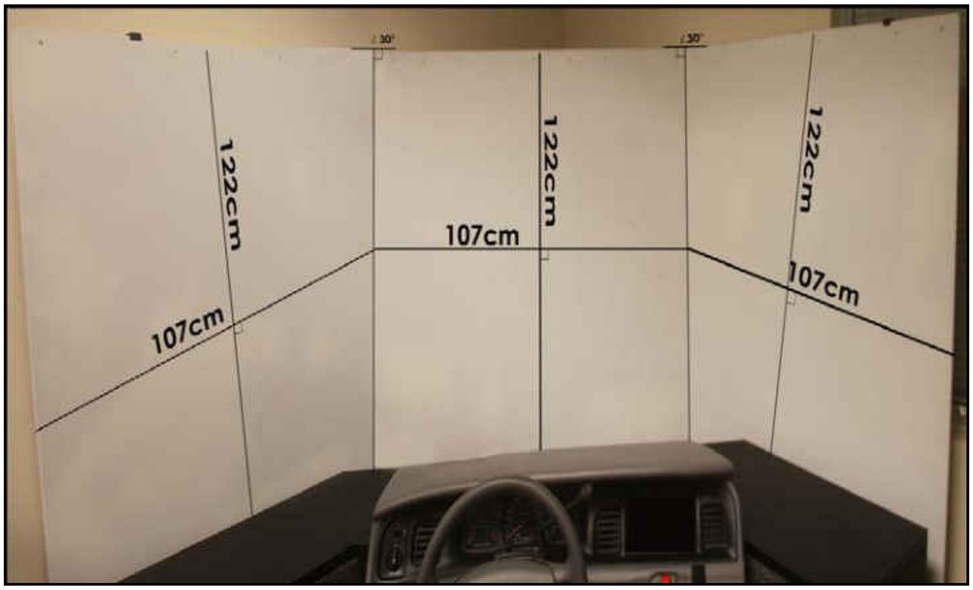


Figure 3. Driving simulator screen dimensions

Driving performance measures.

Highway scenarios are far more commonly examined than city scenarios in driving distraction research (Rupp, 2012). Thus, the present study focused on a city/suburban scenario. There were several measures of driving performance in the simulator that were key to determining the effects of practice, training, and distracters on driving the simulator. The goal for each phase of the design was to have participants reach a steady-state before advancing to the next phase.

Johnson and Pennypacker (2009) discussed what a steady-state means. Based on Johnson and Pennypacker (2009), there are no hard-set rules on what a steady-state is in terms of objective criteria, which has been criticized by some behavioral analysts such as Perone (1999) and Shull (1999). Nevertheless, the steady state according to Johnson and Pennypacker (2009) implies that the individual’s performance or response is not increasing or decreasing in general, and that the variability between the responses, scores, errors, etc. is close to being consistent, without any excessive outliers. Johnson and Pennypacker (2009) suggested that with increasing sessions, a clearer picture of individual performance appears, and one can identify whether performance has reached a steady-state.

The reason for including ambiguity in defining steady-state is because the decision as to whether performance has reached a steady-state and what is considered non-excessive variability must be based on several factors. These include the research question, previous research, response class, procedure, manipulation, and the environment in which a response occurs (Johnson & Pennypacker, 2009). The decision made regarding whether the behavior has reached a steady-state is important to determine whether the next phase/condition should be initiated, or whether the present condition should continue with or without modification (Johnson & Pennypacker, 2009).

Therefore, it was important for the participants to reach a steady-state before moving forward to the next phase. Unless there were unusual circumstances, each phase lasted at least three sessions. Including three sessions as opposed to one or two allows for a better picture of performance as discussed by Johnson and Pennypacker (2009) who pointed out that a manipulation condition that is too short would only be able to reveal the primary effects. Therefore, it could not be determined if the effects shown were robust or brief. Below are descriptions of the driving performance measures. For the overall errors collapsing across all dependent measures for two raters, Cohen's Kappa was $\kappa = .615$ ($p < .001$) and the correlation was $r = .932$ ($p < .001$) for 432 data points.

Speed maintenance. The speed limit throughout the scenario was 35 miles per hour (a typical city/suburban speed limit). Participants were told to try to maintain the speed limit as they should in the real-world. An error in speed maintenance was recorded when the speed was +/- 3 mph from the speed limit, thus 31 mph and lower and 39 mph and greater. This value was selected as it is roughly 10% of the speed limit, a value that was used in the Cooper and Strayer (2008) study. Speed maintenance was only recorded when the driver is at cruise on straight portions of the road. In other words, it was not recorded when the vehicle was accelerating from a stop or decelerating to a stop. Successful speed maintenance originally may take more mental processing, giving more reason to have participants adapt to the simulator before initiating distracting activities while driving.

For Participant A, only one error was recorded per straight portion of the road. For instance, if she drove 40 mph at one point, slowed to 36 mph, then accelerated to 39 mph, only one speed limit error was recorded for that particular road, with the highest speed recorded. For Participant B, however, this same scenario was recorded as two separate errors because it was realized that participants may make a "speed error over", decrease their speed to under the margin of error (i.e. 38 mph) and then make another error by going over 38 mph on the same road. This change was made as a result of observing Participant A and deciding that the measurement needed adjustment. Speed errors were recorded by watching the video of the drive after the data was collected. Cohen's Kappa for "speed errors over" was .907 ($p < .001$) and the correlation was $r = .973$ ($p < .001$) for 72 data points. Cohen's Kappa for "speed errors under" was $\kappa = .887$ ($p < .001$) and the correlation was $r = .99$ ($p < .001$) for 72 data points across two raters.

Lane deviations. Lane deviations were assessed on the roads of the course that contain lane lines. A lane deviation was recorded whenever the back tires of the vehicle touched the lane lines either on the left or right side of the vehicle. If the vehicle continued to touch or cross the lane lines, it was recorded as one deviation. If the vehicle went back inside the lane lines, the next time it touched or crossed the lane line was considered another lane deviation. The number of lane deviations was coded by raters watching the video of the drive after data was collected. The video of the drive could be watched from various angles; for example, top down or birds-eye view, from behind, and from the front of the vehicle to increase accuracy of coding. The raters consisted of the author and a research assistant. Training was thorough and included many practice sessions with the experimenter working with the assistant and then with the assistant working on her own. Interrater reliability between the two raters was assessed across three of the four participants in Study 2 for random sessions. Reliability was based on the number of errors per measure. Cohen's Kappa for lane deviations was $\kappa = .522$ ($p < .001$) and the correlation was $r = .947$ ($p < .001$) for 72 data points across two raters.

Lane positioning. Lane position errors functioned similarly to lane deviations; however, lane position errors were assessed only on the roads that did not contain lane lines. These roads were found in the suburban areas of the scenarios. Although there were no lane lines to judge whether the vehicle crossed over them, an error was considered if the vehicle at any time crossed over the middle of the street, which was determined using visual approximation. In addition, an error was measured if the vehicle on the roads without lane lines crossed over the side of the road, such as on the curb. If the vehicle continued to make an error, for instance as long as it was crossing the middle of the street, only one error was recorded. Once the vehicle returned to the correct lane position (i.e., not crossing over middle of street, on wrong side of road, off side of road), the following incident where the participant made a lane position error was considered another error. The number of lane position errors was coded by raters watching the video of the drive after data was collected. Cohen's Kappa for lane position errors was $\kappa = .359$ ($p < .001$) and the correlation was $r = .88$ ($p < .001$) for 72 data points across two raters.

Stop errors. Each drive involved going from points A to B and then back from B to A. In total there were six stop signs in one direction of the drive, and therefore a total of 12 for each drive. Only one error was recorded per stop. A stop error was defined as one of three possibilities: the front of the vehicle stopping before the first line of the crosswalk, the front of the vehicle stopping past the first line of the crosswalk, and a rolling stop where the vehicle did not come to a complete stop (0 mph). This dependent measure was in place to assess both control/handling of the vehicle, as well as the effects of attention lapses or carelessness. Although stopping short of the line may not be illegal or dangerous, it does reveal that the participant is not optimally skilled in terms of control over the vehicle in the simulator, and may represent increased cognitive load. For errors past the line, this was visually determined by whether the vehicle was over the midpoint line of the first crosswalk marking. If it was over this point, an error was recorded. For errors before the line, an error was recorded if the vehicle stopped a distance before the line that is equal to or greater than the distance between the edge of the crosswalk line and its midpoint. This flexibility was considered given the difficulty of being perfectly on the line. The stop errors were recorded visually with the top-down or birds-eye view perspective of the video. Cohen's Kappa for stop errors was $\kappa = .524$ ($p < .001$) and the correlation was $r = .914$ ($p < .001$) for 72 data points across two raters.

Turn quality. There were a total of 10 turns in one direction of the drive, thus 20 total in one drive. Two of the turns were on roads containing lane lines, whereas the others were on roads without lane lines. Although turns could have been evaluated in several different ways, such as angle and speed of turns, the method chosen for this study was the deviation over lane lines, or sides/middle of the road for roads without lane lines. This measurement did to some extent take into account the angle of turn, but determining the angle of turn could have been based on other factors as well, such as the steepness of the angle in the middle of the turn. Also, on roads without lane lines, an error was not recorded as long as the vehicle did not cross the middle or sides of the road when turning. Thus even if the angle of the arc while turning was not ideal, it was not counted as a turn error. Only one turn error was recorded per turn thus, at most, there could have been 20 errors in one drive. If a turn error was recorded, the lane deviations or lane position errors created during the turn were also coded as errors for those variables. These errors were recorded by raters watching the video after that data was collected. Cohen's Kappa for turn errors was $\kappa = .402$ ($p < .001$) and the correlation was $r = .885$ ($p < .001$) for 72 data points across two raters.

Table 1. Driving performance measures and their description

Driving performance measures	**Sublevels**	**Description**
Speed maintenance	Speed errors over	Defined as 39mph or greater. Multiple errors could occur on a single road.
	Speed errors under	31mph or lower as the highest speed on a single road.
Lane deviations		On roads that did contain lane lines, an error was recorded if the vehicle touched with their back wheels on the line on either side of the lane.
Lane position errors		On roads without lane lines, an error was recorded if the vehicle penetrated the middle of the road or the right side of the road
Stop errors (max 12/ drive)	Stop before line	If the vehicle comes to a complete stop roughly half a car length from the line, an error was recorded
	Stop after line	If the vehicle comes to a stop past the line by roughly half a car length an error was recorded
	Rolling stop	If the vehicle does not come to a complete stop defined as 0mph, an error was recorded
Turn errors (max 20/ drive)		Error recorded when vehicle crossed over the middle of the road or lane at start or end of turn, only 1 error recorded per turn

Manipulations: Training.

In the training session, verbal feedback was given to participants while they were driving. The feedback covered all the dependent variables mentioned above. The experimenter sat next to the participant as a passenger would. While the participant was driving, the experimenter gave suggestions about how to control the vehicle and commented on any participant errors.

Manipulations: Distracter types.

There were several types of distracters as mentioned earlier in the chapter. The four distracters used cover several different types of distraction described by Olson, Dewar, and Farber (2007). Talking on the hand-held cell phone includes aural, biomechanical, and cognitive distracters. Reading and texting (intermittent and continuous) tasks include biomechanical, visual, and cognitive distracters. A search of the literature indicates that no previous research has examined all these different types of distracters in the same longitudinal study.

Cell phone conversation. Since talking on a cellphone is so common, using it as a distracter is ecologically valid. Further, the results of the present study will be more comparable to studies on practice and distraction conducted by Cooper and Strayer (2008) and Shinar et al. (2005). Effects of hand-held cellphone use may be compounded if the participant has not adapted or been trained on the simulator in terms of control and handling. The added manual distraction of holding a phone may play more of a role in a city as opposed to a highway scenario because the city scenario necessitates more control due to frequent turns.

There are arguments to having a naturalistic conversation as the distracter task, and there are those who favor having an information processing task such as an N-back (Kane, Conway, Miura, & Colflesh, 2007) or a mathematical computation task. Using conversation and information processing tasks as distracters has been examined heavily in the literature (Caird et al., 2008; Horrey & Wickens, 2006). The advantage of naturalistic conversation is that it is a realistic task that drivers actually engage in while driving. The problem with naturalistic conversation is the loss of standardization. Shinar et al. (2005) pointed out that naturalistic conversations have various effects on different people, and that no two conversations will be alike, even if the experimenter remains the same for all participants. The other issue with any conversation task is establishing whether the participant is engaged and distracted, thus it is difficult to determine whether the manipulation had its maximum intended effect.

Some researchers have instead employed more scripted and therefore less naturalistic conversation to enhance standardization across participants. However, even with this method, the conversation remains different across participants, as some will talk more than others, some may not understand the question, etc. Further, the same issue with naturalistic conversations remains in that it is difficult to determine how engaged participants are and whether they are maximally distracted. If the researcher did decide to use a conversation task, aside from these previously mentioned issues, it would be extremely difficult to conduct a study longitudinally, developing new questions and not running out of topics to discuss. One method is to ask participants to list topics that are of interest to them, but again, over a long period of time, particularly if the experimenter is not familiar with the topics, it could make it very difficult to sustain the distracter task.

A specific cognitive task has the advantage of being able to assess engagement and making sure the manipulation has its intended effect. It also allows for the collection of data from the secondary task fairly easily. Moreover, it would not have some of the same challenges as a conversation task such as creating topics, keeping the participant engaged, not running out of topics, having the same experimenter, standardization, etc. The drawback of using a cognitive task is that it lacks realism to what an individual would be doing driving, and therefore researchers could argue that the results are not generalizable to real-world driver distraction.

An alternative would be to have a conversation task, but have it so it is much more standardized and contains elements of a cognitive task. In Study 1, both participants watched a movie series/documentary in parts just before they drove in the simulator in the phone conversation condition. The series participants watched was titled *New York*, which is a 2003 PBS home video directed by Ric Burns. Prior to the driving task, the two participants watched the video in 30 minute segments per session. During the phone conversation task, the participants were asked several thought provoking questions about what they had watched. The questions contained comprehension and opinion type questions that forced the participant to expand and apply what they had watched. How many questions were asked depended on how long the participant took to respond and how long it took them to drive the scenario. Some of the questions were scripted, whereas others were asked based on the natural flow of the participant's responses. The scripted questions are found in the Appendix B.

The advantages of this method are that it combines features of a conversation and a cognitive task. There is much more standardization than a naturalistic conversation, and the questions are much more easily comparable in terms of difficulty as they are about the same topic. Many of the questions could not be answered briefly. This is an improved method to insure that participants are engaged and the manipulation is distracting. At the same time, the problem of running out of topics to discuss is eliminated. In a way, this task would be similar to an in-depth discussion taking place between two individuals who had watched the same movie--an activity that occurs often in real life.

Continuous texting. A search of the literature has not revealed any studies that have longitudinally investigated texting while driving in a simulator. The texting task used a Samsung Captivate Galaxy S. It was an Android version 2.1 smartphone that contained a 1 GHz processor. It weighed 4.41 oz., and the dimensions were 4.83 in. x 2.52 in. x 0.41 in. The touch screen was a 4 in. OLED display with a resolution of 480 x 800 pixels and with 24 bit color.

Participants were asked to text a short essay on a general topic for each session. The topic was meant to elicit a response that would last for the entire session. Each session therefore would include a different topic. For Participant A, examples of topics included were "Where do you see yourself in the future?" and "Where do you see the state of the country in the future?" These are topics that were meant to be very open-ended and allow for an extended response.

Although they did not have to read a text that is sent to them, they did have to look at the text that they were sending. Thus this task combined several different subtasks. They needed to have a hand on the phone and move their finger(s) to physically create the message. They needed to think about the question asked and the answer they wished to give, as well as type that answer on the phone. Participants were told to text nonstop as much as possible, while making glances to the road when necessary while still texting. The rationale for this is so that maximum effects can be observed. It should also be noted that participants only texted continuously for around 4.5 minutes for each direction of the drive. In between trails particiapnts did not text. Although it may be unrealistic participants would text incessantly for half an hour, it is quite reasonable that they would be texting for less than 5 minutes nonstop if they were involved in an important conversation.

Intermittent texting. Intermittent texting involved an exchange in texts between the experimenter and Participant A only. This was to simulate a natural texting conversation, where one individual sends a text, the other individual receives and reads the text, and that individual in turn sends a text to the original sender. Therefore, compared to continuous texting, Participant A was less distracted in this condition because they did not have to text as frequently throughout the drive. Although this may be more ecologically valid, it did not show the full effects of texting as a distracter. The questions texted to Participant A were conversational, such as “What are you doing this weekend?” The questions were meant to be answered with a relatively short response and were tailored to Participant A’s responses. Intermittent texting was omitted for Participant B because it was not clear for how much time the participant would actually be distracted when factoring in time to send, receive, and compose the text. Moreover with intermittent texting it is not clear that any driving errors observed were due to the texting given that the participant could have been doing something else when the errors occurred. On the other hand using continuous texting is a valid measure because it only takes one distracted event to cause a crash.

Reading. This distracter task was similar to reading long text messages while driving. Participant A only read a journal article (Straker et al., 2008) from the journal Human Factors while driving. The dimensions of the journal were 25.5 x 17.5 cm. Participant A held the journal in her right hand, while holding the steering wheel with her left hand. The illumination of the room was based solely on the projectors and their reflection off the screens, as the room lights were off and the window in the room was completely covered. The illumination from the projectors varied somewhat due to the different scenes in the simulation while the participant was driving. Participant A did not have to read the tables, graphs, references embedded in the paper, or the reference section. The height that Participant A held the journal while reading was flexible to her preference. Participant A was required to read out loud to ensure that she was actually reading, and was required to read nonstop during the drive to maximize the effects of the distracter. The reading distracter was omitted with Participant B because it lacked ecological validity compared to talking on the phone or texting.

Design.

This study consisted of a small-n design. The design began with each participant driving on the simulator without training or distracters. This served as the initial baseline to determine the number of errors made by the participant across the dependent variables, as well as to determine whether any practice effects occur when driving the simulator without any distracters or verbal feedback. There were multiple baselines across the participants for the initial baseline (first phase). Although multiple baselines can have several different meanings, in this context it meant that the baseline phases lasted for different amount of times across the participants. More specifically, Participant A experienced the first baseline phase for three sessions, whereas Participant B experienced the first baseline phase for nine sessions.

The purpose of multiple baselines in the first phase is to enhance the argument that the change in error levels (likely a decrease in error levels) in the following training phase is in fact due to the training as opposed to changes that would have occurred naturally without training. In other words, the goal is to show that behavior changed for each participant only immediately after the introduction of the training. This is particularly an issue given that once training takes place, the research design cannot revert back to the original baseline because the training will permanently alter the participant's behavior. Thus a reversal design cannot be used for that segment.

The second phase involved training in driving the simulator. This was to ensure the participant's simulator driving performance has adapted to the highest level possible before the distracter conditions. In the training phase, the experimenter gave real-time verbal feedback and suggestions on how to improve handling and control over the driving. Practice alone may allow the participants to reach a steady-state in performance eventually; however, this level of performance may not be at its peak.

The next phase introduced the distracter task. Participant A experienced four different types of distracters in the following order: conversing on a cell phone, reading a journal, texting continuously on a cell phone, and texting intermittently on a cell phone. Participant B experienced only two types of distracters: talking on a cell phone and texting continuously on a cell phone. Detailed explanation of the different distracters is included later in this chapter.

In between each distracter condition for both participants there were conditions without distracters which served as return to baseline conditions. It should be noted that these baseline conditions were different from the initial baseline condition given the initial baseline condition took place before the training, whereas the later baseline conditions took place after the training. More about the training is discussed later in the chapter.

The design for Participant A can be signified as A_1,B,C,D,A_2,E,A_3, F. A's represent the baseline conditions. A_1 is the first phase consisting of driving in the simulator without any distracter or training. B is the training phase. C represents the first type of distracter (talking on the cell phone). D is the second distracter condition (reading). A_2 is the second baseline. E is the third type of distracter encountered (continuous texting). A_3 is the final baseline measurement, and F is the final distracter (intermittent texting).

The design for Participant B can be denoted as A_1, B, C, A_2, D, A_3. Participant B also experienced three baseline phases but only two distracters. After the training phase (B), Participant B experienced the first distracter (C) which was the cell phone conversation condition, and after the second baseline, experienced the third distracter (D) which was continuous texting.

Screening/pre-experiment questionnaires.

DEQ and DHQ. The driver experience questionnaire (DEQ) and the driving habits questionnaire (DHQ) (Owsley, Stanley, Wells, & Sloane, 1999) were both given to participants to obtain basic demographic information. The surveys contained a mixture of closed-ended items such as “yes” or “no” and multiple choice. Although the DHQ is used more for elderly participants, the current study used it for all participants. See Appendix C and D for both of these surveys. Both surveys were administered by email.

CPEQ. The cell phone experience questionnaire (CPEQ) was developed by the author to assess the amount and type of participant previous cell phone use, whether using handheld or hands-free, as well as texting behavior. Most of the items were in the form of short-answer written responses, however there were also a few Likert-type items. Individuals did not need to have a certain amount of cell phone use while driving experience to participate in the study. See Appendix E for full survey. This survey was administered by email.

Visual Screener. Participants took a Snellen far visual acuity test using the Optec 5500 visual screener (seen in Figure 4). The participants read the lowest row of letters possible, and if one mistake was made, the experimenter asked the participant to read the next highest line. Their score represented the line they read completely correctly. If the participant had worse than 20/40 corrected with contacts or glasses, they were not able to continue with the study. The left and right eyes were tested individually, as well as both eyes together. A similar Snellen test was used to examine near acuity. As with far acuity, the participants were asked to read the lowest line possible, and their score was based on which line they read perfectly.

Participants also took a contrast sensitivity test on the Optec, as some researchers stress the importance of it in driving and some contend that it may be a better predictor of driving performance (Ginsburg, 1996). The contrast sensitivity test was composed of five different spatial frequencies, ranging from lower to higher (thicker to narrower gratings). With each spatial frequency, there were nine possible contrasts ranging from more to less contrast. If the participant fell below the normal range for two or more of the frequencies, they were not able to continue with the study. The normal range is depicted on the score sheet.

Also tested on the Optec was far distance color vision using Ishihara type color plates (Goldstein, 2010), which are numbers embedded in circles with various colors. The participant needed to correctly identify four of the five plates to continue with the study. The sheet the experimenter used when testing vision is included in Appendix F.

Figure 4. Optec vision screener

Route on driving simulator.

The participants learned the route from a starting point to an end point, and then from the end point back to the starting point, in other words from point A to B and point B to A. The rationale for having participants learn the route was to be more realistic as to what drivers do every day, so the route should have become second nature to them like in the real-world. The goal was to know how distraction affects driving on a familiar route other than driving straight on a highway or a route in which the participant is constantly given directions.

Another reason to have participants learn the route had to do with the scenario type. Most driver distraction studies incorporate highway scenarios, which do not require instructions on directions. With a city/suburban scene, it is ideal to have participants eventually be able to drive without having someone give them verbal directions or follow visual directions as they take up more cognitive capacity. If participants made a mistake with the directions in the study, they were instructed to go back and drive the route correctly. Both routes (A to B and B to A) used a city/suburban scenario that was pre-programmed with various traffic and obstacles. Obstacles could have included pedestrians, motorcyclists, bicyclists, signs, barriers, etc.

There were several different scenarios used that all had the same map, but differed in traffic type and amount. The purpose of alternating the traffic and obstacles while maintaining the same route was to simulate a drive that is made daily, is well known, but consists of natural variations in traffic and hazards on a day-to-day basis.

Route A to B. The route from A to B took about 4.5 minutes and covered a distance of about 1.8 miles. The short route aided in its memorization. Including the starting point, there were 15 intersections, six containing a stop sign where the participant needed to stop, as well as 10 turns (six left and four right) the participant had to make. The scenario started at an intersection with a stop light, however other than that, there were no stoplights. Starting at the intersection of 7th and A street, the participant traveled down A street and turned left on 1st street. This was followed by a left on D street, left on 3rd, right on B, right on 4th, left on D, left on 5th, right on B, right on 6th, and left on D street, which came up to 7th street.

Route B to A. The route from B to A also started at the intersection of 7th and A street, but participants made a left on 7th street and a right on D street, then followed the first route in reverse. This route could have taken a few minutes longer than route A to B due to the added distance driving from the intersection of 7th and A street to the end point of the first route, as well as the addition of three stop lights (however the last of which a right turn was made). The extra distance was .02 miles, which was not included in the analyses. Thus the amount of data collected from both routes was identical for consistency. In other words the extra distance was not counted for data collection. The reason for having the same starting point for each route was to reduce the number of programmed scenarios in the simulator, which has a limited amount of memory.

Procedure.

Before driving the simulator. The experimenter first determined if the individual gave their consent to participate. Participants took the vision tests on the Optec machine. For the cell phone conversation distracter task, both participants watched a 30 minute segment of the *New York* documentary at the beginning of the session, prior to driving in the simulator.

Simulator sessions. The first session consisted of the practice baseline condition, driving the simulator without distracters or training. The participant drove the route A to B then immediately drove the route B to A. This process was repeated three times in one session, and one session was equal to one day of testing. The first route took about 4.5 minutes, whereas the second route took about 5 to 6 minutes. Thus the total time for the participants to drive in one session was around 30 minutes given there were 6 routes per session. Breaks between drives were not required, but could have been taken to resist fatigue and symptoms of simulator sickness. The drives themselves were kept short to also decrease the chances of fatigue and simulator sickness.

Long-term study plan. What happened after the first session depended somewhat on the participant's driving performance. They were not able to advance to the next phase until they completed a minimum of three consecutive steady-state sessions. Because participants' schedules varied, there was flexibility as to when they could come into the lab. Ideally participants were to come to the lab for three to four sessions a week. Participants were allowed to complete more than one session per day if practical and/or was necessary. It was ideal to have as consistent of a schedule as possible, however this was not always practical. In Study 1, the participants had a very consistent schedule and averaged three sessions per week for every week until they completed the study. Each participant in Study 1 took about eight weeks to complete the study. In Study 2 (see next section) there was more variability in the participants' schedules, rate of coming into the lab, and the amount of time it took them to complete the study.

Results and discussion Study 1

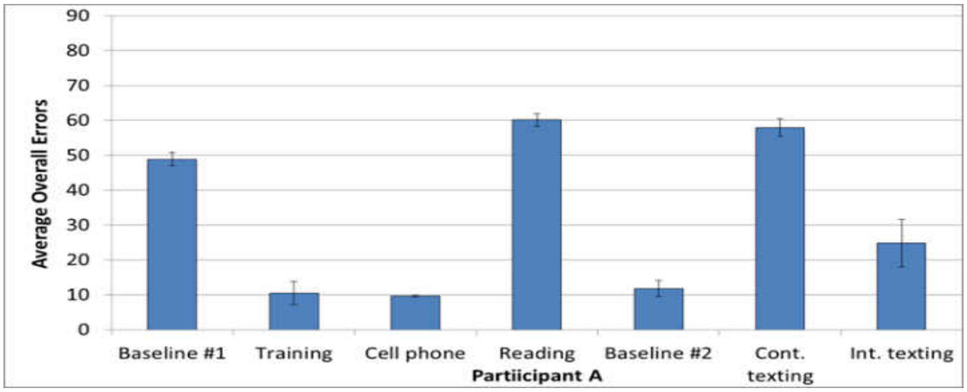


Figure 5. Overall average errors across each phase for Participant A

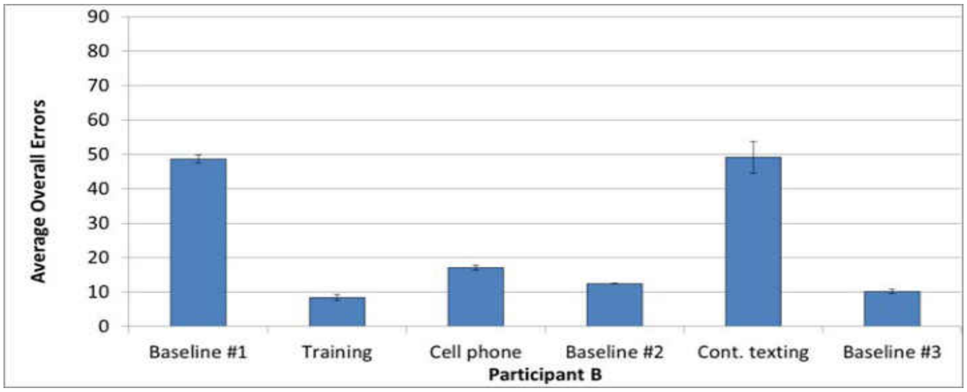


Figure 6. Overall average errors across each phase for Participant B

*Note: Participant A: 3 sessions for all phases except for intermittent texting which was two sessions. For Participant B, Baseline 1 was 9 sessions, and texting was 6 sessions.

Participant A overall errors. Bar graphs were used throughout when there was only one point depicted per phase. Also the phases were not continuous as a line graph would suggest. All phases consisted of three sessions with the exception of the third baseline, which lasted only one session, and the intermittent texting phase, lasting two sessions. The reason for these shorter phases at the end of the experiment was due to logistics of the participant's schedule. First, examining the overall average errors across each phase, the initial baseline before training had an average of 50 errors. This number decreased to 10 in the training session (80% decrease), indicating that training had its intended effect of lowering errors. After training, the distracters were introduced beginning with the phone conversation. The results indicate about the same average number of errors in the cell phone phase as in the training phase, showing that there was no overall effect of conversing on the phone.

The next phase consisted of the reading distracter and had average errors increase from 10 to 60 (500% increase), therefore the reading distracter raised the average error rate above the initial baseline before training. The second baseline had a similar error level rate as in the training phase, which was expected. The continuous texting phase had average error rates reaching close to the level of the reading distracter, and as with the reading distracter, the average error rates increased to above the initial baseline levels. Lastly, the average of intermittent texting errors was also elevated as it reached a level almost 15 points greater than the second baseline (150% increase). This shows the effect of the distracter on performance. However, as expected, the number of errors in this phase was not as high as that with the reading and continuous texting distracters.

Participant B overall errors. There was an average of 50 errors in the initial baseline for Participant B. Given Participant B experienced an initial baseline that was three times the length of the initial baseline with Participant A, their baseline error rates were the same (i.e. practice was not enough to improve performance).

The error rate declined in the training phase to lower than 10 errors (80% decrease), showing that the training was effective in lowering errors. In the phone phase, the errors increased to the high teens, and then the second baseline (post-training) had errors drop to the low teens. This may indicated that the phone phase had some effect. If the phone phase did not have any effect, it would have been expected that the errors in the second baseline would be closer to the phone phase than the training phase. This is also corroborated with the error rate in the final baseline, which had error rates very close to the training phase. Errors increased dramatically in the texting phase in between the second and third baselines to an error rate roughly equivalent to the initial baseline. This showed that texting had an effect on errors and that it brought errors to the same level as when participants started the study.

Comparison between participants on overall errors: The phases in common between the two participants were the initial baseline, training, cell phone, a post-training baseline, and continuous texting phases. A very similar pattern and number of errors were noticed. Cell phone errors did increase more compared to the training phase for Participant B. On the other hand, overall errors in the training and the phone phase for Participant A were almost identical. Both had a large jump in the continuous texting phase, suggesting that even after training, texting had a large impact on overall driving performance. However, the increase from the post-training baseline to continuous texting was greater for Participant A. It appears that texting had a much larger impact than phone.

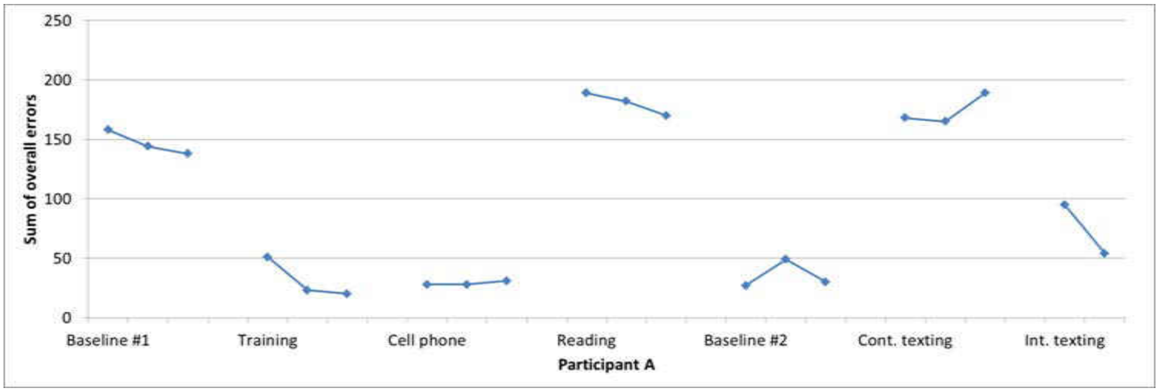


Figure 7. Sum of errors per session per phase for Participant A

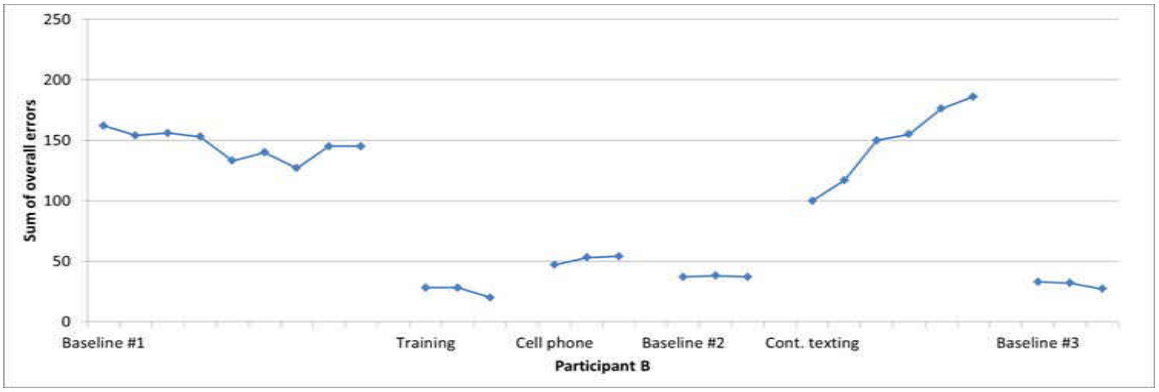


Figure 8. Sum of errors per session per phase for Participant B

Comparing the overall errors in the initial baseline, in both participants the errors decreased across the sessions, although there was a steeper drop evident for Participant A. Although there was a drop in errors in the training session for Participant A between session 1 and 2, errors were relatively steady for Participant B. For both participants, performance was steady in the cell phone distracter phase. Participant A did show a gradual decrease in the reading distracter phase. Both participants had an increase in errors throughout the continuous texting phases, although the increase was more noticeable with Participant B. It is possible that having more sessions for Participant A would have shown a continual increase in errors. One research question of this study was whether practice could help diminish errors when texting, and it appears that the opposite effect occurred. Intermittent texting in Participant A showed a decline in errors across the two sessions, although it is impossible to determine whether this decrease was due to practice effects or because there was less time the participant was distracted in the second session. Although intermittent texting may have more external validity due to enhanced realism, the internal validity is questionable.

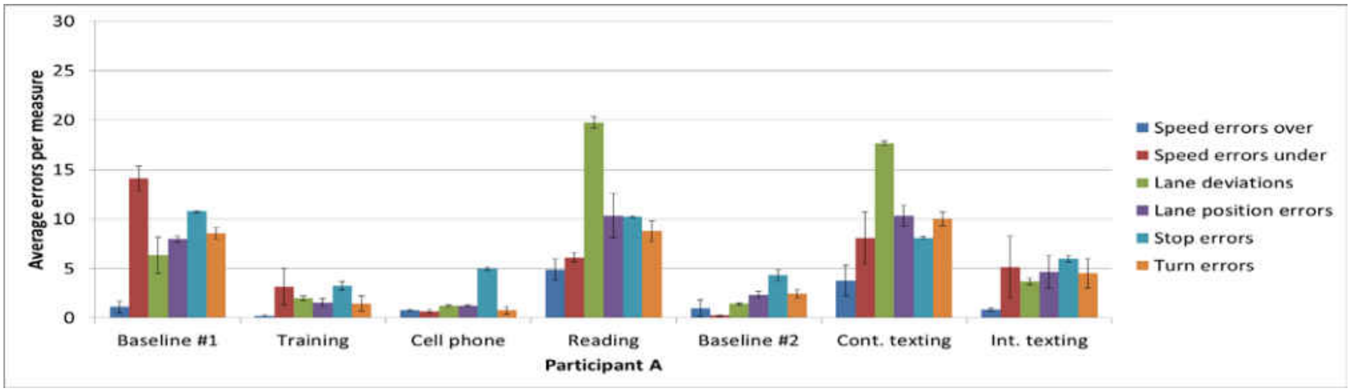


Figure 9. Average errors for all measures across each phase for Participant A

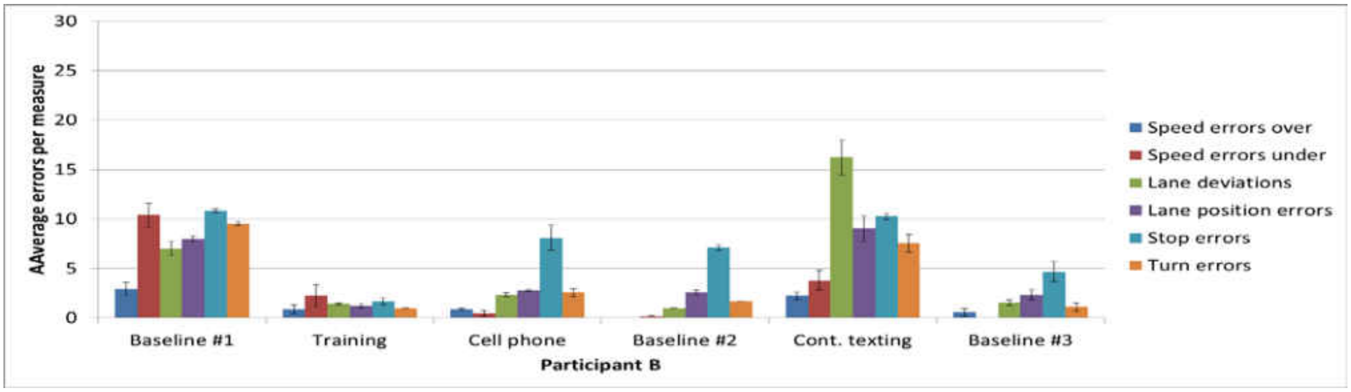


Figure 10. Average errors for all measures across each phase for Participant B

Participant A errors per measure. In Figure 3, the overall errors are broken down into the individual dependent measures. The measure with the fewest average errors was the "speed errors over;" the participant did not have difficulty driving over the speed limit. It is important to note however that the "speed errors over" increased in the reading distracter phase as well as in the continuous texting phase. This possibly indicates a drop in situational awareness and vehicle control when distracted in these two phases. "Speed errors under" are most severe in the initial baseline, but then drop in the training phase and even more in the phone condition. However in the reading, continuous texting, and intermittent texting phases, average "speed errors under" increased when compared to training and the second baseline. This may indicate that the participant was attempting to accommodate for the distracter by driving slower.

The average "lane deviations" decreased in the training phase from the initial baseline and did not seem to be affected by the phone distracter. "Lane deviations" were the highest type of error in both the reading and the continuous texting phases. The average error rates in those phases for lane deviations were between 10 to 15 errors higher (around 2005 increase) than the initial baseline. Although there was an increase in the average lane deviations in the intermittent texting phase as compared to the second baseline, the average errors for lane deviations in this phase were slightly lower than in the initial baseline and were not as high as in the reading and continuous texting phases. "Lane position" errors followed a similar pattern as to the other measures, with a drop in the training, no increase in the phone phase, and an increase in the other distracter phases. "Lane position" errors increased in the reading and continuous texting phases more than they did in the intermittent texting phase. Average turn errors exhibited an almost identical pattern to the average lane position errors.

Participant B errors per measure. Stop errors dropped from the initial baseline to the training phase, although increased in the phone phase, and increased even more in the other distracters, to reach the highest level in the reading phase. Although it may at first appear that the stop errors increased in the phone condition because of the distracter, these errors were very similar to those in the second baseline indicating that the increase in stop error rates in the phone condition was more likely due to the effects of the training fading. When breaking down the overall errors per measure per phase, it is clear that the “speed errors over” were the lowest errors across all the phases. Similar errors (about 3) existed in the initial baseline and the texting phase, which were the two phases that had the highest “speed errors over”. “Speed errors under”, “lane position errors”, and “turn errors” followed a similar pattern throughout the study for this participant, with error rates decreasing in the training phase, having little change in the phone phase and the second baseline, increasing in the texting phase, and then reducing in the final baseline to error levels similar to the second baseline.

Stop errors decreased in the training phase as with all the other measures, but unlike the other measures, increased by a multiple of 4 (300% increase) in the phone condition from the training phase. There was a small drop in the second baseline for stop errors, however, with the similar performance in stops between the phone and second baseline phase, it is difficult to determine conclusively whether the phone phase had an effect on stop errors, or if it did, how much of an effect was present. All measures worsened in the texting phase, although most dramatically with lane deviations, increasing from 2 to 16 errors (700% increase) between the second and third baselines. The errors for stops, lane position errors, and turn errors were all ranging from 7 to 10, and “speed errors under” and “speed error over” were the lowest errors in the texting phase, between 0 and 5. Errors in the final baseline were similar to the second baseline across the measures, although stop errors were lower in the final baseline compared to the second baseline by 3 errors (43% decrease).

Comparison between participants for errors per measure: It was noticed in the initial baseline that the highest errors were for “speed errors under” and stop errors. For Participant A, the “speed errors under” were higher than the stop errors, whereas for Participant B the two measures had similar levels of errors. The highest errors in the phone phase were for stop errors for both participants, as also seen in the second baseline. Further, the highest errors for the continuous texting phase was in lane deviations for both participants.

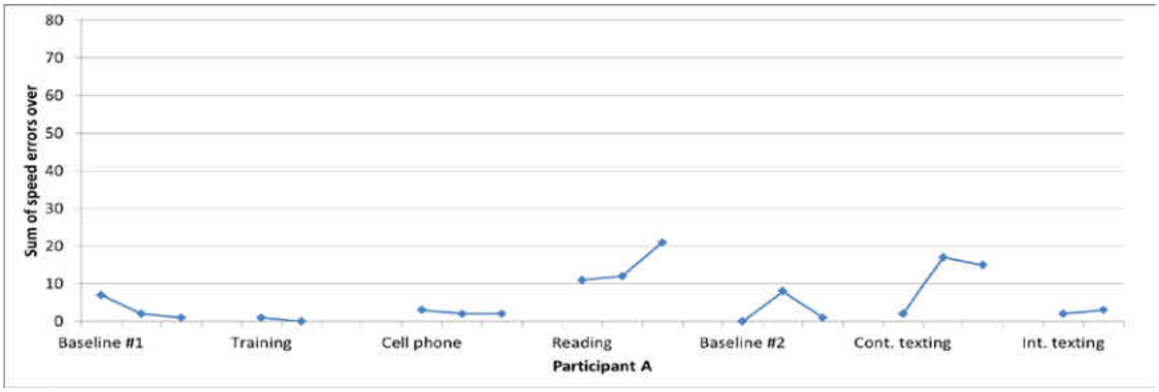


Figure 11. Sum of “speed errors over” per session per phase for Participant A

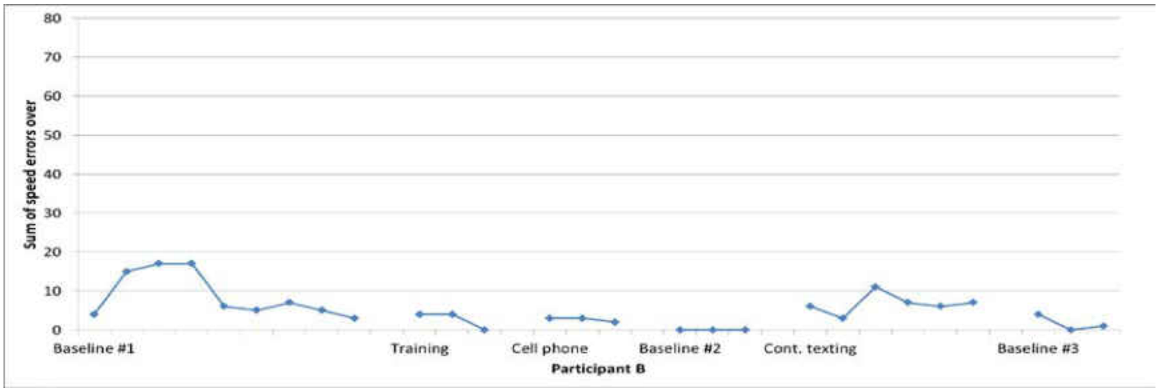


Figure 12. Sum of “speed errors over” per session per phase for Participant B

Whereas Participant A had a continual decline in “speed errors over” through the sessions of the initial baseline, Participant B first had an increase, then by the fifth session had a decrease back to the level observed in the first session for the durations of the phase. For both participants, errors were steady in the training and cell phone phases. Unlike Participant B who had a relative steady level of errors for continuous texting, Participant A increased by 20 from the first to second session. Reading for Participant A increased from the second to third session, and intermittent texting has a steady level of errors.

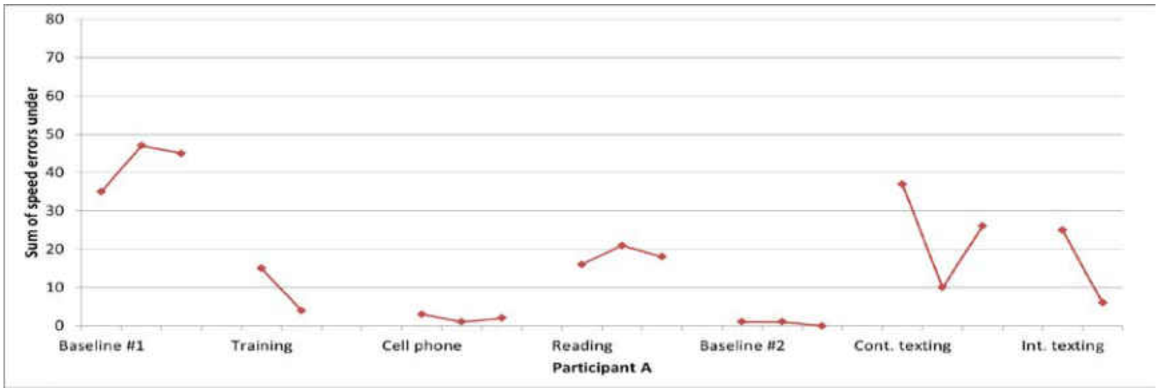


Figure 13. Sum of “speed errors under” per session per phase for Participant A

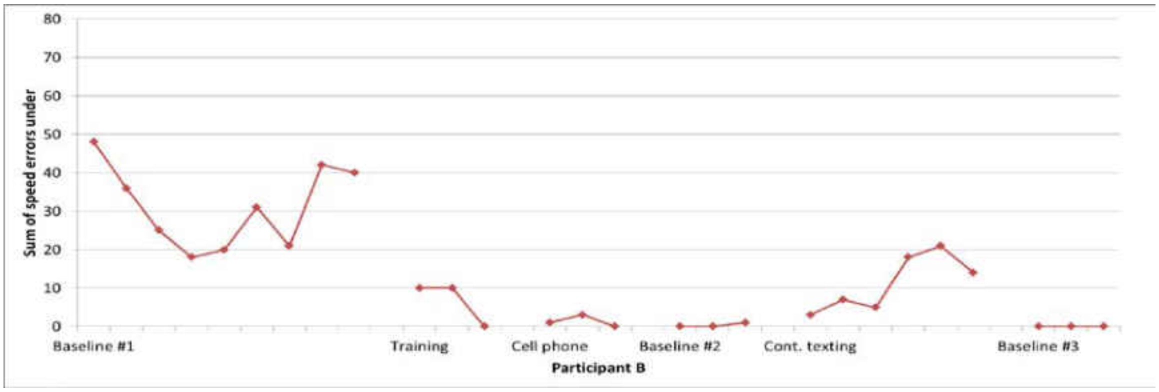


Figure 14. Sum of "speed errors under" per session per phase for Participant B

Very different patterns emerged for "speed errors under" in the initial baseline. Errors increased initially for Participant A whereas they decreased for Participant B, then increasing again in the last two sessions to levels approaching what was observed in the first session. Both participants had a decline in errors in the training phase, but steady error levels in the cell phone phase. Very different patterns existed in the continuous texting phases for both participants, overall decreasing for Participant A from the first to last session and increasing over the six sessions for Participant B. Reading error levels were steady, whereas intermittent texting had a steep decline for Participant A.

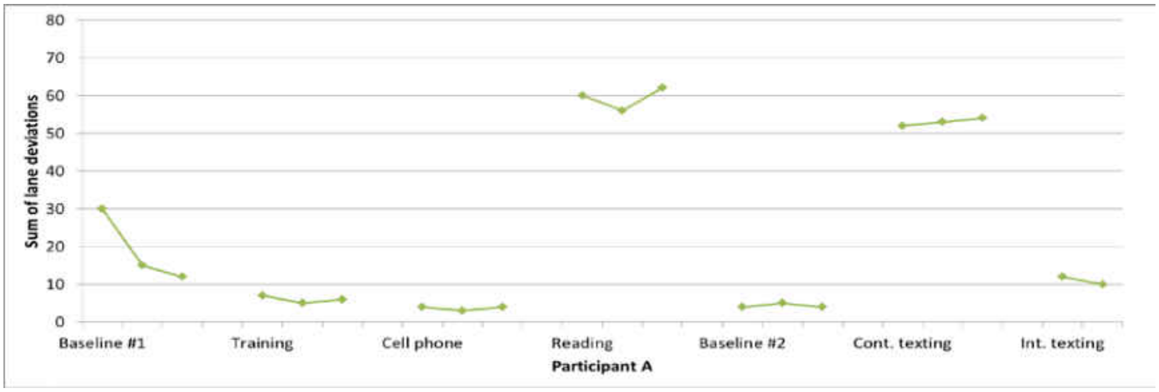


Figure 15. Sum of lane deviations per session per phase for Participant A

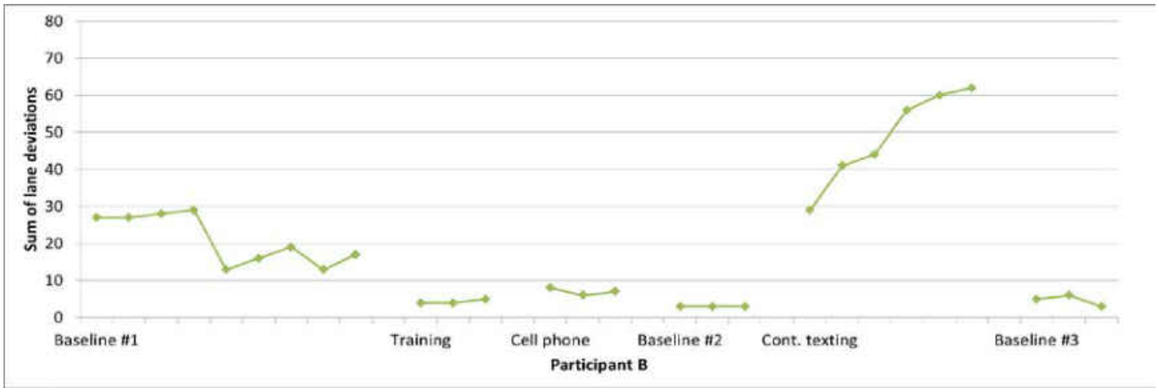


Figure 16. Sum of lane deviations per session per phase for Participant B

Although both participants reduced their number of lane deviations in the initial baseline, the improvement occurred immediately for Participant A while it took five sessions for the improvement to occur with Participant B. Training and cell phone phases had steady levels of errors for both participants. Although Participant A had a small increase in errors in the continuous texting phase, Participant B had an increase for every session, doubling in errors from the first to sixth session. Participant A had steady levels in the reading and intermittent texting phases.

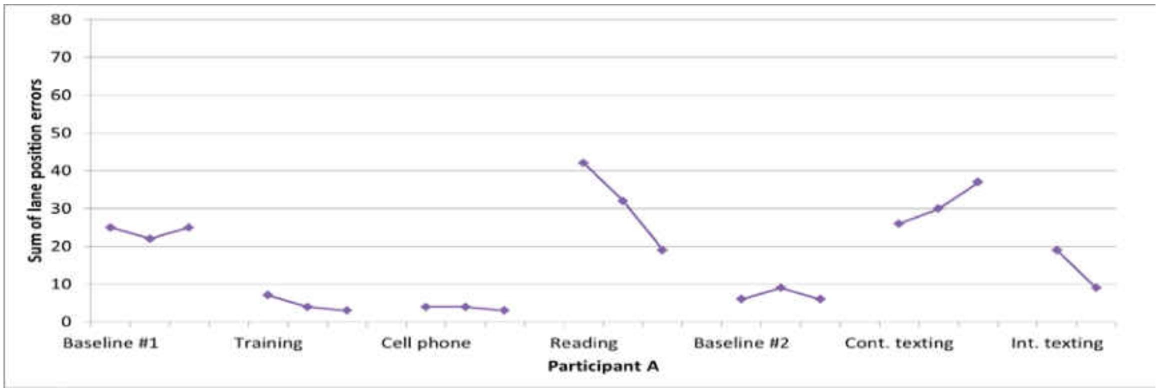


Figure 17. Sum of lane position errors per session per phase for Participant A

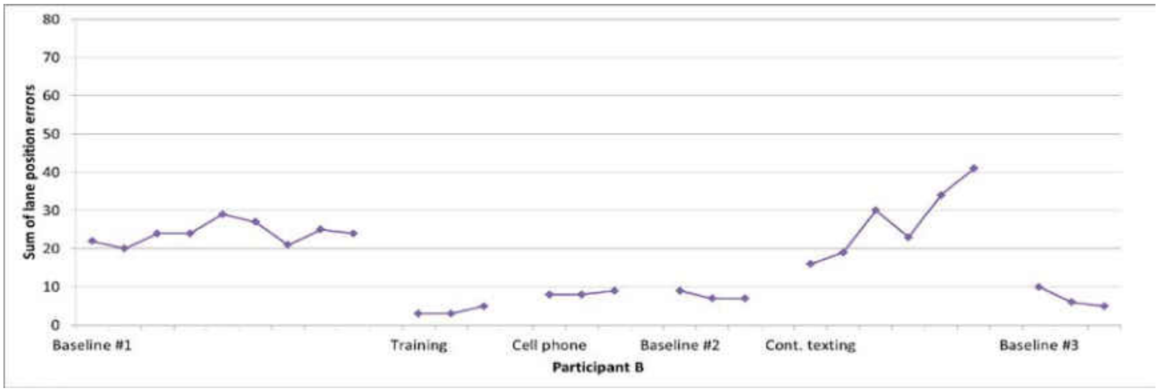


Figure 18. Sum of lane position errors per session per phase for Participant B

For both participants lane position errors were fairly stable in the initial baseline. Participant A had a decrease in errors in the training phase whereas Participant B did not. Errors in the cell phone phase were stable for both participants. Both had an increase in continuous texting, especially Participant B although there were more sessions to examine. A decrease was noticed in the reading and intermittent texting phase for Participant A. It is interesting to note in Participant A the decrease in reading but the increase in continuous texting.

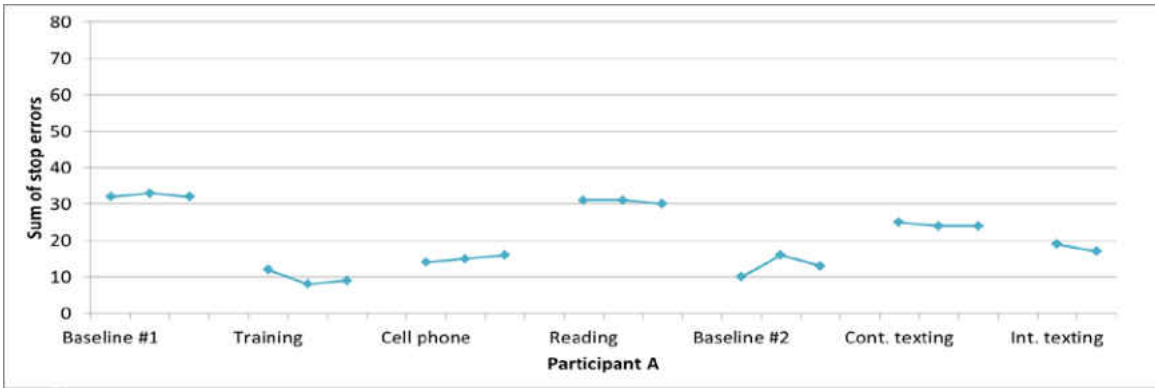


Figure 19. Sum of stop errors per session per phase for Participant A and B

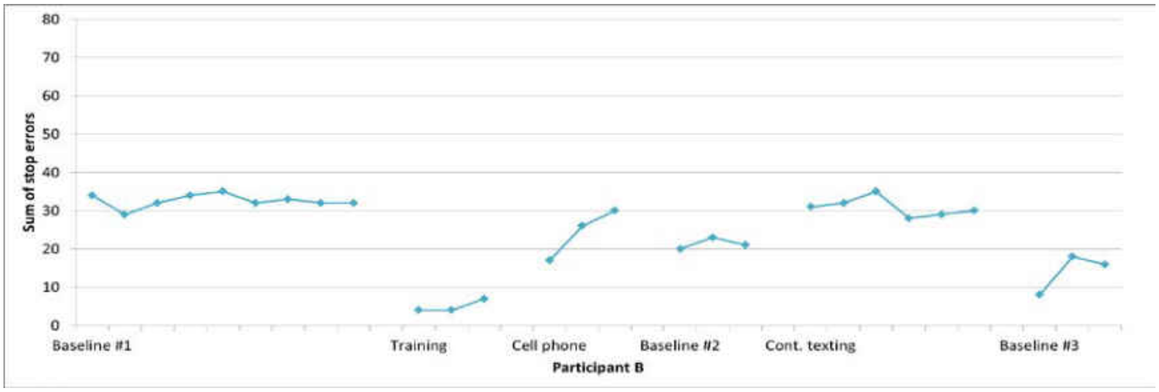


Figure 20. Sum of stop errors per session per phase for Participant A and B

Stop errors were rather consistent in the initial baseline, training, and continuous texting phase for both participants. There was a clear difference with the cell phone phase. An increase was noticed with Participant B. Reading and continuous texting was fairly stable for Participant A.

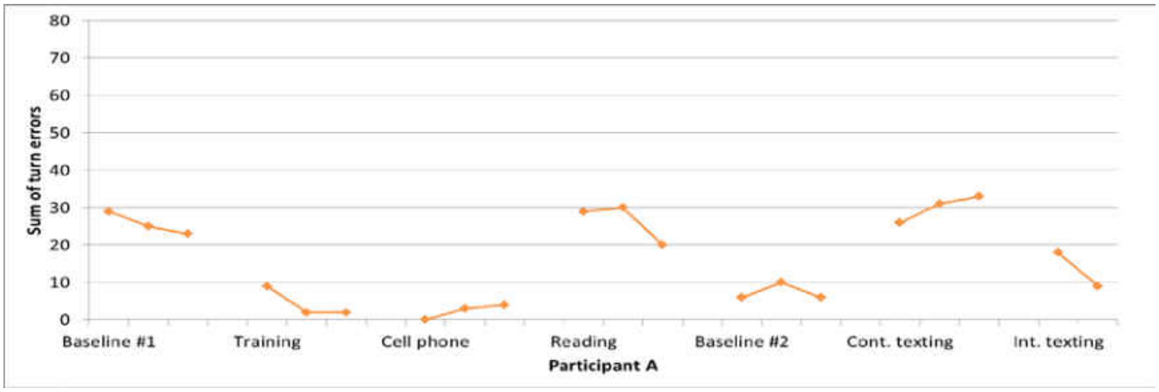


Figure 21. Sum of turn errors per session per phase for Participant A and B

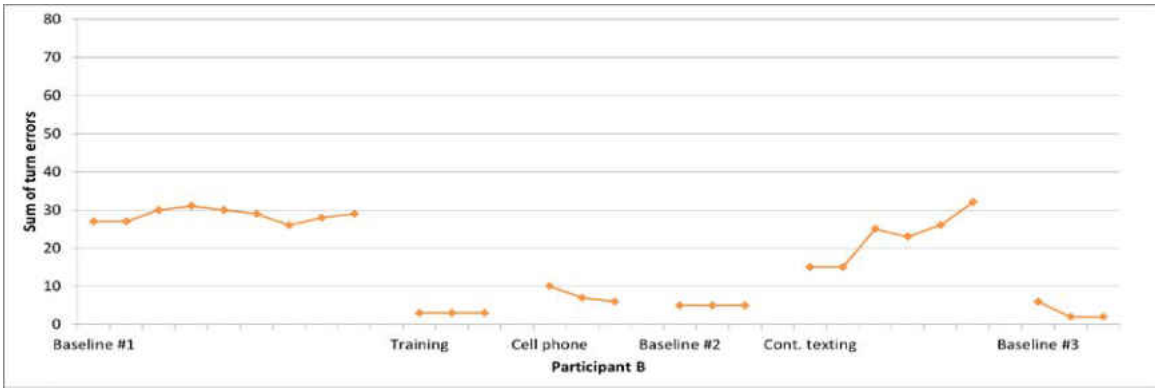


Figure 22. Sum of turn errors per session per phase for Participant A and B

Although there was a decline in turn errors in the initial baseline for Participant A, there was no such decrease with Participant B. Training showed an improvement in errors within sessions for Participant A, whereas for Participant B errors were stable. A slight increase was observed in the cell phone phase for Participant A, while the opposite occurred for Participant B. Both experienced an increase in errors in the continuous texting phase. Participant A had a decrease in errors for the reading and intermittent texting phases.

CHAPTER 4: STUDY 2

Method

Participants.

There were a total of four participants in Study 2, resulting in a total of six participants between the two studies. Including at least six participants total is based on the advice of Davison (1999), who recommended using six as opposed to three or four participants in a single-subject design study. The participants included a college-aged male (age 18) called Participant C who drives commercially, a female college student (age 18) called Participant D who does not have much driving experience, a teenage high school female (age 16) called Participant E who received her license recently, and a male college student (age 24) called Participant F. Participants for Study 2 were recruited by word-of-mouth from the local area/university. The participants for Study 2 were volunteers, but differed from those in Study 1 in that they were compensated $100 cash if they completed the entire study.

Design.

Study 2 also consisted of a small-n design. The decision on what the design and variables would be in Study 2 was based on the results from Study 1. The design was represented as A_1, B, C, D, A_2, C_2, A_3, B_2, A_4. As with Study 1, A's represented the baseline conditions. A_1 was the phase consisting of driving in the simulator without any distracter or training. B was the first distracter phase, whereas C represented the second distracter phase. D was the training phase. A_2 was the second baseline. B_2 was the second introduction of the first distracter. A_3 was the third baseline. C_2 was the second introduction of second distracter. Lastly, A_4 was the final baseline measurement.

The two distracters chosen for Study 2 were the cell phone conversation and the continuous texting. Continuous texting was used primarily because intermittent texting contains too much variability in terms of when the participant is actually distracted. There would be a substantial amount of variability when factoring the amount of time to send and receive texts as well as the time to read and respond to texts. In this sense, realism may be sacrificed for internal validity. If the participant experienced the cell phone distracter first followed by texting, then after the training, the participant would experience texting first and the cell phone distracter second. And vice versa, if the participant started with texting first followed by the cell phone conversation, then after the training, they would experience the cell phone conversation first and texting second. Participant C and F started with continuous texting as the first distracter, whereas Participant D and E started with the cell phone conversation initially.

The distracters were reintroduced after the training to compare performance while driving and distracted before and after training, which was not done in Study 1. Unlike Study 1, a baseline session was added after the training session. This was done because the performance of the participant could decline when not given feedback for their driving. To use the training phase as the new baseline may not be the most accurate. Participants should be given a chance for their performance to stabilize on its own.

Multiple baselines with the initial baseline phase were also used in Study 2. This was to increase the chances that the change in error rates in the following distracter phase is due to the actual manipulation (distracter). Participants C and F all experienced six sessions of the initial baseline, whereas Participants D and E experienced three sessions of the initial baseline.

Apparatus.

The apparatus used in this study was the same as in Study 1.

Manipulations: Training and distracter types.

The same manipulations were used as in Study 1 above.

Screening/pre-experiment questionnaires.

The same screening questionnaires used in Study 1 will be used in this study.

Questionnaires administered during experiment.

NASA-TLX. The NASA Task Load Index (TLX) (Hart, 2006) was created to assess subjective workload with the advantage of being quick to administer. Workload is essentially the "difference between the amount of resources available within a person and the amount of resources demanded by the situation" (Sanders & McCormick, 1993, p. 78). If workload is too high for the primary task, than the individual will not have enough resources to share for conducting the secondary task concurrently. If this is the case, then performance will suffer on the primary, secondary, or both tasks. Many studies that have used this measure have determined that the scale is reliable, does not demand excessively of the participant, and is sensitive to measuring workload (Hart, 2006; Jerome, Ganey, Mouloua, & Hancock, 2002).

The NASA-TLX measures workload on a multidimensional scale consisting of six subscales (Mental workload, Physical workload, Temporal workload, Subjective rating of performance, Effort, and Frustration), each of which the participant rates from 0 to 100 (Hart, 2006). Participants also rated these dimensions in a series of pairwise comparisons. Each dimension was compared against each other, and the participant decided which of the two dimensions had more impact on their workload for each paired comparison. The measure was administered by paper. Workload was measured three times per session (after each drive). See Appendix G for survey.

Driving performance measures.

In addition to the measures discussed for Study 1, Study 2 also included a measure of reaction time for correct trials only (excluding misses and false alarms). Reaction time is a critical measure of driving performance when participants are distracted, as shown in previous research (e.g. Caird et al., 2008). Because of the difficulties of assessing brake reaction time with the simulator that is being used for the study, a response button was mounted on the steering wheel instead. The button was placed on the upper left part of the middle of the steering wheel. The button is the StealthSwitch3 Programmable USB Switch Controller by H-Mod, Inc. The button programs keystrokes, hotkeys, macros, and mouse clicks. In this study, it was programmed to represent the space bar. It supports up to five switches and it contains configurator software for Windows XP, Vista, Win7, and MAC OSX. It is roughly triangular in shape and its diameter is about 7.5 cm.

The participants were instructed to press the button whenever they detected the stimulus shown on the simulator center screen. The stimulus consisted of a red rectangle shown from a projector situated behind the dashboard to be as least distracting to the driver as possible. The red light stimulus subtended on average (across participant distance from screen) of about .05 radians, or about 2.87 degrees of arc. The red rectangle was programed to flash at random times across the drive, and the stimulus lasted approximately 2 seconds. When this stimulus appeared, the participant needed to press the button as quickly as possible. This action represented braking in response to the red brake lights of a car ahead of the driver illuminating.

A small laptop computer was connected to the projector and the reaction time button, therefore the timing of the stimulus presentation and reaction of the participants was recorded by a system entirely independent of the driving simulator. Reaction time was assessed based on the amount of time from when the red light stimulus was first illuminated until the participant pressed the button. The program recorded the time in milliseconds.

Route on driving simulator.

The route used in Study 2 was identical to that used in Study 1.

Procedure.

Before driving the simulator. Same as Study 1.

Simulator sessions. In addition to the information presented in the procedure for Study 1, the NASA-TLX was administered after each drive.

Long-term study plan. Same as Study 1.

Results and Discussion for Chapter 2

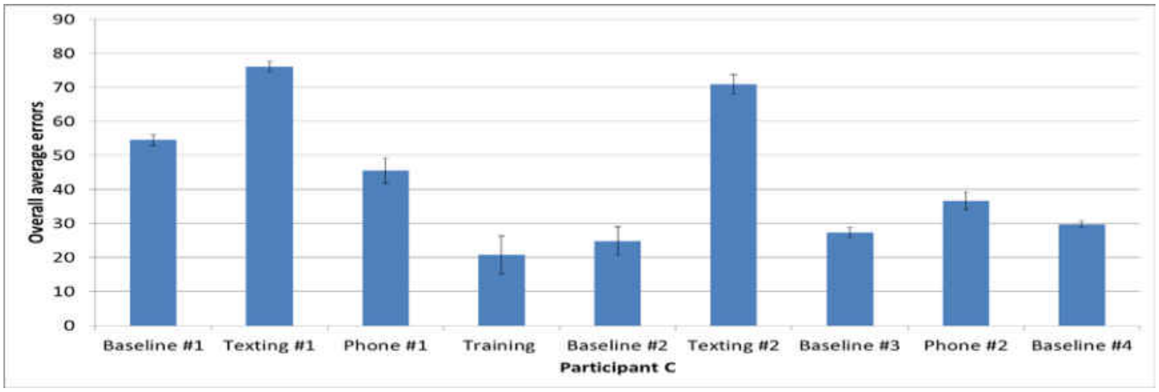


Figure 23. Overall average errors across each phase for Participant C

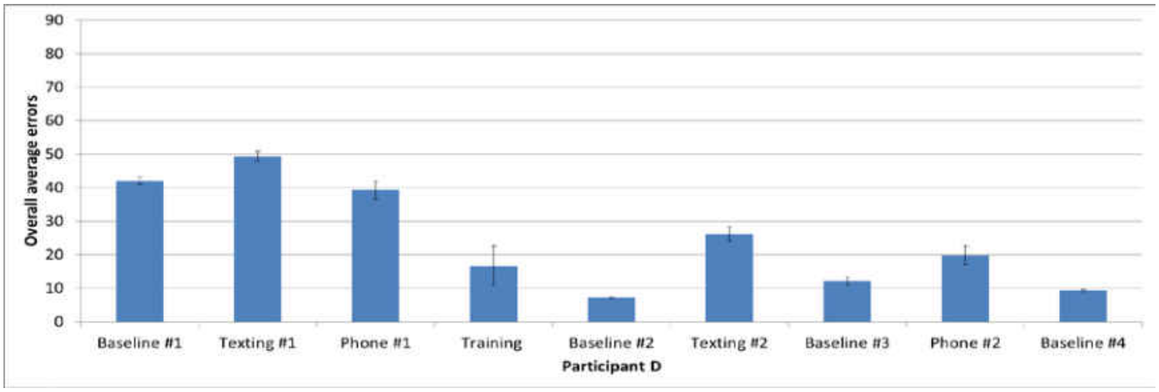


Figure 24. Overall average errors across each phase for Participant D

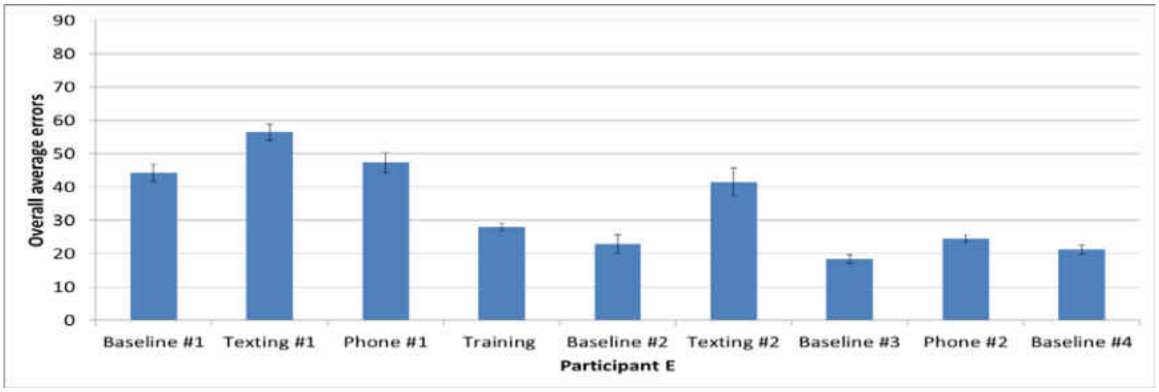


Figure 25. Overall average errors across each phase for Participant E

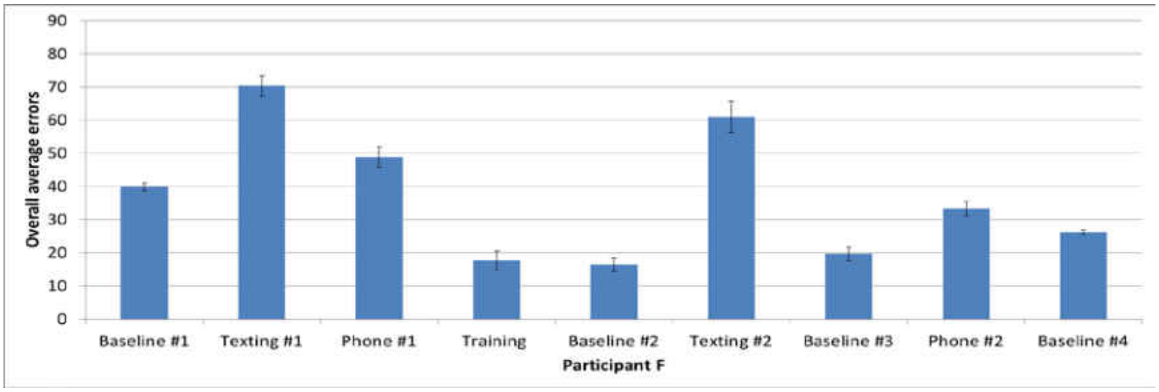


Figure 26. Overall average errors across each phase for Participant F

*Note: Participant C: Baseline 1 was 6 sessions, baseline 2 was 4 sessions; Participant D: all phases were 3 sessions; Participant E: all phases were 3 sessions; Participant F: Baseline 1 was 6 sessions and Baseline 2 was 4 sessions. Differences in phase length for baseline 1 were due to preplanned staggering of baselines to determine whether changes in performance were due to the manipulation or to the number of sessions. Differences in phase length for other phases were due to wanting to further examine performance in that phase.

Participant C overall errors. The errors centered around 55 in the initial baseline, but then increased to about 75 (45% increase) in the texting phase. Interestingly, overall errors dropped in the phone phase to a lower level than in the initial baseline to a rate of about 45. It is possible that the participant is compensating for the phone distracter and is driving more cautiously than in the initial baseline. In the training session errors dropped to 20 (64% decrease) and then increased by about 5 (25%) errors in the second baseline phase, showing some degradation of skills from the training phase. Errors increased in the second phone phase, and were higher than the second and third baselines, seemingly showing an effect of phone on performance.

The error rates were lower in the second phone phase than in the first phone phase. The difference between the second phone phase and the second and third baselines and the first phone phase and the initial baseline is of interest. Whereas the initial baseline had more overall errors than the first phone phase by about 10 (25% increase) errors, the second phone phase had more errors by about 10 (about a 40% increase) than the second and third baseline. Errors in the second texting phase climbed to past the initial baseline error level and to almost the error level of the initial texting phase. This astonishing finding shows that the training had virtually no effect on texting, showing the enormous impact of texting on driving performance.

Participant D overall errors. Overall errors dropped slightly from the initial baseline to the initial phone phase, although the drop was only a few errors. Errors increased by 10 (25% increase) from the initial phone to the initial texting phase. The highest errors across the phases were in the first texting phase. A substantial decrease was noticed in the training phase. However, errors reached a lower point in the second baseline immediately following the training session. This also occurred with Participant E. Overall errors dropped by almost 10 errors (55% decrease) from the training to the second baseline. Errors increased once again in the second texting session, although the errors were much lower than in the initial texting phase. Both the third and fourth baseline had similar error levels to the second baseline. Errors increased in the second phone phase by about 10 (100% increase).

As seen with some of the other participants, there was a decrease from the initial baseline to the initial phone phase, but then an increase in the second phone phase compared to the post-training baselines before and after the second phone phase. In other words, it seems that for some of the participants, the effects of the phone condition only appear after training. Nevertheless, the errors in the second phone phase were much less than the initial phone phase. The second texting phase had more errors than the second phone phase. There was a larger difference between the second texting phase and the second and third baselines than between the initial baseline and texting phases.

Participant E overall errors. The overall error rates from the initial baseline to the initial phone condition increased but only slightly. There was an increase in errors from the first phone phase to the first texting phase, with the highest errors of all the phases for this participant. Errors decreased by about 27 errors (50% decrease) in the training phase from the initial texting phase. Interestingly errors decreased in the second baseline immediately following the training session. This is unusual, as with other participants the error rates either remained the same or increased in the baseline following training.

Errors jumped from about 20 to 40 (100% increase) in the second texting phase from the second baseline. The difference between the errors in the second texting session and the second and third baselines was greater than the difference between the initial texting phase and the initial baseline. In other words, the effects of texting seemed more dramatic after training, even if the overall number of errors was far less than the initial texting phase. The third and fourth baselines had similar error rates to the second baseline. The second phone phase had about 5 more errors (23% greater) than in the third and fourth baselines. The difference between the second phone phase and the third and fourth baselines was the same as the difference between the first phone phase and the first baseline. The errors in the distracter phases before training were much higher than in the distracter phases after training.

Participant F overall errors. The overall errors increased from 40 in the initial baseline to 70 in the initial texting phase (75% increase). Although errors were higher in the first phone phase than the initial baseline, errors were only higher by 10 (25% increase). Errors dropped to under 20 in the first training session (45% decrease from baseline), and that error level remained consistent in the second baseline. Errors increased again in the second phone phase, jumping from under 20 in the previous baseline to the low 30s (50% increase). The third baseline had a level similar to the second baseline. Errors once again jumped in the second texting phase, increasing by 40 errors from the third baseline (200% increase).

Errors dropped in the last baseline, although they did not reach the level of the third baseline, ending at about 7 errors (35% increase) more than the third baseline. This could have been due to some deterioration of driving skills over time. The error rates in the distracters pre-training were higher than in the post-training, particularly for the phone distracter. The difference between the initial baseline and the initial texting phase was not as great as the difference between the second and third baselines and the second texting phase. Also, the difference between the initial baseline and the initial phone phase was not as large as the difference between the second and third baselines and the second phone phase.

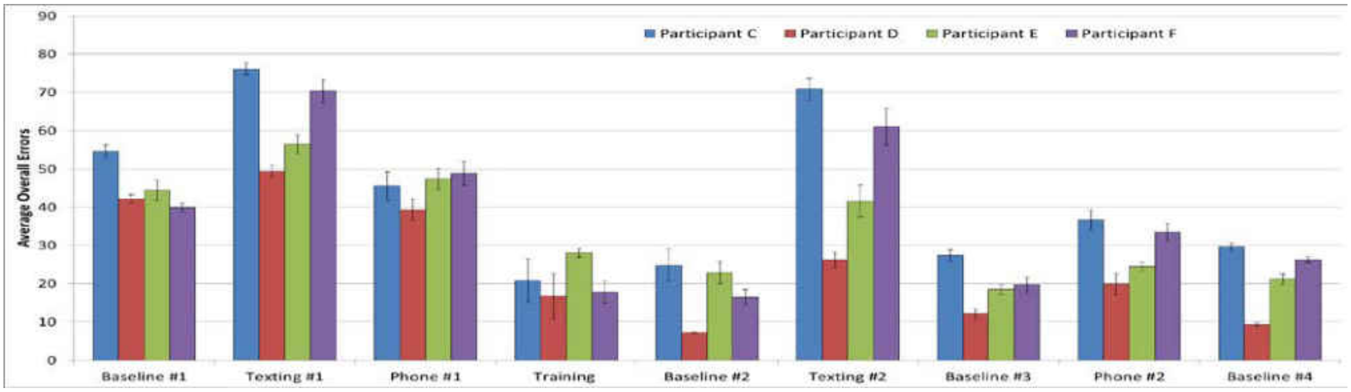


Figure 27. Average errors across each phase for each participant

Comparison across participants for overall errors. Order effects did not seem to be a factor based on comparing patterns between participants who experienced the phone then texting distracter to those who had the opposite order. Therefore the graph above was created that has the same order of conditions for each participant to compare to overall errors per phase. A common graph was also possible given that each of the four participants experienced the same phases. Comparing the initial baseline to the training phase for overall errors, training for all participants was much lower than for the initial baseline. This suggests that the training is working to reduce errors. However, just based on that information, it is not clear whether the effects of training would continue in subsequent baselines. If error levels increase back to initial baseline levels in subsequent baselines, this indicates that the training may not have resulted in learning, or that forgetting took place. Either way, the usefulness of the training would be very limited.

The results indicated that across the four participants the error levels remained relatively stable for the measures in subsequent baselines after training, suggesting that learning did take place. Comparing the initial baselines to the initial phone phase, errors were quite similar, indicating little to no effect of phone on driving performance. On the other hand, the initial texting phase had higher errors than the initial baseline and phone phase, showing that the effects of texting were noticeable over baseline and more distracting than phone. After training took place, the error differential between texting and phone was generally greater across the participants, with once again texting having greater errors than phone, and after training both distracters having more errors than baselines. The error differential was also higher between the post-training baselines 2-4 and the texting post-training than between the initial baseline and texting phases. This was also true for phone, with a larger difference between baseline and phone post-training than pre-training. In fact, errors were greater for all participants in the second phone phase compared to the post-training baselines, whereas the initial phone phase had a similar level of errors to the initial baseline. What this seems to indicate is that the effects of both distracters are more evident post-training, once the errors in baseline were improved through training. Results could have been a drop in errors post-training, but the differential between the baselines and distracters could have been similar.

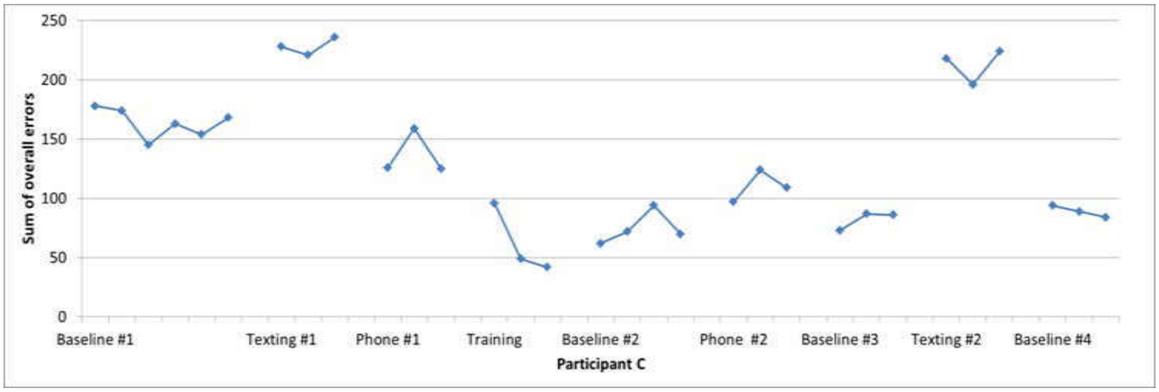


Figure 28. Sum of overall errors per session per phase for Participant C

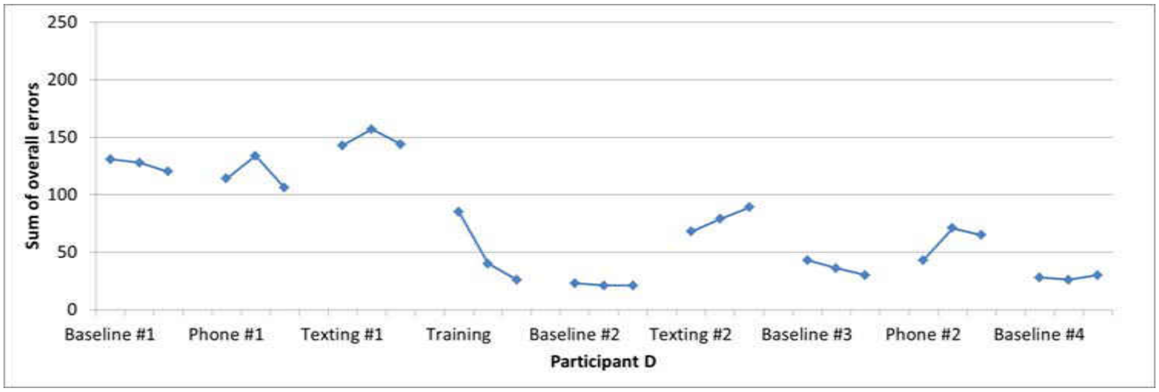


Figure 29. Sum of overall errors per session per phase for Participant D

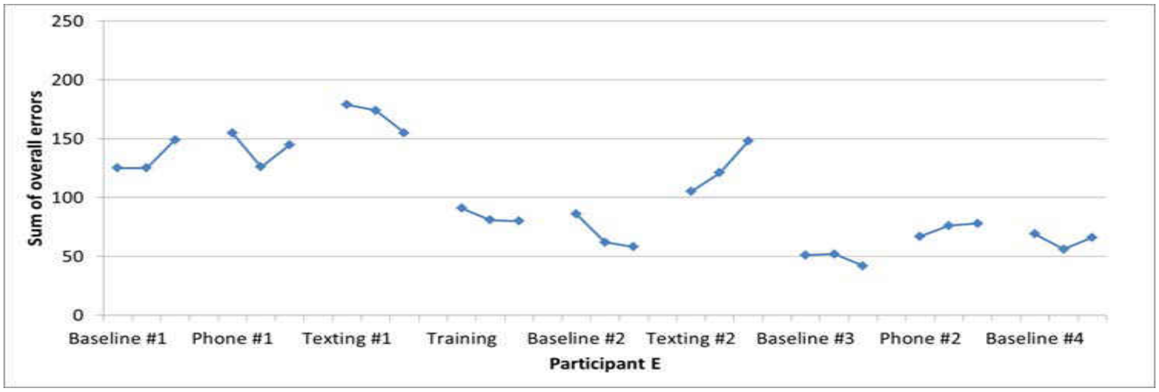


Figure 30. Sum of overall errors per session per phase for Participant E

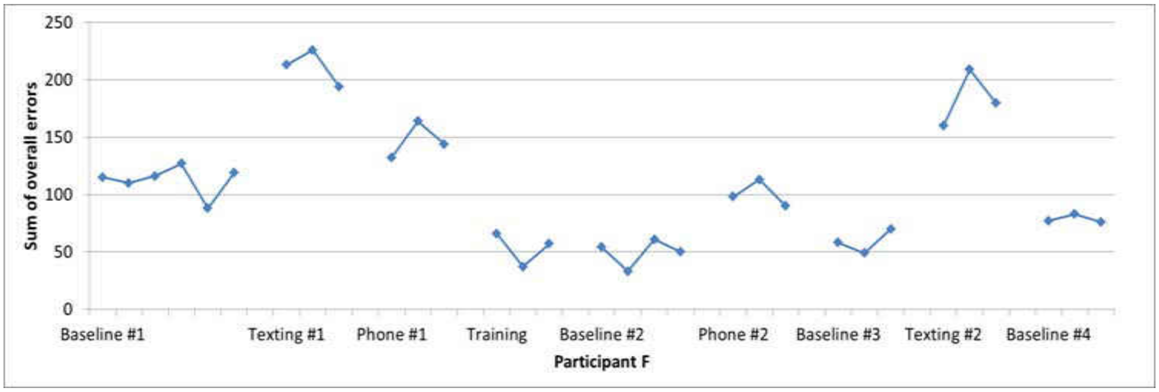


Figure 31. Sum of overall errors per session per phase for Participant F

There were mixed results for the initial baseline. It was expected that errors would reduce for each participant, although not reduce to the lowest point possible with practice alone/without training. For some of the participants errors did decrease, but one had an increase and the other had stable errors from the first to last session in the initial baseline. All had an expected decrease in errors across the training phases. Interestingly, what was unexpected was that errors increased in the second texting phase for all participants. The question of whether performance can improve with the dual-task condition post-training showed that the answer is not only negative, but that error levels actually increase over time. Also, for most of the participants, error levels increased in the second phone phase across the sessions. It seemed that there was more consistency in the patterns across sessions for the distracters post-training.

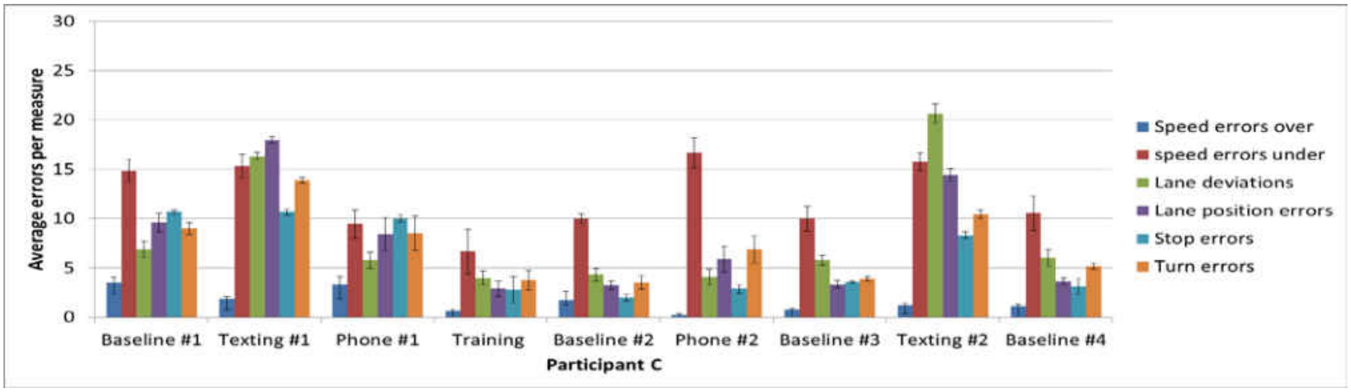


Figure 32. Average errors for all measures across each phase for Participant C

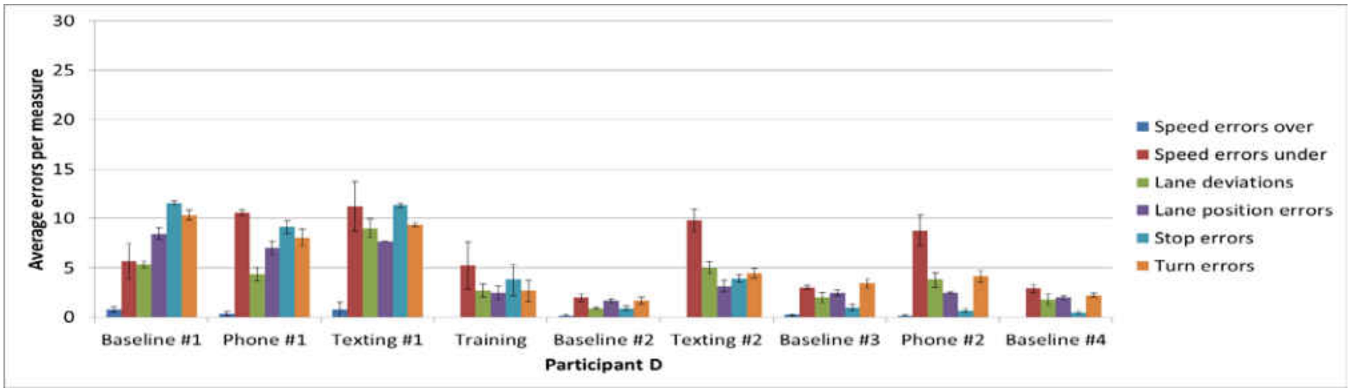


Figure 33. Average errors for all measures across each phase for Participant D

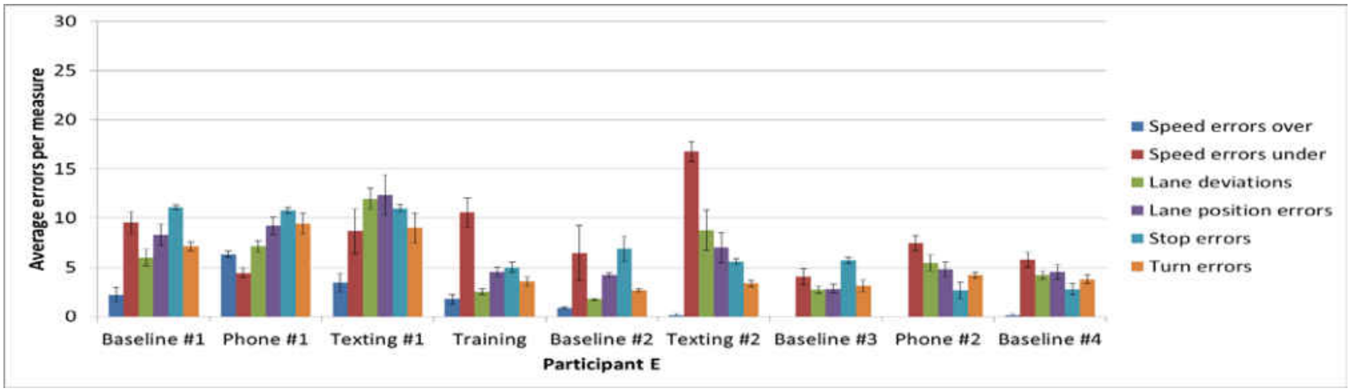


Figure 34. Average errors for all measures across each phase for Participant E

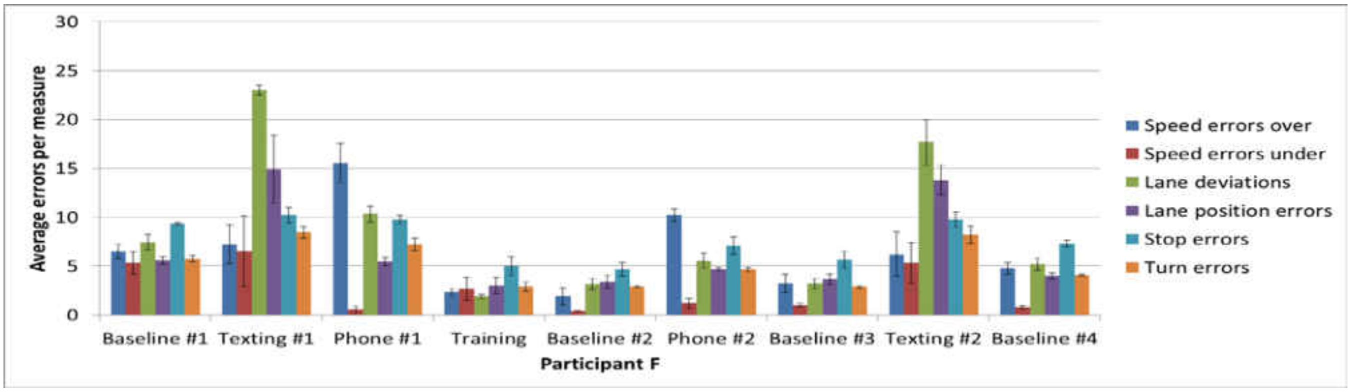


Figure 35. Average errors for all measures across each phase for Participant F

Participant C errors per measure. "Speed errors over" did not vary much across the phases, although were higher before training than after. "Speed errors under" were stable from the initial baseline to the initial texting, showing no apparent effect from texting on "speed errors under". In the phone phase, "speed errors under" decreased by about 5 (33% decrease) from the initial baseline, and then decreased by about 3 (33% decrease) in the training phase from the initial phone phase. The errors returned to the level seen in the phone phase in the second baseline, showing possibly some decline in the skills learned in training, and then increased to its highest level in the second phone phase. It is interesting that the "speed errors under" increased to its highest level in the second phone phase after training, an increase of 7 (77% increase) errors from the initial phone phase. The second, third, and final baselines had similar "speed errors under" at 10 errors, and those errors increased again in the second texting phase to the same level roughly as the initial texting phase.

Lane deviations increased substantially from the initial baseline to the initial texting phase, then declined to a level lower than the initial baseline in the initial phone phase. Lane deviations continued to decline in the training phase, remained relatively constant in the second baseline, phone, and third baseline phase. Lane deviations increased dramatically in the texting phase to its highest level, then declined substantially once again in the final baseline. Lane position errors and turn errors followed a similar pattern to lane deviations, although there were vast differences in the error rates across those measures in the second texting phase. Interestingly performance was much more variable in the second texting phase as compared to the first. Stop errors remained consistent in the first three phases, declined as expected in the training phase, and then remained stable for the rest of the study with the exception of the increase in the second texting phase.

Participant D errors per measure. "Speed errors over" were almost non-existent across the session. Having low "speed errors over" is consistent with many of the other participants. The measure with the highest errors in the initial baseline was stop errors. Most of the errors showed a similar pattern across the phases, decreasing in the initial phone phase, increasing in the first texting phase, dropping substantially in the training phase, increasing in the second texting phase, and then remaining relatively steady in the third and fourth baselines as well as in the second phone phase. Other than "speed errors over", the other exception was with "speed errors under". Unlike the other measures, "speed errors under" increased in the first phone session by almost 5 (100% increase) errors. This could suggest that the participant is compensating for the phone distracter, in other words, driving slower to improve performance. "Speed errors under" increase slightly in the first texting phase, and then follow a similar pattern to most of the other measures the rest of the phases. It should be noted however that "speed errors under" increased the most in the second texting phase, 5 (166% increase) errors above the measure with the next highest errors which was lane deviations. “Speed errors under” also increased in the second phone phase, consistent with the first phone phase. Although errors for all measures were lower in the second phone phase compared to the first, “speed errors under” was approaching the level observed in the first phone phase.

Participant E errors per measure. “Speed errors over” actually peaked in the initial phone phase, then decreased in the first texting phase, and continued to decline through the rest of the phases until it reached zero errors by the second texting session. On the other hand, “speed errors under” were much higher across the phases, as seen with the other participants. Errors decreased in the first phone phase compared to the first baseline, but then increased in the initial texting phase to slightly lower than the initial baseline. The errors rose in the training session to surpass the level in the initial baseline, than decreased in the second baseline.

The highest level of the “speed errors under” was in the second texting phase. It is important to note that the errors were almost 10 (212% increase) errors greater than in the initial texting phase. This surprising finding could be because the participant after training was completed started to learn to drive slower and more cautiously when distracted by texting. On the other hand, in the initial texting phase, the participant was not trained to drive as cautiously as she should, and may have been overconfident in her ability to drive while texting. Errors decreased again in the third baseline as expected, and had a similar level in the fourth baseline. “Speed errors under” increased however in the second phone phase, to a higher level than in the initial phone phase. Therefore with this measure, the difference between the initial baseline and the distracters, compared to the difference between the rest of the baselines after training and the distracters after training was very salient. The effects on this measure after training were more pronounced than before training.

Lane deviations increase from the initial baseline to the first phone phase, then increased again in the initial texting phase. Errors dropped in the training session, remained low in the second baseline, rose again in the second texting phase, lowered in the third and fourth baselines although not as much as the second baseline. And in the second phone phase, errors were slightly higher than the third and fourth baselines. The difference between the texting and baseline pre training and texting and baselines post training were similar. The difference between the phone and baseline pre-training and the phone and baselines post training were also similar.

Lane position errors followed a similar pattern to the lane deviations. Stop errors were constant from the initial baseline to the initial phone and texting phase. Stop errors decreased in the training session, but increased somewhat in the second baseline. The errors declined in the second texting phase and the third baseline, then decreased more in the second phone phase and the final baseline to the lowest levels in the experiment. Turn errors increased in the distracters pre training after the initial baseline, with similar levels in the initial phone and texting phases. Errors dropped in the training session and remained at a stable level through the rest of the phases. It slightly increased in the second phone and fourth baseline phases.

Participant F errors per measure. Unlike other participants, “speed over errors” were not low compared to the other measures, and were highest in the first phone phase. The lowest errors overall were with the “speed errors under”, which were the highest in the initial baseline phase. Errors for all measures increased in the initial and second texting phase. The highest errors in both texting phases were with lane deviations, followed by land position errors.

Nevertheless, lane deviations were about 6 (35% increase) errors greater in the initial texting phase than in the second texting phase. Lane position errors on the other hand were similar in both texting phases. Comparing the first and second phone phase, the pattern of errors across the measures were similar, although were higher with the exception of "speed errors under".

Comparing the four participants on errors per measure. There was a similar pattern in the initial baseline for the participants for turn errors, stop errors, lane position errors, and lane deviations. Most of the participants had "speed errors under" as the highest errors in the second phone phase. The measures that had the highest error levels in the second texting phase across the participants were with lane deviations and "speed errors under".

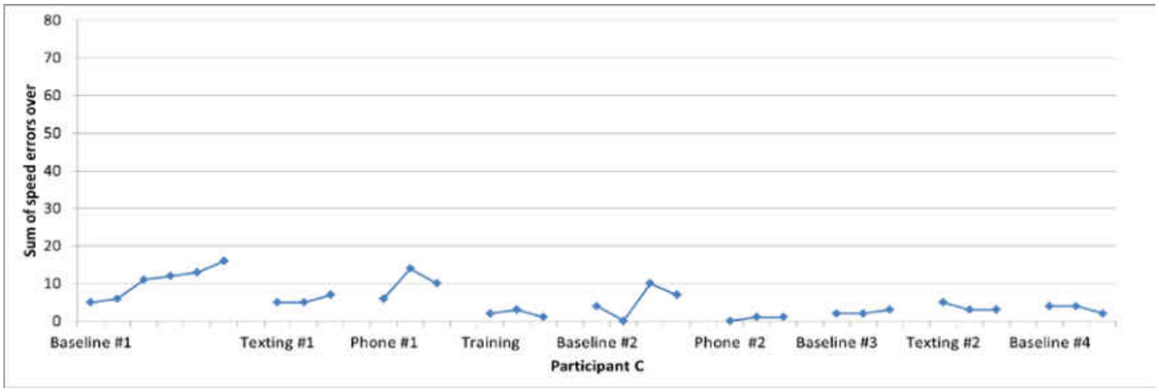


Figure 36. Sum of "speed errors over" per session per phase for Participant C

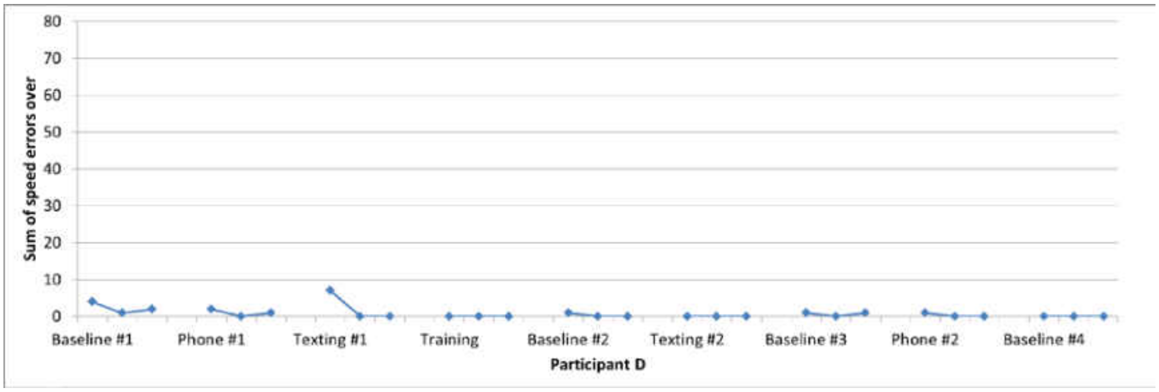


Figure 37. Sum of “speed errors over” per session per phase for Participant D

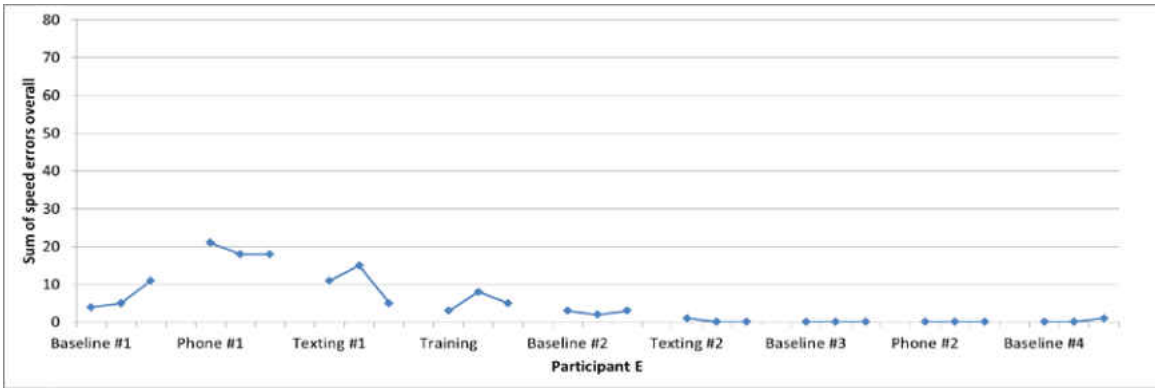


Figure 38. Sum of “speed errors over” per session per phase for Participant E

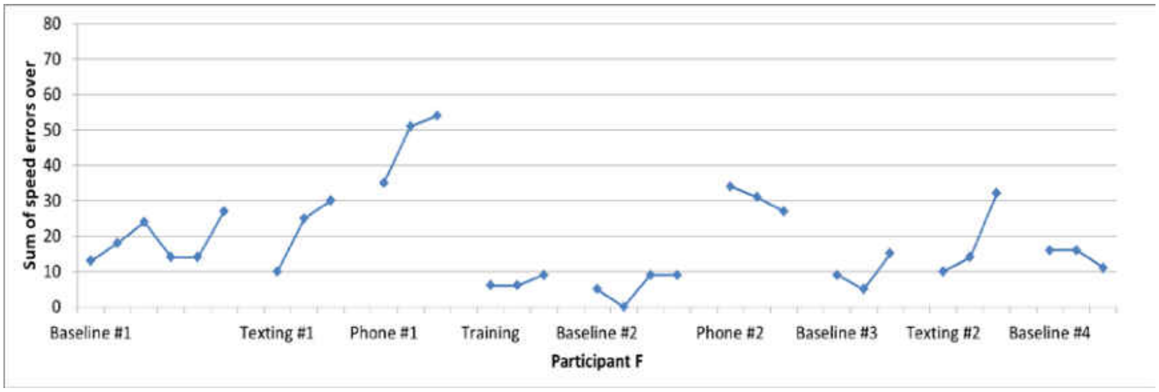


Figure 39. Sum of “speed errors over” per session per phase for Participant F

Most of the participants actually had an increase in "speed errors over" in the initial baseline as opposed to showing improvement across sessions. There were no distracter phases where there was a consistent drop in errors across participants.

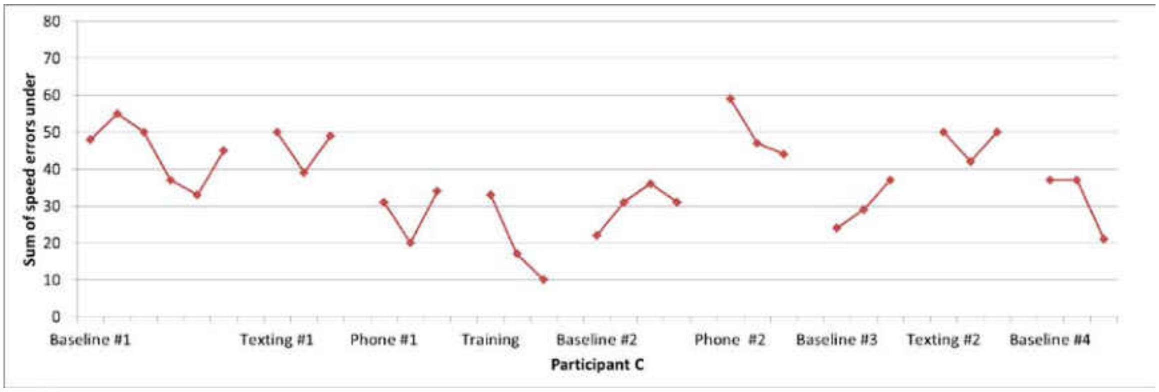


Figure 40. Sum of "speed errors under" per session per phase for Participant C

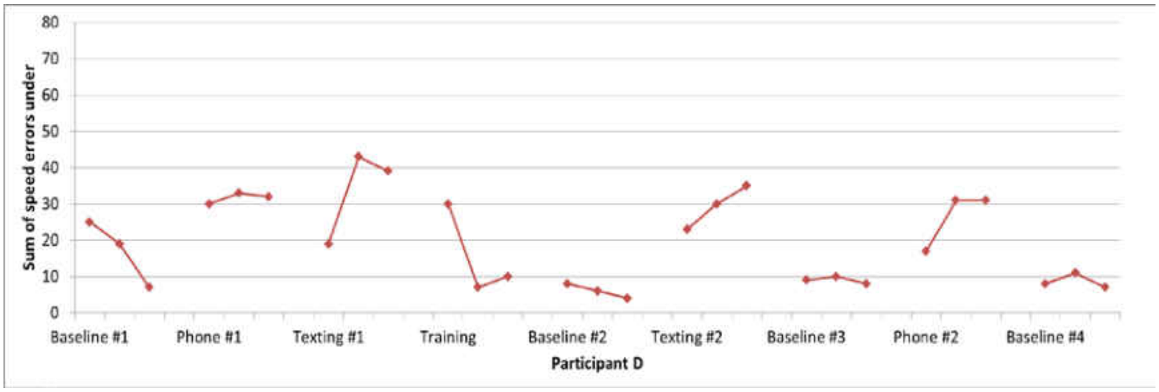


Figure 41. Sum of "speed errors under" per session per phase for Participant D

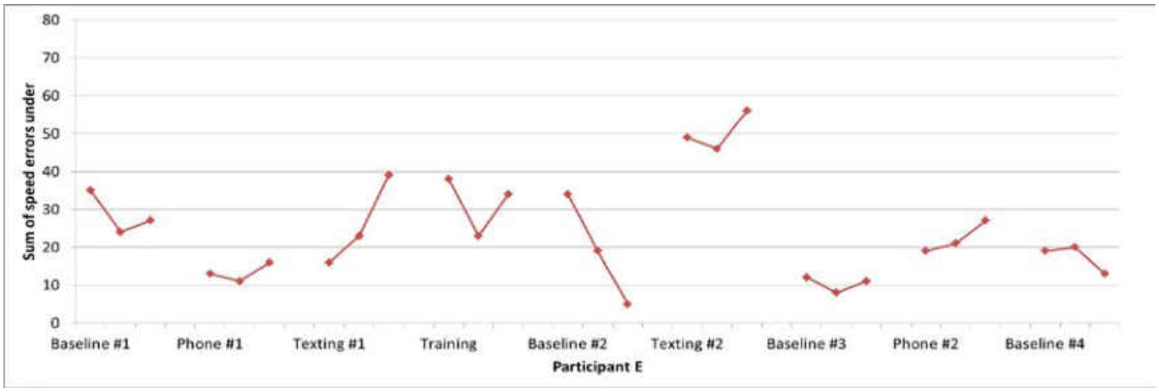


Figure 42. Sum of "speed errors under" per session per phase for Participant E

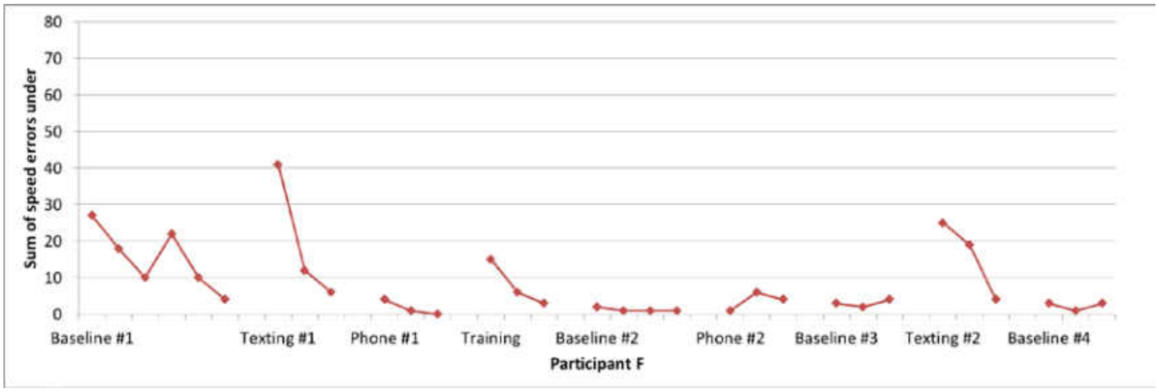


Figure 43. Sum of "speed errors under" per session per phase for Participant F

There was a noticeable drop in "speed errors under" for most of the participants for "speed errors under" in the initial baseline, showing that without training, most participants through practice on their own improved on this measure. Also, there was a decline for all participants across sessions in the training phase. No consistent declines were noticed within distracter phases.

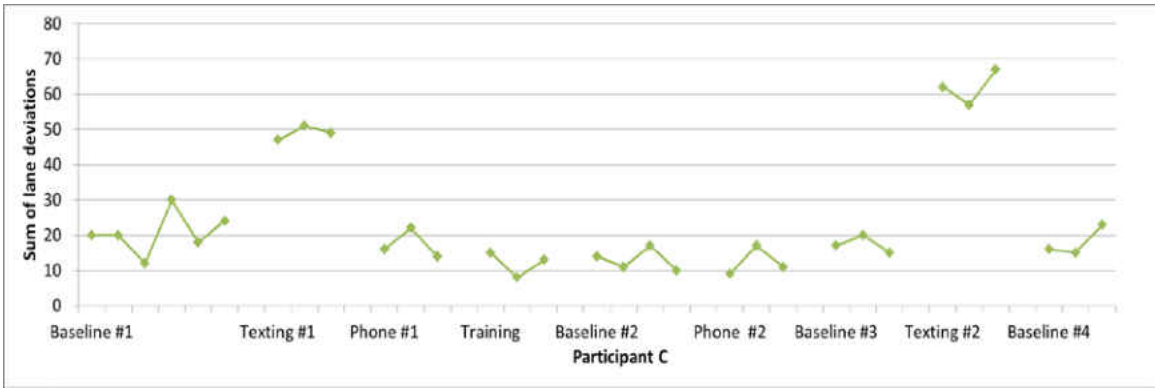


Figure 44. Sum of lane deviations per session per phase for Participant C

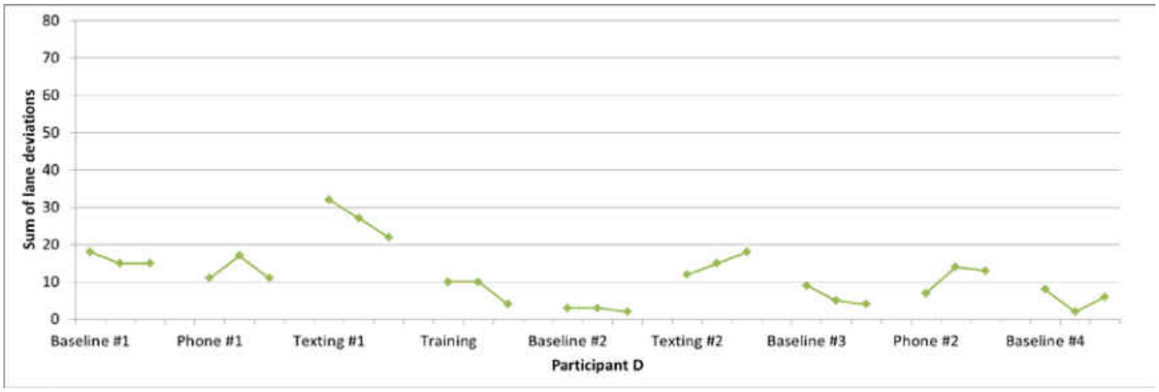


Figure 45. Sum of lane deviations per session per phase for Participant D

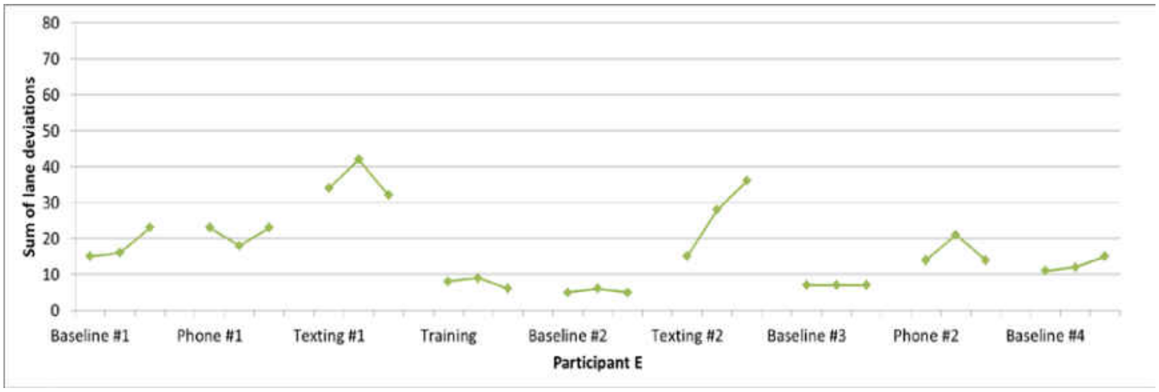


Figure 46. Sum of lane deviations per session per phase for Participant E

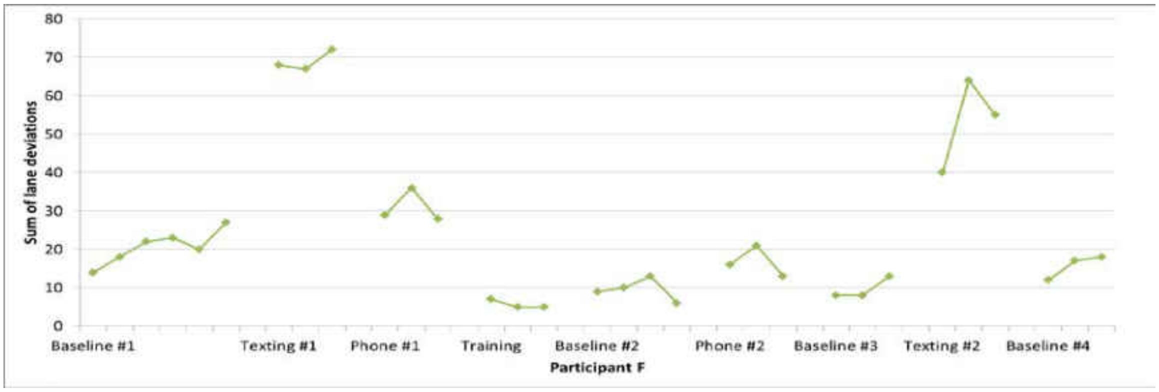


Figure 47. Sum of lane deviations per session per phase for Participant F

No consistent declines in lane deviations were noticeable across participants in the initial baseline or distracter phases; however there was a consistent increase in errors in lane deviations in the second texting phase across all participants.

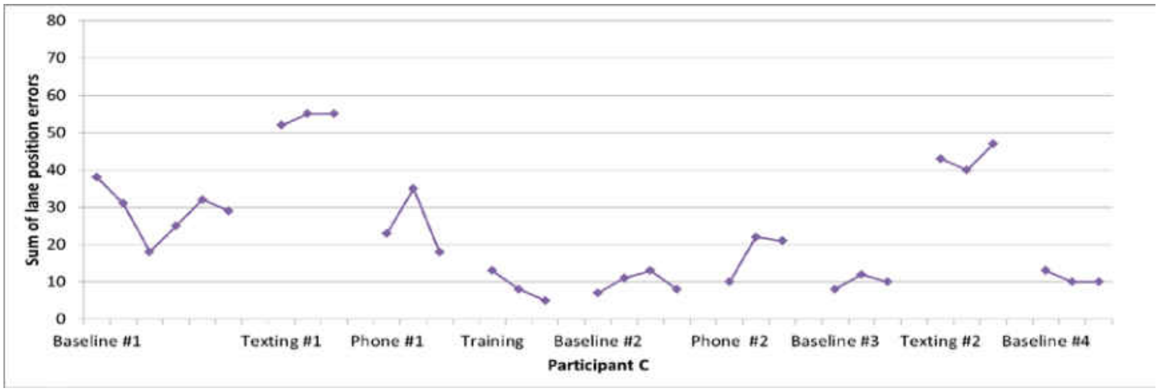


Figure 48. Sum of lane position errors per session per phase for Participant C

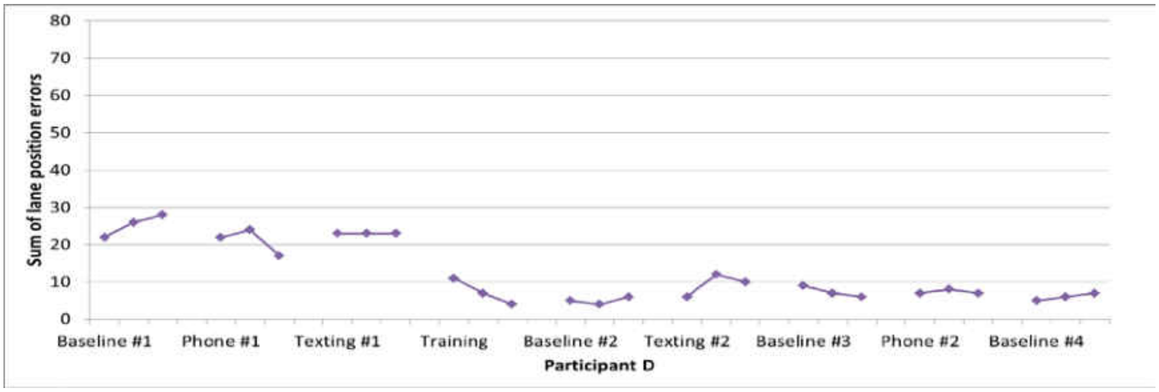


Figure 49. Sum of lane position errors per session per phase for Participant D

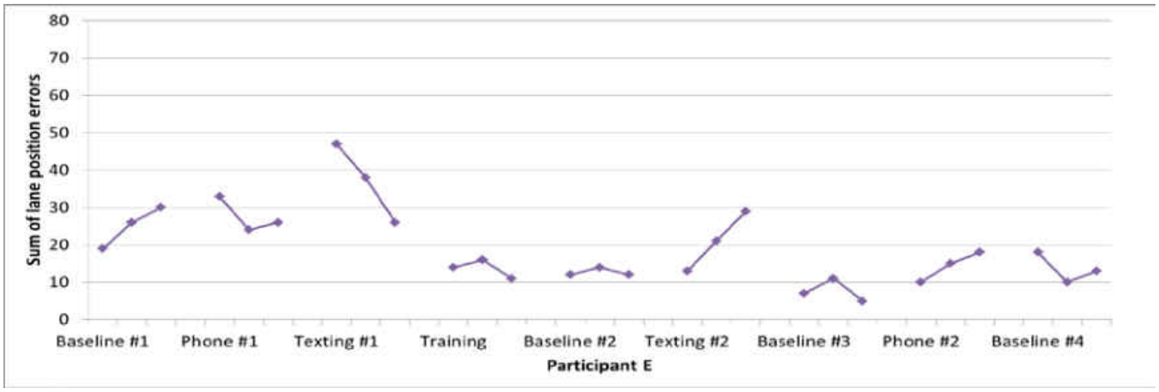


Figure 50. Sum of lane position errors per session per phase for Participant E

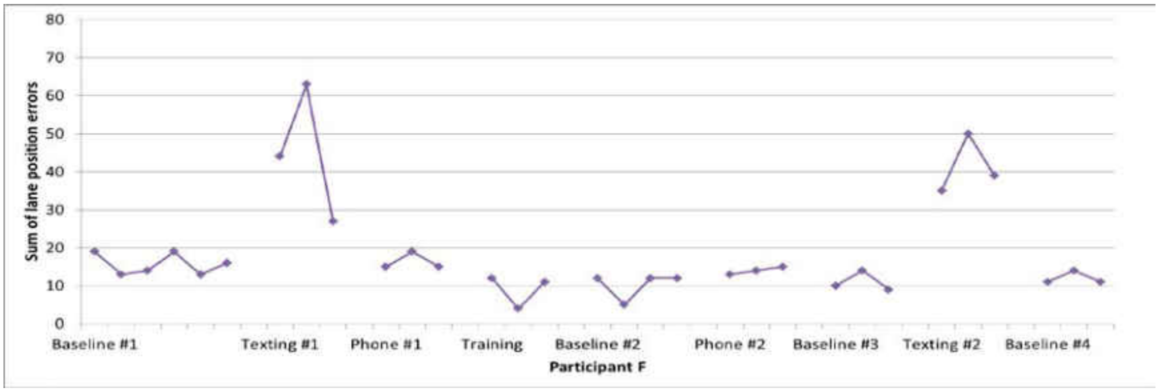


Figure 51. Sum of lane position errors per session per phase for Participant F

With the exception of training, there were no consistent declines in lane position errors across sessions for the initial baseline or distracter phases. For most of the participants there was a decline in errors in the training session. Like with lane deviations, lane position errors actually increased consistently across participants in the second texting phase.

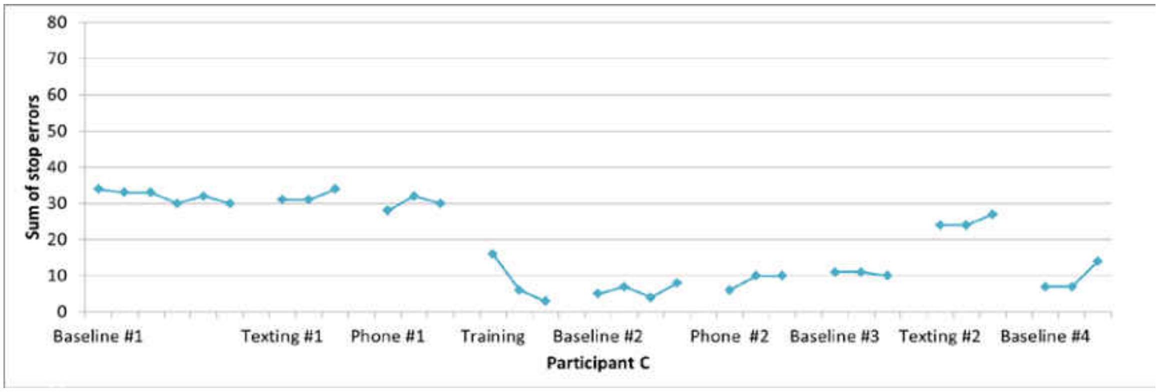


Figure 52. Sum of stop errors per session per phase for Participant C

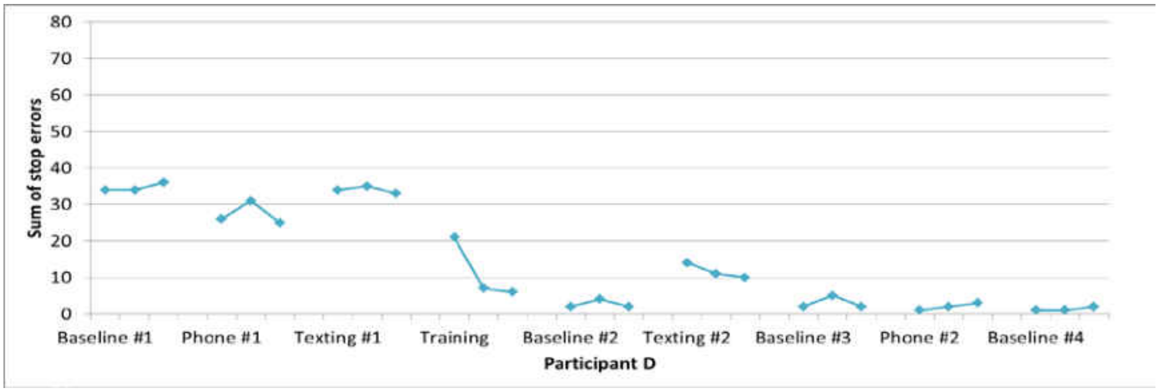


Figure 53. Sum of stop errors per session per phase for Participant D

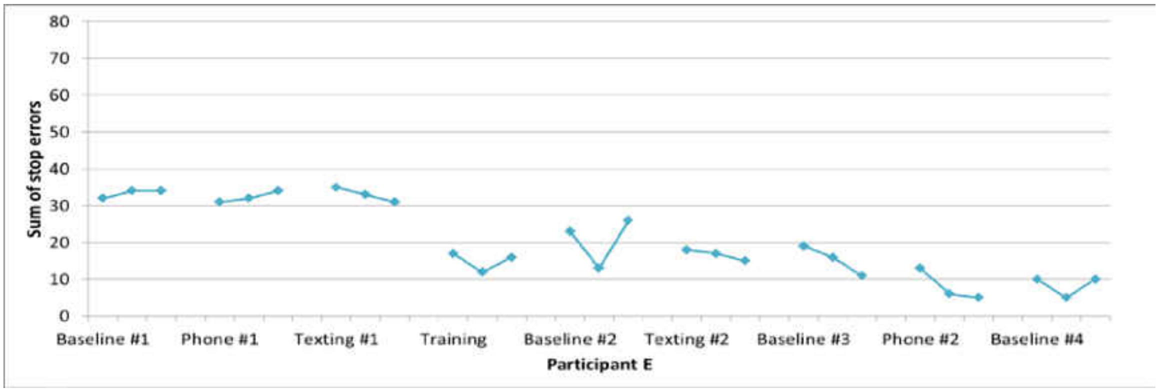


Figure 54. Sum of stop errors per session per phase for Participant E

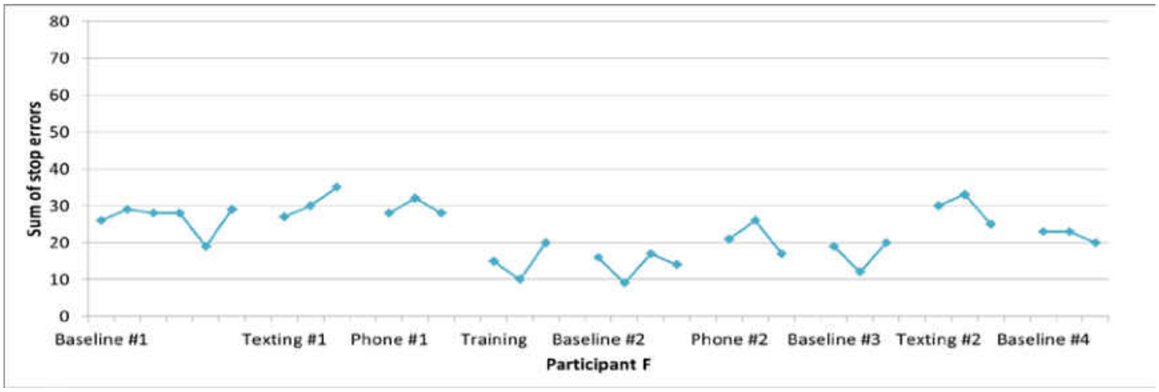


Figure 55. Sum of stop errors per session per phase for Participant F

Although stop errors increased in lane deviations and lane positions in the second texting phase, errors actually declined for most of the participants in the second texting phase. No other consistent declines were noticed in the initial baseline or distracter phases.

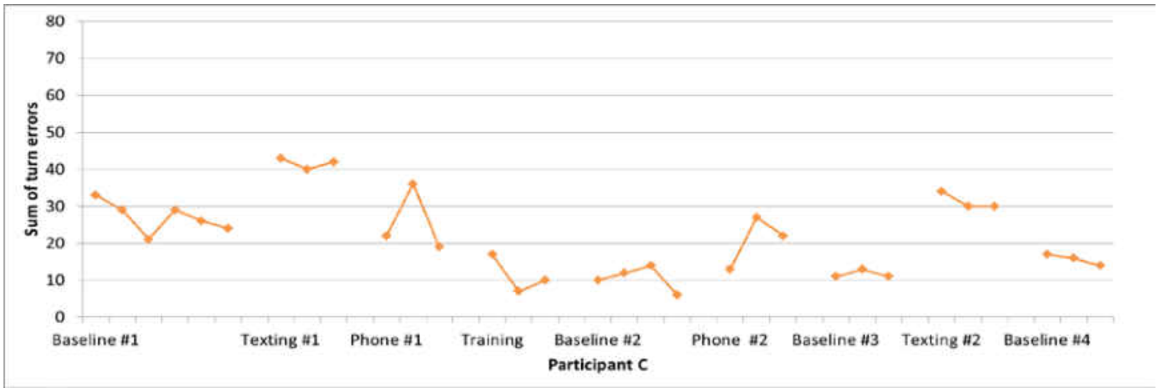


Figure 56. Sum of turn errors per session per phase for Participant C

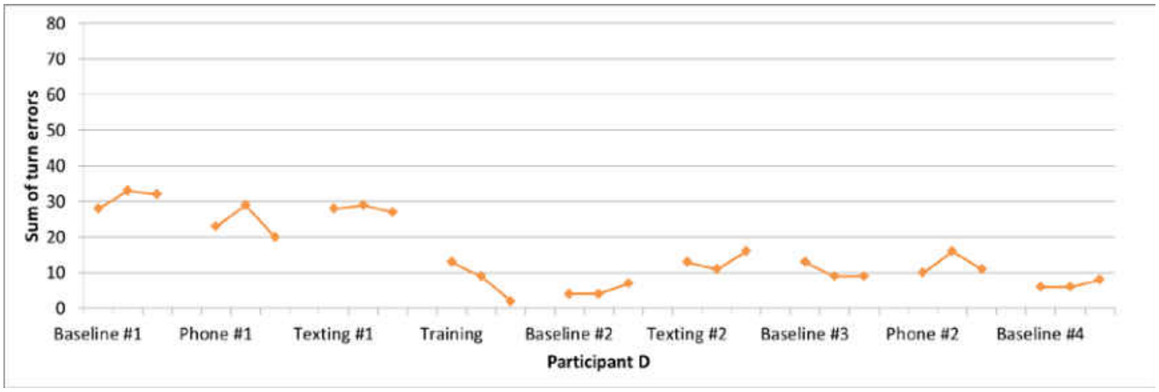


Figure 57. Sum of turn errors per session per phase for Participant D

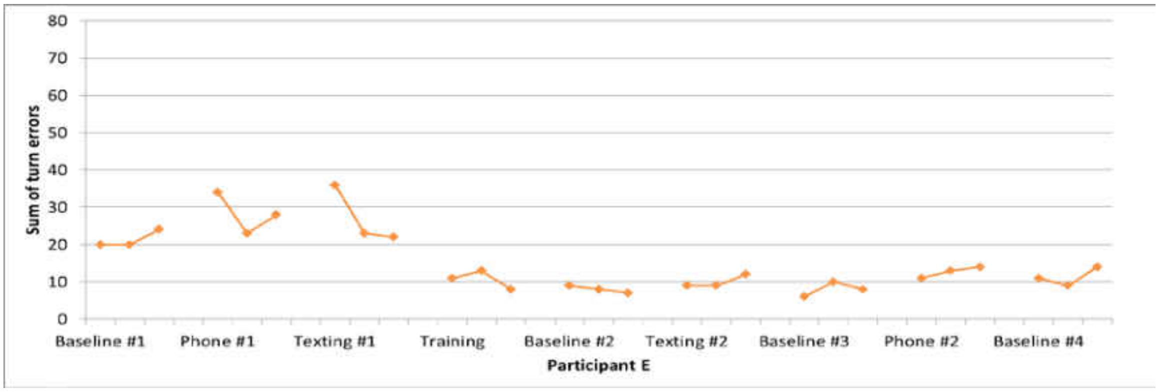


Figure 58. Sum of turn errors per session per phase for Participant E

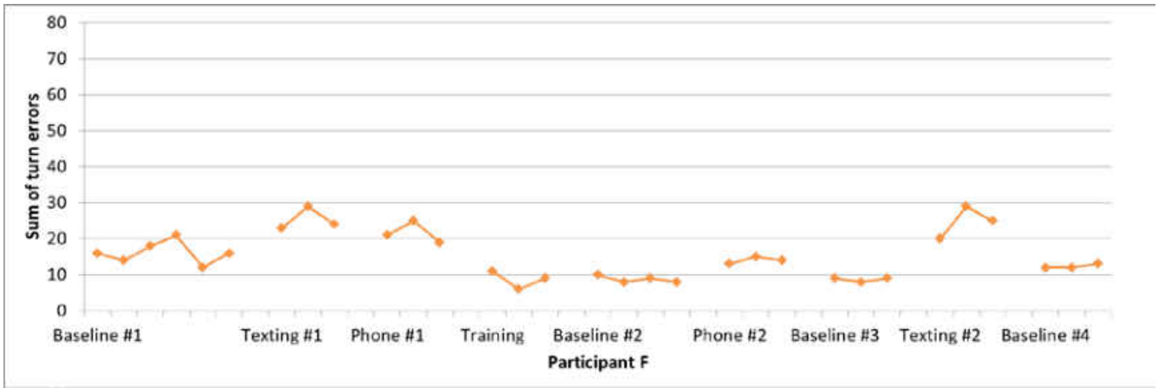


Figure 59. Sum of turn errors per session per phase for Participant F

Although lane deviations and lane position errors increased across the participants in the second texting phase, there was no consistent increase for turn errors. There were no consistent declines in turn errors in the initial baseline or distracter phases.

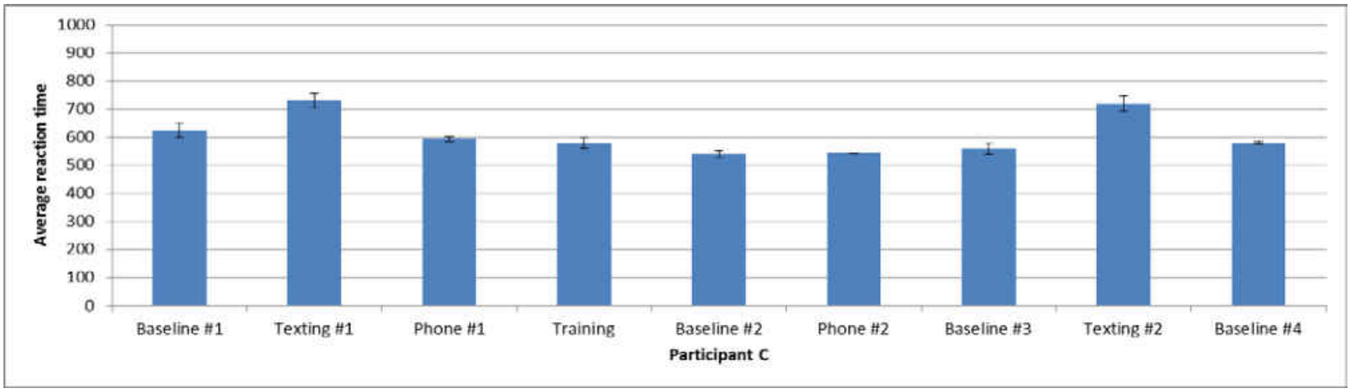


Figure 60. Average of reaction time in seconds across all phases for Participant C

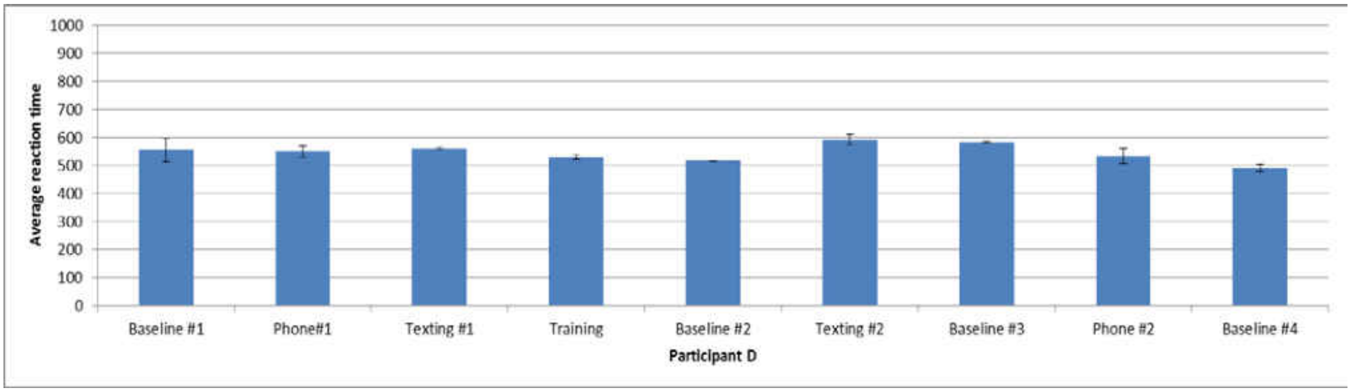


Figure 61. Average of reaction time in seconds across all phases for Participant D

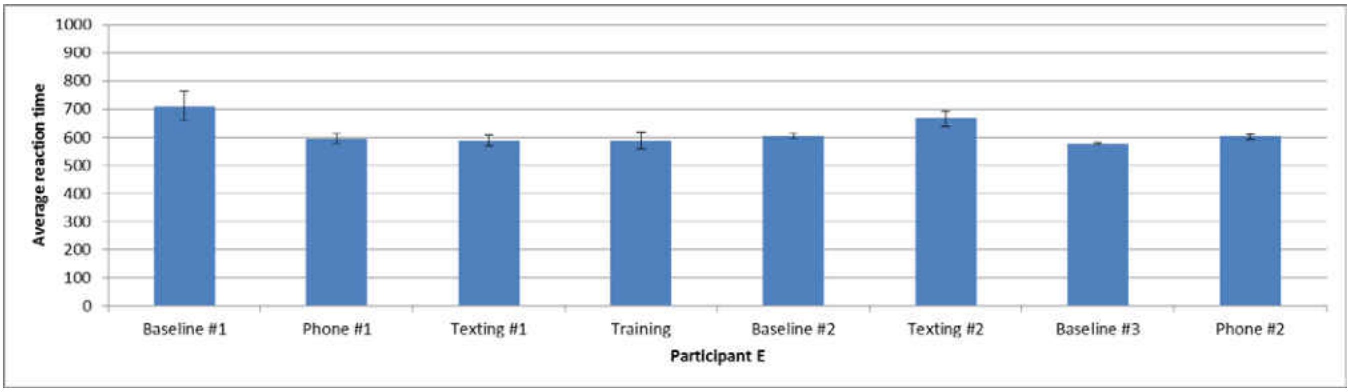


Figure 62. Average of reaction time in seconds across all phases for Participant E

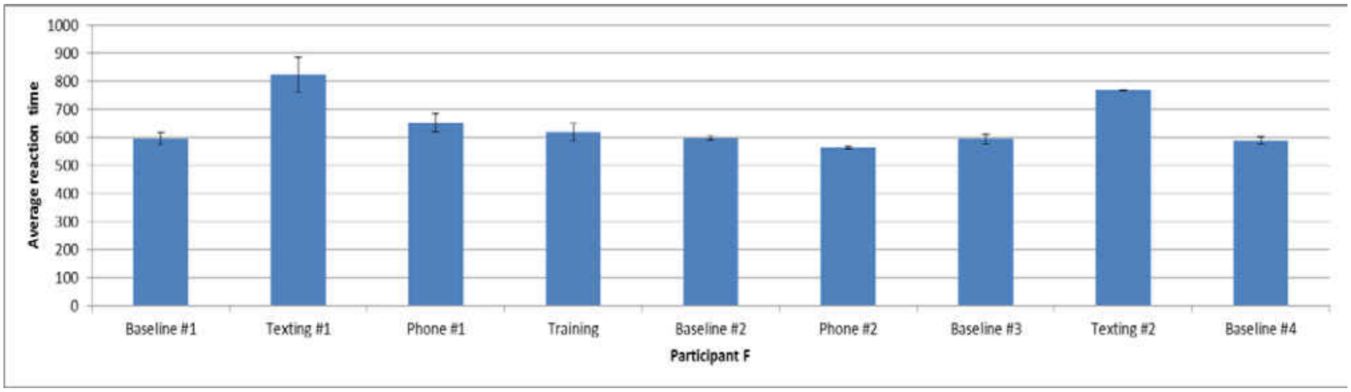


Figure 63. Average of reaction time in seconds across all phases for Participant F

Average reaction time generally increased in the texting phases, particularly for the second texting phase. This seems to be consistent with the larger differential between post-training baselines and the second texting phase in driving performance. Although it was expected that there would be an increase in reaction time in the phone distracter phase, this was not evident. This could be due to the reaction time task being too easy for participants. For example, perhaps the red rectangle stimulus described in the methods section was too noticeable. With the exception of a consistent drop in reaction time across sessions in the initial baseline for the participants, there was no indication of a drop across sessions for any of the distracter phases that was consistent for the participants.

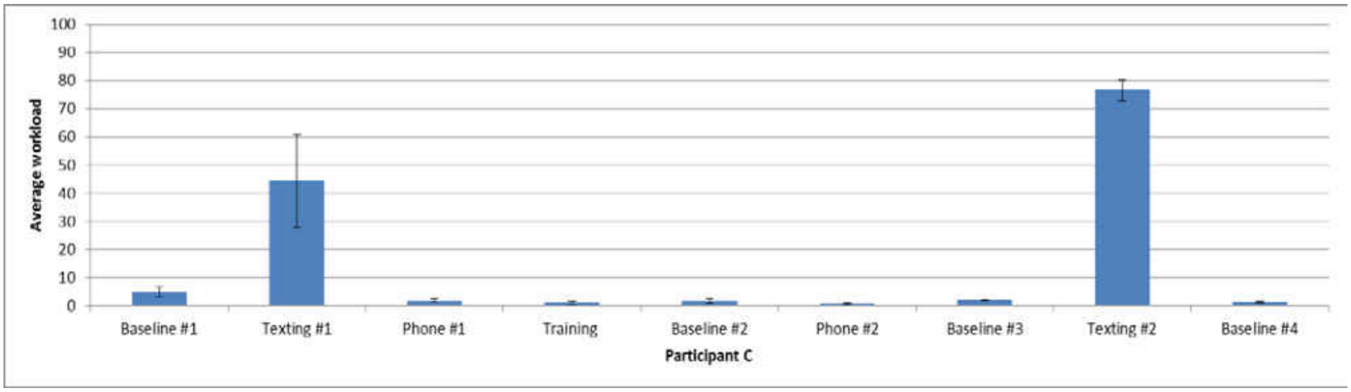


Figure 64. Subjective workload ratings across each phase for Participant C

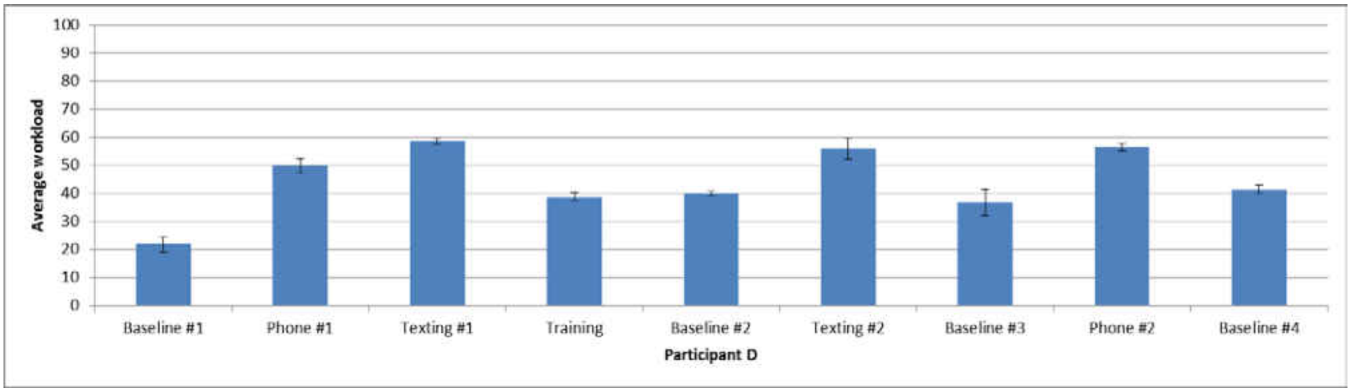


Figure 65. Subjective workload ratings across each phase for Participant D

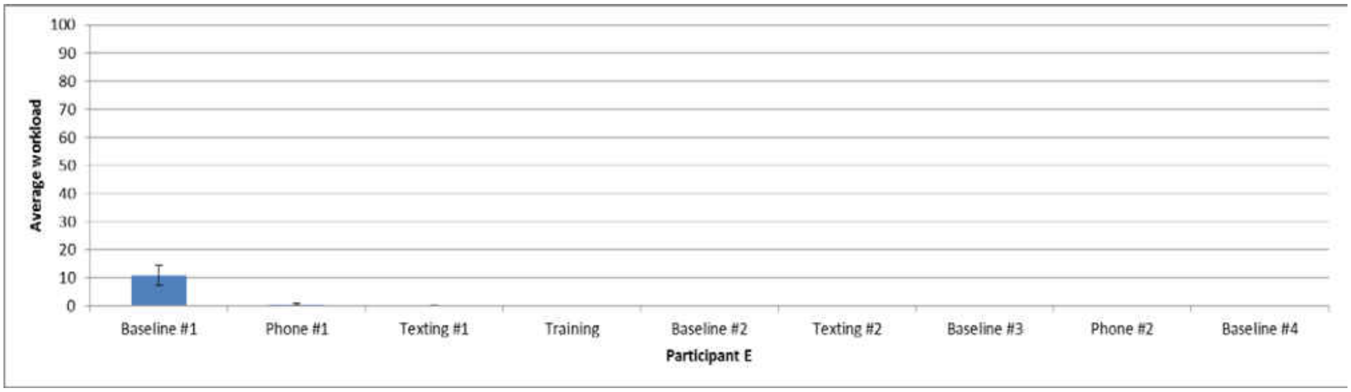


Figure 66. Subjective workload ratings across each phase for Participant E

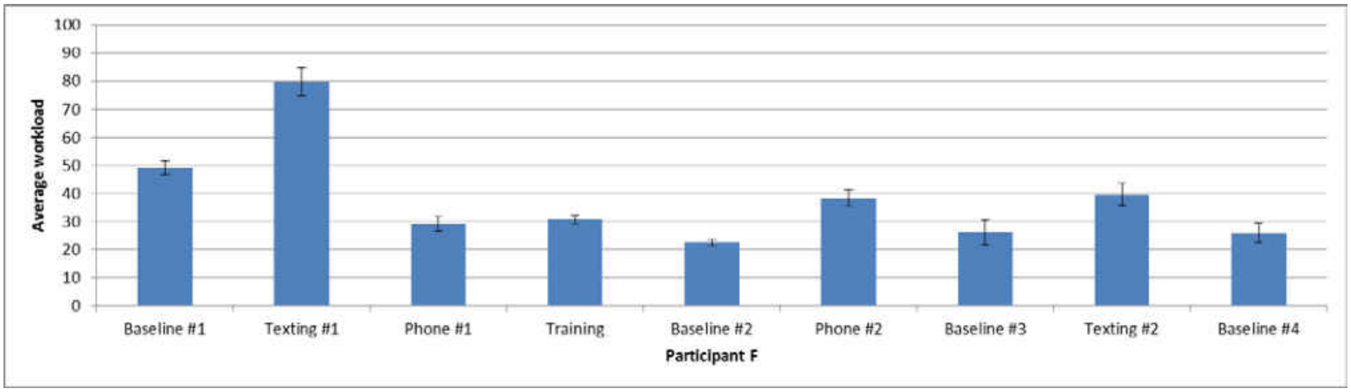


Figure 67. Subjective workload ratings across each phase for Participant F

There was a wide variability in subjective workload across the participants throughout the phases, which is in contrast to the pattern of results for the driving performance measures across the participants across phases. This would indicate that workload is not a good measure of actual driving performance. This is particularly true for the two participants who stated they had no workload in several phases. For most of the participants, there was a higher workload for texting as expected given the greater errors for that distracter. Interestingly, the second texting phase was actually rated higher on workload by Participant C than the first texting phase.

Most of the participants had a decline in perceived workload in the initial baseline and in the first texting phase. This relatively consistent drop was not noticed in the second texting phase however. There were no other consistent improvements in errors across sessions for training or the other distracter phases across participants.

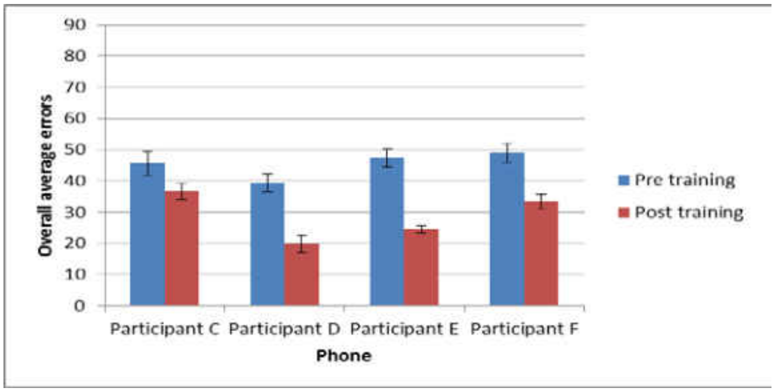


Figure 68. Average overall errors pre and post training for phone distracter

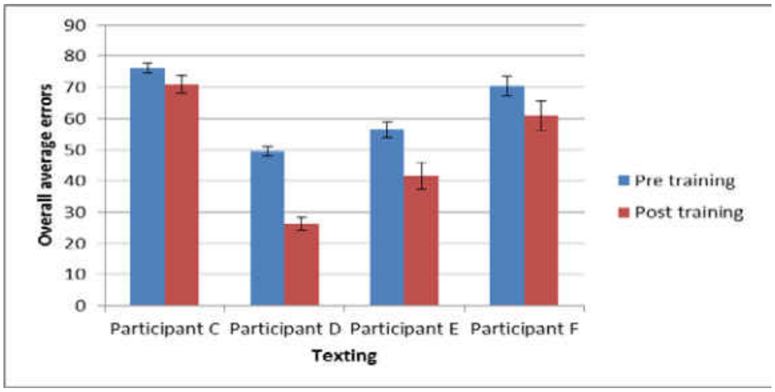


Figure 69. Average overall errors pre and post training for texting distracter

Comparing the impact of training on phone versus texting across the four participants, it appeared that training on overall errors had a larger impact on phone as opposed to texting when looking at the percentage drops from pre to post. In other words, there was a larger drop in errors from pre to post training in the phone phase for most participants. The exception was with Participant D, where training had a larger impact on texting for overall errors.

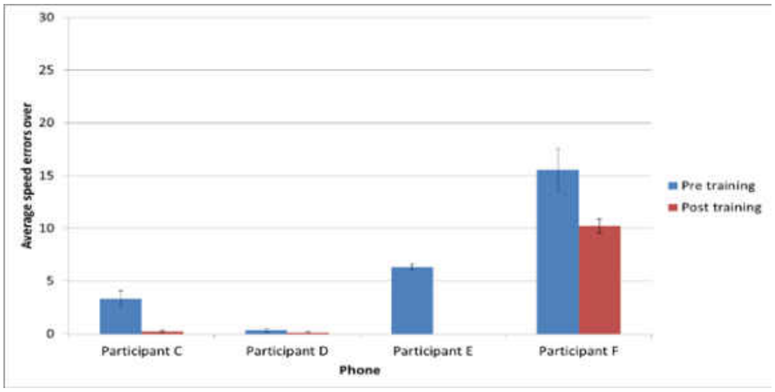


Figure 70. Average “speed errors over” pre and post training for phone distracter

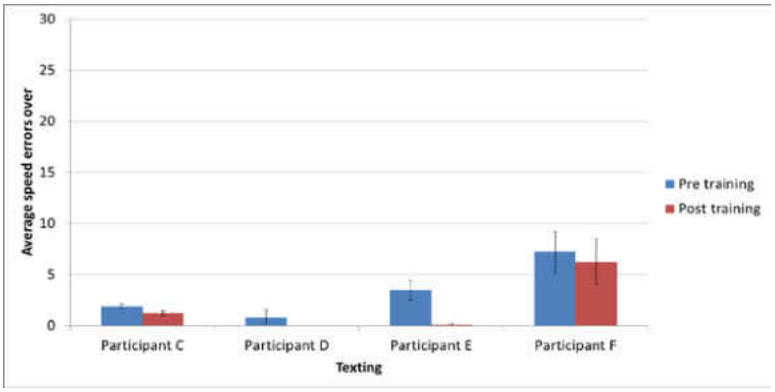


Figure 71. Average “speed errors over” pre and post training for texting distracter

As with the overall errors, there was a larger impact of training on phone with the exception of Participant D for “speed errors over”. However the errors pre and post training were almost zero for Participant D. Errors were low for all participants in pre and post training for phone and text with the exception for Participant F. Over all phases this participant seemed to driver faster than others.

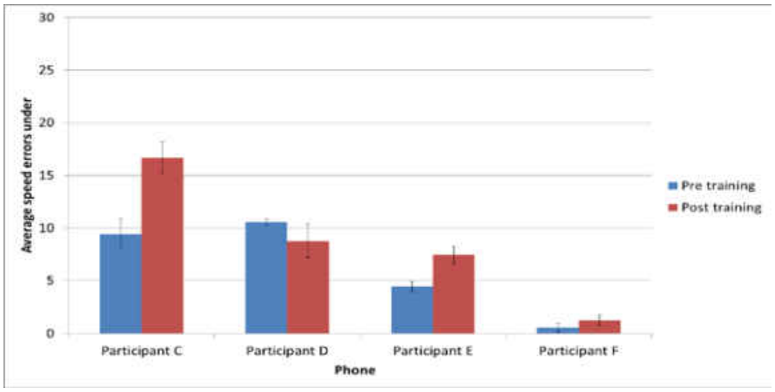


Figure 72. Average “speed errors under” pre and post training for phone distracter

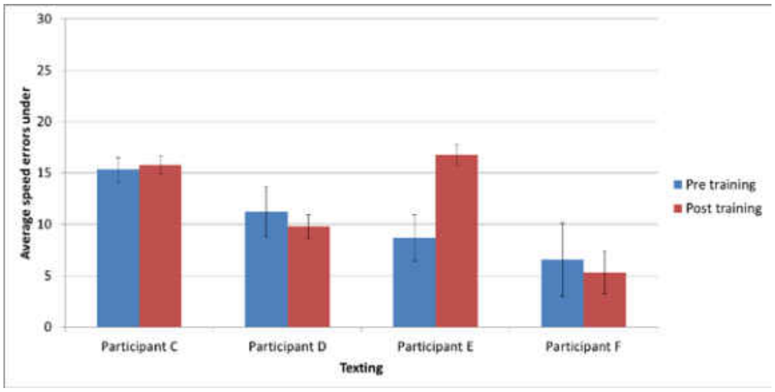


Figure 73. Average “speed errors under” pre and post training for texting distracter

Results were mixed for “speed errors under”. In fact, for some participants, errors were higher in the post-training, indicating that training certainly was not helpful in reducing errors. It could be that in some situations training led participants to be more cautious in distracter conditions, or attempt to compensate more, even if driving performance still suffered. For Participant C, training helped texting slightly but for phone errors in post-training were larger than in pre training. The effects of training were similar for phone and training for Participant D. For Participant E, errors increased in post-training for both phone and texting, although more so in texting. For Participant F, errors were similar between pre and post training for phone, with a slight decrease in post-training for texting.

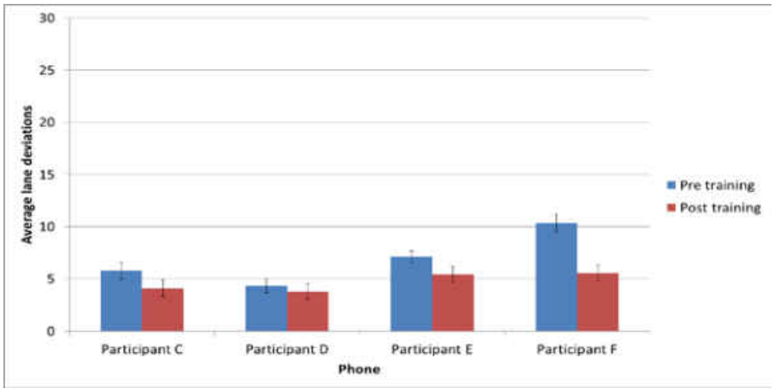


Figure 74. Average lane deviations pre and post training for phone distracter

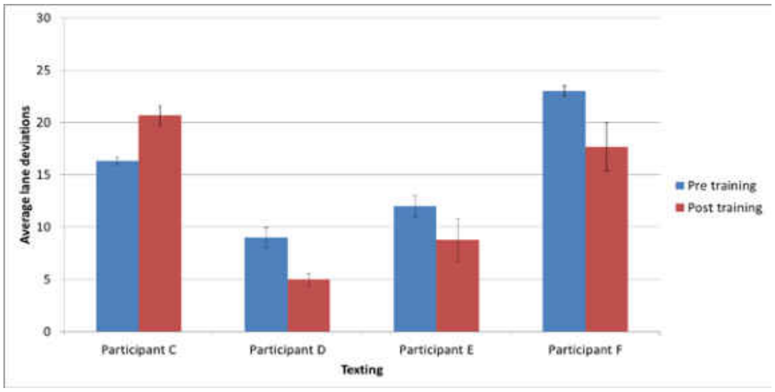


Figure 75. Average lane deviations pre and post training for texting distracter

Examining lane deviations for Participants D-F, training seemed to have slightly more effect on texting than phone. For Participant C, there was a similar level of errors for pre and post training in phone, with a slight decline in the post-training. However, in the texting phase, training did not seem to improve lane deviations and in fact performance worsened after training.

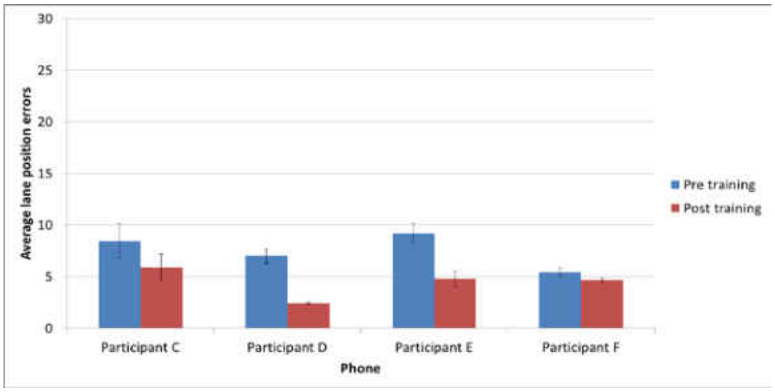


Figure 76. Average lane position errors pre and post training for phone distracter

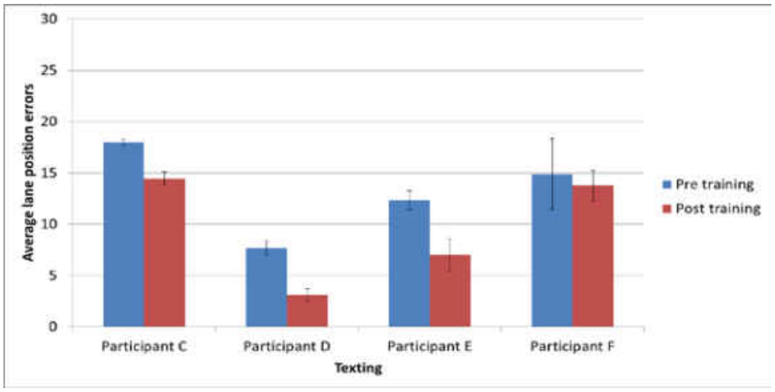


Figure 77. Average lane position errors pre and post training for texting distracter

It was not clear whether training helped phone or texting more across the participants for lane position errors. Unlike lane deviations and "speed errors under", all participants had a decline in errors from pre to post training for both distracters. Thus training had an impact on both phone and texting.

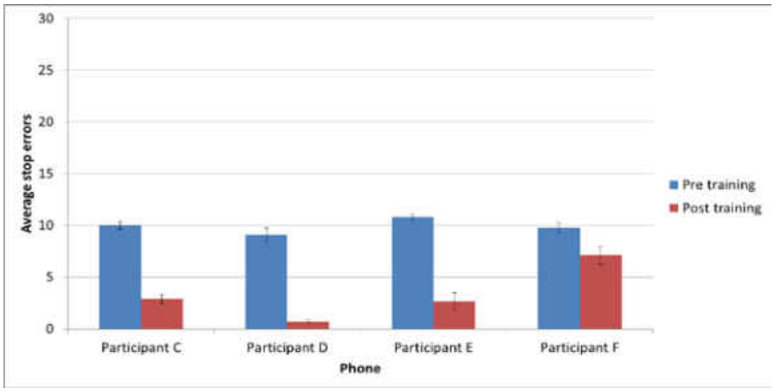


Figure 78. Average stop errors pre and post training for phone distracter

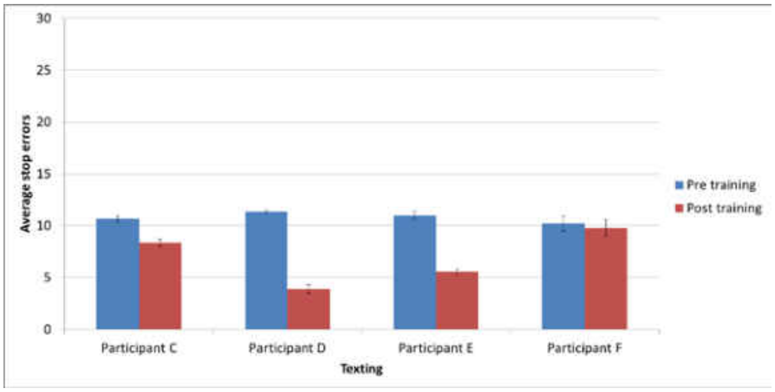


Figure 79. Average stop errors pre and post training for texting distracter

Like with overall errors, stop errors had a larger drop in errors from pre to post training for phone as opposed to texting. This was consistent across all participants.

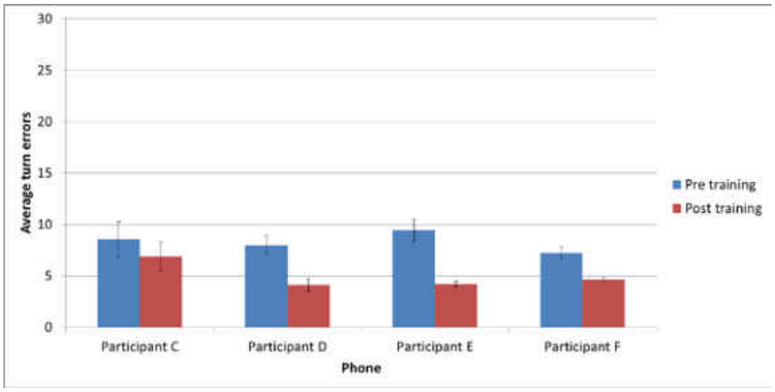


Figure 80. Average turn errors pre and post training for phone distracter

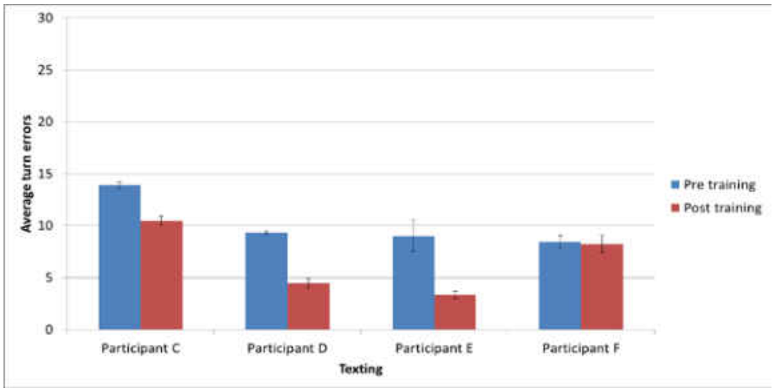


Figure 81. Average turn errors pre and post training for texting distracter

Although most of the participants had a larger drop in errors from pre to post training for texting, there was an exception for participant F, which had a larger drop for phone, indicating that for this participant, training had a larger impact for phone. For Participant F, errors were virtually identical between pre and post training for texting.

The following figures depict the interaction between pre/post training and baseline/distracter phase. Overall there was a larger error differential between baseline and distracter post-training. For post-training, the baseline refers to baseline #2, which was the baseline that directly followed the training session.

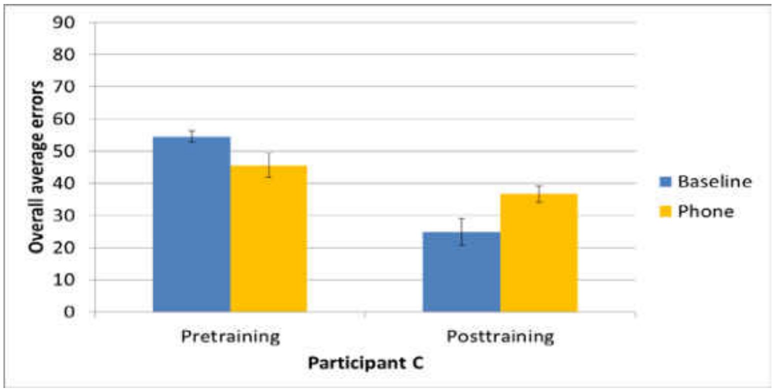


Figure 82. Pre vs post-training comparison baseline to phone distracter for Participant C

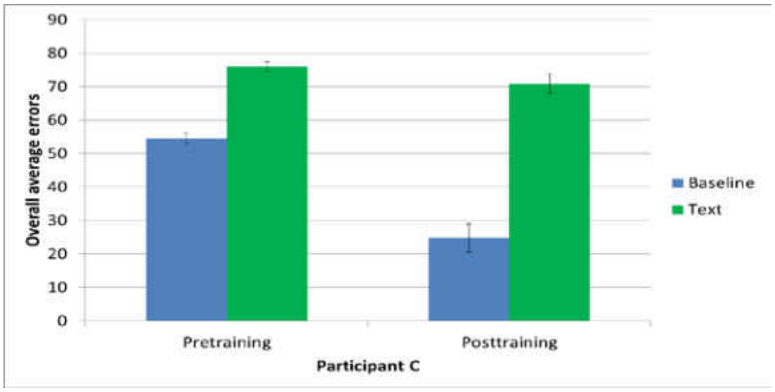


Figure 83. Pre vs post-training comparison baseline to texting distracter for Participant C

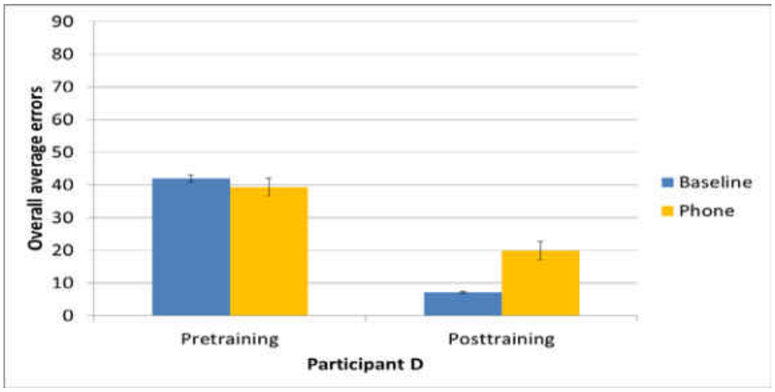


Figure 84. Pre vs post-training comparison baseline to phone distracter for Participant D

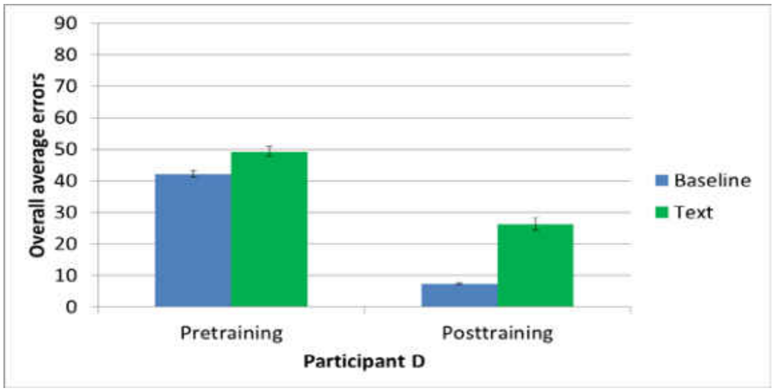


Figure 85. Pre vs post-training comparison baseline to texting distracter for Participant D

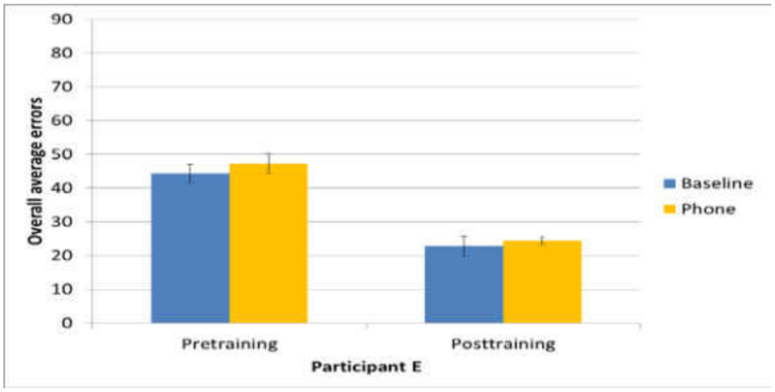


Figure 86. Pre vs post-training comparison baseline to phone distracter for Participant E

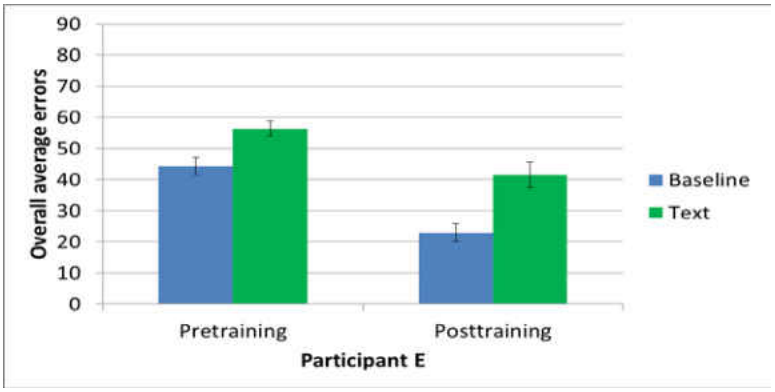


Figure 87. Pre vs post-training comparison baseline to texting distracter for Participant E

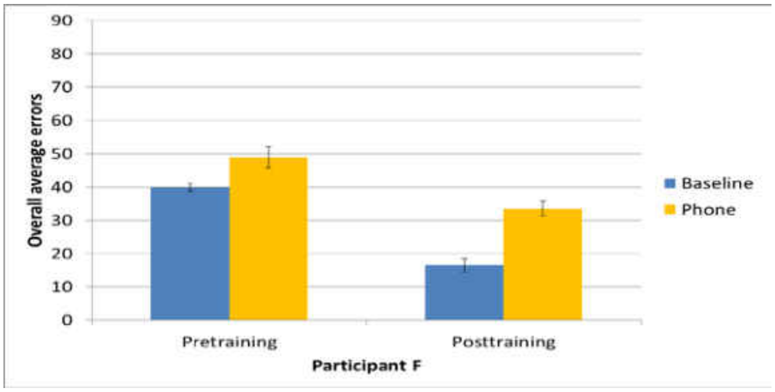


Figure 88. Pre vs post-training comparison baseline to phone distracter for Participant F

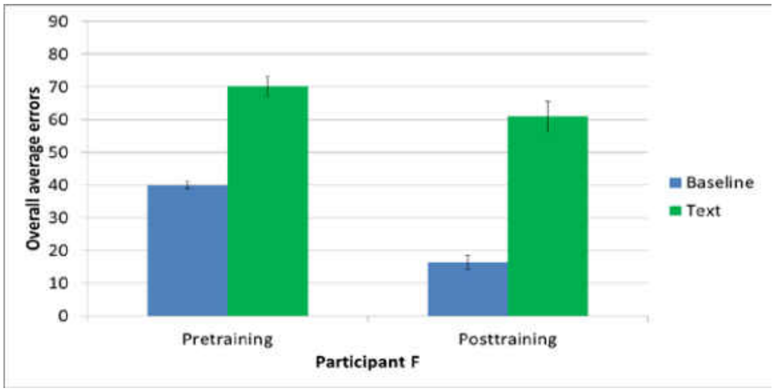


Figure 89. Pre vs post-training comparison baseline to texting distracter for Participant F

Table 2. Comparison of results from Study 1 and Study 2

Analysis	**Study 1**	**Study 2**
Baseline 1 vs. training overall	Training had much lower error levels	Training had much lower error levels
Training compared to post-training baselines overall	Similar levels showing learning occurred	Similar levels showing learning occurred
Baseline 1 vs. phone and text post-training overall	Much higher error levels in baseline 1 than post-training phone, equal error levels between baseline 1 and post-training texting	Higher levels in baseline 1 than phone 2, mixed results across participants for the comparison of baseline 1 to text 2
Phone vs. text post-training overall	Text higher errors than phone	Text higher errors than phone
Post-training baselines vs. phone and text overall	Baselines about the same as phone but much lower than texting post-training	Baselines lower than both phone and text, although much lower than text compared to phone
Sum of overall errors across sessions	Decrease in errors in baseline 1 and increase in texting post-training	Increase in errors across sessions for text and phone post-training, mixed results for baseline 1
Sum of speed errors over across sessions	No consistency	Increase in baseline 1
Sum of speed errors under across sessions	No consistency	Decline baseline 1
Sum of lane deviations across sessions	Decrease in baseline 1 and increase in texting post-training	Increase in texting post-training
Sum of lane position errors across sessions	Increase in texting post-training	Increase in texting post-training
Sum of stop errors across sessions	Increase in phone post-training	Decrease in texting post-training
Sum of turn errors across sessions	Increase in texting post-training	No consistency

*Note: Consistency represented 2 out of 2 participants for Study 1, and 3 out of 4 for Study 2 and was analyzed for initial baselines and distracter phases pre and post-training.

CHAPTER 5: CONCLUSION

Study 1 summary of results

In Study 1, it was noticed that texting led to many more overall errors across pre and post-training levels than conversing on the phone. The idea that texting can have severe negative effects on driving was mentioned and realized by (e.g. Drews et al., 2009) for example. This effect is likely due to participants needing to focus their gaze on the phone away from the road, which even momentarily can cause the driver to veer to the side. The more time participants spent at the task, the worse their performance became particularly with lateral control of the vehicle (lane deviation, lane position, turn errors). The overall error rates in continuous texting conditions were actually higher than in the baseline before the training. This is especially alarming given that the training had such a powerful effect in reducing errors when no distracters were present. In Study 1 which did not have a pre-training distracter phase, the second texting phase had the same level of errors as the initial baseline, revealing that texting brought error levels to the same as driving without distraction before participants were trained. If that effect generalized to the real-world, it could be stated that texting while driving could bring driving performance to that of a novice driver just learning to drive.

Training was clearly helpful in reducing errors from the initial baseline. Moreover training was effective immediately and its effects continued for the most part when tested in baselines immediately after training and later in the study. This would indicate that learning took place, which can be defined as a relative permanent change in behavior due to experience (King, 2011). Also, keeping errors low in baselines post-training bolstered the effects of the distracters presented post-training. If errors had increased during a distracter phase but did not lower much in the following baseline phase, this would have limited the interpretability of the effects of the distracter.

The phone distracter had no clear impact on driving performance in Study 1, which was only assessed post-training. Although some research shows that talking on the phone can be very detrimental to driving performance (e.g. Strayer & Drews, 2004), some have shown that performance can actually increase likely due to compensation such as with a reduction in lane deviations (e.g. Tornros & Bolling, 2006). It could also be that the phone distracter task itself was not distracting enough. Although there was a manual distracter in holding the phone in one hand, asking participants about the New York video they watch may not have been taxing enough on the mental demand of participants. It was noticeable in all the participants that they were engaged in the task, talked a substantial amount throughout it, and did have some difficulty with answering some of the questions.

A major research question of this study as well as Study 2 was whether there would be practice effects within the initial baseline and distracter phases. No consistent practice effect occurred in the distracter phases, showing that practice in a dual-task condition did not improve performance with the distracters examined. This is contrary to some research on practice and dual-task practice, as well as in contrast with Shinar et al. (2005) and Chisholm et al. (2008). However the results do concur with Cooper and Strayer's (2008) work showing that not only did performance fail to improve, but in some cases became worse. It should be noted that neither of these studies examined continuous texting. Although Shinar et al. (2005) and Cooper and Strayer (2008) examined a hands-free phone task, Chisholm et al. (2008) did have a visual task that in some ways mimicked texting by working with an i-pod while driving. It is possible that with the

Chisholm et al. (2008) study the participants were distracted for less amount of time throughout the sessions as they became better at the i-pod tasks allowing for more time to focus solely on the drive itself. This could have been what occurred with the intermittent texting distracter with Participant A. Although no consistent practice effect occurred within the distracter phases, another research question was whether errors would decline in the initial baseline. In Study 1 errors did decline, although by not as much as expected. The drop in overall errors within the initial baseline could be explained primarily by a decline in lane deviations for both participants, possibly due to adapting to the lateral control of the simulated vehicle.

Study 2 summary of results

Training had a large impact on reducing errors from the initial baseline, which held fairly stable in subsequent baselines indicating learning occurred. Given the distracters were presented both before and after training, a comparison could be made on whether training had an impact on baseline drives as well as on distracter drives. It appears that training did impact both phone and texting distracters, reducing errors for both post-training. However, it appeared that for overall errors, training was more of an aid to the phone distracter. Given that training reduced errors in both distracters, it would suggest that part of the effects in the distracters pre-training were due to difficulties in driving the simulator.

When comparing the initial baseline to the initial phone and texting phase, texting led to higher error levels but phone did not. This would indicate that talking on the phone was not that distracting if at all. However, after training, phone errors were greater than post-training baselines, showing a small effect of phone. Although it seemed that before training there was no effect of phone, the effect was noticed after training occurred. This was consistent across all four participants, all showing an increase in errors in the second phone phase compared to the post-training baselines although some more of an increase than others. The dependent measure having the largest impact from the phone distracter, given the participant should have been able to keep their eyes on the road at all times, was with speed maintenance. Research has shown that drivers compensate for the distracter and drive slower, thus increasing “speed errors under”. And in fact the participants in Study 2 in both phone phases had trouble with speed maintenance, mostly driving slower than they should have been.

Further, the effects of texting post-training were magnified. In other words there was a larger difference between control/baseline and texting post-training compared to pre-training. After training, texting still had far more errors than phone even though both had higher error levels than post-training baselines. In some cases texting post-training had higher error rates than in the initial baseline.

Most of the participants had “speed errors under” as the highest errors in the second phone phase but not in the initial phone phase. The measures that had the highest error levels in the second texting phase were lane deviations and “speed errors under”. Therefore driving slower seemed to be a commonality among participants in the distracter phases after training. Like in Study 1, practice effects within sessions across the initial baseline and distracter phases were of interest. There were no practice effects in either distracter across sessions post-training for any of the participants in either study. There was actually an *increase* in overall errors across both distracter phases post-training. In other words, overall driving performance worsened over time when texting even in one instance when there were six sessions (approximately 180 minutes) of practice texting and driving. However it is not clear for how long this trend would continue or if at some point errors may eventually decrease.

Therefore not only were the effects of the distracters overall more prominent post-training when compared to post-training baseline, the performance worsened over time with both distracters consistently after training. It is not clear why performance after training in the distracter phases became worse, as some researchers had shown performance improves with practice in the dual-task condition (e.g. Shinar et al., 2005). For post-training texting, overall errors increased mostly because of the large increase in lateral control (lane deviations and lane position errors). Rather than the old saying of practice makes perfect, it seems to be in this case that practice makes worse. Given performance did not consistently worsen in the pre-training distracter phases, there must be something about the training that made the difference.

In the initial baseline, consistent practice effects were not noticed for overall errors, however there was a fairly consistent drop in “speed errors under” in the initial baseline. This could be due to participants getting more comfortable with driving the simulator and thus becoming less cautious, even if improvements were not evident with other dependent driving measures. It was also noticed that training helped reduce overall errors more in phone than in texting. This could be because of the high difficulty of the texting task versus the lower difficulty of the phone task. The higher difficulty may make the texting task more resistant to training.

Reaction time was relatively stable across the phases with the exception of texting, particularly the second texting phase. It would appear that the increase in reaction time in the texting phase was due more to the participants focusing on the phone rather than the road as opposed to increasing cognitive demand as increases in reaction time were not consistently noticeable in the phone phases. The lack of an increase in reaction time while conversing on the phone goes against research by Strayer and colleagues for instance who claimed large increases occurred in reaction time when talking on the phone either with handheld or hands-free while driving. It could have been that the reaction time task was too easy. For instance, the red stimulus may have been too large. Also by having the button on the steering wheel so close to participants' hands may have reduced increases in reaction time. If the task had been more similar to a car following task used in previous research (e.g. Strayer & Drews, 2004), where participants would see small brake lights ahead illuminate and had to press the brake with their foot, increases may have been seen in the phone phases. The visual angle of the tail lights of a car can be quite small to the driver depending on how close the car is that they are following and how large the lights are.

Practice effects of reaction time were also tested in the initial baseline and distracter phases. No effect was noticed or expected by training on reaction time because reaction time was not trained unlike the driving performance measures. No practice effects were noticed in the distracter phases; however there were consistent improvements in reaction time in the initial baseline. This shows that improvement was possible with the reaction time task through practice, although not evident when distracted.

Workload increased in the texting phases overall but not in the phone phase overall. It could be that participants thought the task was easy or were just comparing their workload to the texting phase. Either way, for most of the participants their workload was not necessarily a good indicator of their performance. If the participants felt no increase in workload in the phone phase from baseline after training for instance, this would not have been reflective of their driving performance decrease. If the participants rated texting as requiring less workload after training, this also would not have been indicative of their driving performance. Therefore it seems to suggest that subjective workload is not a good measure of performance. Asking participants how comfortable they feel with driving the simulator and how good they feel their driving performance is should not be used. Shinar et al. (2005) not only found practice effects in driving performance while distracted but also reductions in workload across sessions. Reductions in workload were found with the initial baseline and with the initial texting phase. Again, just because the participants had less perceived workload in those phases did not necessarily correspond to better driving performance.

Examination of the hypotheses

Hypothesis 1: *"Training should lower overall error rate substantially from the baseline and distracter phases, and should lower it immediately in the first session of training."* This hypothesis was confirmed, finding that training did reduce errors to a much lower level than practice in the initial baseline did alone for any of the participants in both studies. Some participants had more of a learning curve in the training session than others. Nevertheless, for all participants, training reduced errors immediately likely due to the real-time feedback and driving suggestions made to the participants.

Hypothesis 2: "*Because of the added mental demand of both distracter tasks and evidence from previous research, it is expected that performance will be lower in both distracter conditions pre-training than in the initial baseline."* This hypothesis was partially confirmed, with error levels higher in the initial texting phase compared to the initial baseline. This is logical given that this secondary task takes away visual attention from the primary task of driving.

Although driving is the most important task, participants were never able to drive as well while texting as without texting. With phone however, performance was similar to the initial baseline, and some participants had better performance in the phone phase. This could be due to compensation to the phone distracter, such as driving slower which may help to maintain better lateral control of the simulated vehicle. As mentioned earlier in this chapter, some research shows that driving performance for some measures do not decline when talking on the phone.

Hypothesis 3: *"Due to the visual demands encountered with continuous texting, it is expected that the number of errors will be higher in the continuous texting compared to the hand-held phone conversation both pre and post-training. Performance should be more stable for the cell phone conversation phase compared to the continuous texting condition. Practice effects may be less evident in the texting task due to its added difficulty."* This hypothesis was partially supported. First off, performance was much worse for texting than phone whether there was training or not. Performance was more stable in phone than text across sessions, although in Study 2 performance with both distracters decreased across sessions post-training. Nevertheless, performance tended to decrease more with texting. It was predicted that practice effects would be less evident in the texting task, but there were no consistent practice effects pre or post-training in either of the distracter phases, contrary to what was hypothesized.

Hypothesis 4: *"Based on pilot data, it is expected that the reduction in errors in the training phase will be due to learning and thus will continue in subsequent baselines."* This hypothesis was confirmed, showing that the errors in subsequent baselines did remain low. There was naturally some degradation in skill for some participants on some dependent driving performance measures, but overall the performance remained close to the levels seen by the end of training.

Hypothesis 5: *"A similar difference in performance is expected between the baselines and the distracters pre and post-training. Training should reduce errors in baseline phases as well as in the distracter phases given the participant should be a better driver overall and thus better equipped to handle the distracter. Distracter performance before training should be worse than after training."* This hypothesis was partially supported. Distracter performance before training overall was worse than after training, indicating that training did reduce the errors to some extent in the distracter phases. However, the difference between baseline and distracter pre-training was not the same as between baseline and distracter post-training. In other words, although training reduced errors in both baseline and distracter phases, it reduced errors more in baseline. Therefore once participants trained to become as good at driving on the simulator as possible, the effects of the distracter were magnified.

Hypothesis 6: *"Based on pilot data, some decline in errors are expected in the initial baseline phase as participants are practicing driving on their own, gradually learning how to control the simulator. There will be some practice effects evident in the distracter phases pre-training as they are first introduced as the distracters, but not in post-training. It is expected that there will be practice effects for some of the individual dependent measures pre-training, particularly lane deviations based on pilot data."* This hypothesis was not supported. First, the results were mixed as to whether participants would have a decline in errors in the initial baseline. For some participants, practicing as much as 270 minutes did not lead to much of a decline in errors, showing that the effects of practice, where participants are limited to driving on their own without help, can be limited. If participants did have practice effects in the overall errors in the initial baseline, the amount of time it took them to reach a steady-state and to show improvement varied. There were also no consistent practice effects in the distracter phases pre-training and performance may have even worsened across sessions. This goes against some research on practice in general (Reisburg, 2006), dual-task training and practice (e.g. Kramer et al., 1995) and research on driving and distraction and practice (Shinar et al., 2005). This would indicate that practice did not free up enough cognitive resources for the participant to handle the distracter over time.

Hypothesis 7: *"Given the expected added difficulty of texting, it is suggested that training will have a larger impact on texting."* This hypothesis was not confirmed. The idea was that because texting should have been more difficult than phone, there would be more room for texting to improve. Thus even though errors after training should have still been higher for text as opposed to phone, the reduction in errors were expected to be greater in texting. It appears on the other hand that since training overall helped reduce errors for phone more, texting was difficult enough that training was not able to make as much of an impact on improving driving performance. With very difficult tasks, it could be possible that performance cannot improve even with training because of human limitations.

Hypothesis 8: *"Based on previous research, reaction time should significantly increase in both distracters pre and post training. It is not expected that reaction time will improve post-training as reaction time will not be trained."* This hypothesis was partially supported. Reaction time did as expected increase in the texting phases, but not in the phone phases overall either pre or post-training. This could be due to the phone task being too easy for participants, or more likely, the stimulus presented was too large for a simulation of brake lights. As predicted, reaction time did not improve after training.

Hypothesis 9: *"Subjective workload should be higher in all the distracter phases compared to baseline, but may be lower post-training after participants supposedly gain skills and confidence in driving the simulator."* The results presented mixed support for this hypothesis. Although workload increased in texting phases, workload did not necessarily increase in the phone phases, even if performance did decline in the phone phase post-training. Workload was not necessarily rated as lower after training. Overall, it seems that workload is not a strong indicator of driving performance, which concurs with some previous research (e.g. Horrey, Lesch, & Garabet, 2009; Tornros & Bolling, 2005). There are of course limitations to subjective workload, and will be discussed in the limitations section later in this chapter.

The influence and importance of training

Training seemed to reduce errors substantially from the initial baseline in both studies. This is an important finding as it was not entirely clear whether the driving performance on the simulator was trainable or if it was something that participants needed to practice on their own to get the "feel" of the simulator. It could have been possible that the driving simulator task was too strange or difficult for the participants that improvement even with training was of little or no help. Even with individual differences across the participants in driving ability and experience, gaming experience, and ability to learn, this was a very consistent effect.

It is important to note that by no means was the experimenter "driving" for the participant. The experimenter had no physical control over the simulated vehicle. Other than speed deviations, the experimenter focused on giving the participant tips on how to improve driving. The experimenter could not capture all speed errors as he had to concentrate on several aspects of driving performance at a time. What is even more convincing regarding the effects of training is that the effects continued in subsequent baselines. If error levels returned to what was observed in the initial baseline then it would demonstrate that learning did not occur and that training only helped temporarily. Furthermore, if the effects of training did not last, there would be little reason to continue the study past training as a major research question was what would occur with the distracter performance post-training and how it would compare to the baselines post-training. If errors were not reduced when participants drove on their own after training, then the post-training part of the study would simply be an exact replication of the pre-training portion.

These studies demonstrated that for some participants, having them practice on their own for many hours may not lead to much if any improvement. There has been a lot of discussion on which is the best method to get participants adapted to the simulator before the actual data collection commences as pointed out by Sahami and colleagues (2009; 2010; 2013). Consistency is a major problem as mentioned in Chapter 2, as some studies for example may have all participants practice for five minutes, some 10 minutes, and some will have participants practice for various amounts of time until the participant feels comfortable. Thus there is not a standard used by researchers, and often times it is not known if performance has reached a steady-state, if performance has improved at all, or what performance level is after the practice sessions. It is therefore recommended that rather than having participants practice for an arbitrary amount of time set by the researcher or having participants practice for a time set by the participant themselves, experimenters instead should incorporate training on the driving simulator prior to the data collection phase.

The advantages to replacing practice with training are several. Sahami and colleagues suggest that participants should reach a steady-state in driving simulator performance or in their words “adapt” to the simulator prior to being tested with distracters. That point is agreed on, but it is argued that it would be better to train thoroughly rather than have participants practice on their own. This should lead to a decrease in the amount of time for participants to reach steady-state. It should also result in the experimenter being more confident that the participant reached a steady-state (floor effect). It is also beneficial to examine how distracters affect participants when their skill level is high on driving in the simulator. Lastly, training should help to enhance consistency in performance between participants for better comparison of results. Training on the commonly used dependent measures creates a standard that all driving simulation studies could incorporate, as long as what was incorporated as training is clearly defined.

Furthermore, training makes more sense due to the differences between the simulator and real-world driving. There are strategies and techniques that cannot be learned on one’s own, and the differences that necessarily exist between driving in any simulator and the real-world create difficulty and confusion. Having participants trained to be as good as possible driving the simulator mitigates the confounding variable of having difficulty driving the simulator alone without distracters. In other words, the performance in the distracter phase could be convoluted by the performance of driving the simulator alone. With training one can parse out those effects better than with practice.

Even though there was an overall effect of the training on reducing errors in the distracter phases, the differential between post-training baselines and distracters is important to examine. Because training had an impact on reducing errors for both distracters, the performance decrement in the distracters pre-training was somewhat due to difficulty in driving. At first glance it would seem that there was an overestimating of the effect of distraction before training. However this is not true given that the post-training performance between baseline and distracter phases were not reduced. In fact the difference in errors between baseline and distracter phases post-training was larger than in pre-training even though training reduced overall errors in the distracter phases. This implies that the distracter effects were actually *under*estimated when comparing the performance of control and distracter drives pre-training.

Novices

One focus of this study was to sample novice drivers to determine how they are affected by distraction. This study cannot compare the effects of novices to more experienced drivers, nor can it make generalizations about novice drivers themselves. Nevertheless the study does allow for conclusions based on the novices in the current studies. For all participants, texting had a large impact even though all the participants had substantial experience with texting and texting while driving (see Appendix E).

The definition of novice is important however. Although all the participants were young, some participants had more experience and had their driver's licenses longer than others. For instance, one participant was a commercial driver. Interestingly this participant had the most errors overall in the study. A few participants had their license for a year or so, and one participant was a new driver at 16 years old. Based on the alarming results particularly post-training with the effects of both distracters, more research is needed on novice/young drivers, particularly since they are more likely to be comfortable and engage in various technologies like cell phones while driving.

With the cell phone culture that is existent today, research on driver distraction continues to be important and relevant, especially for novice drivers who are still learning to drive and gaining experience driving in various conditions. Rupp (2012) has shown that distracted driving studies tend to neglect examining these novice teenage drivers probably due to the difficulty of obtain this population compared to college students. Novice drivers may be more impressionable in terms of learning about distraction and driving.

Limitations and future research

Due to the limitations of the simulator, there was not a car following task that could measure headway (distance between the vehicle the participant is driving and the vehicle ahead) or the reaction time to a car in front of them applying the brakes. The simulator can be programmed so that the vehicle the participant is driving follows another vehicle; however, this is difficult in a city scenario including stops and many turns. Further, response time could not be accurately measured by pressing the brake on the driving simulator.

Because it was not possible to have a car following task, it was not possible to have a reaction time task where the participant must respond suddenly to the car in front of them braking. To create a simulated car braking situation, a response button was attached to the steering wheel for participants to press when they see the stimulus. This simulated situation could have been more realistic. The red rectangle stimulus was much larger than brake lights from a car in front of the driver, which may have impacted the results of the reaction time task.

It was not possible to place the button on the brake pedal for practical reasons, and having a pedal button on the left side of the floor may have been too difficult for participants to become accustomed to. An issue with placing the button on the steering wheel was that when the participant turned the wheel, the button moved as well. Thus it could have been awkward to press the button when turning which was at times necessary. This was particularly difficult during the distracter phases where participants held a phone in their right hand. In future research, the button would be a pedal on the floor or the brake pedal itself, and the stimulus would be the brake lights of the car ahead illuminating.

Another limitation of the driving simulator used was that there was no method of collecting driving performance data accurately or practically for a city scenario. The simulation does allow for the recording of speed at 60Hz, which could be easily averaged on a highway scenario. However, problems occur if this is done on a city scenario where there are slowdowns for turns, slowdowns for traffic and obstacles, and stops for stop signs. If the participant stopped for longer than typical because of traffic, this would skew the results of average and variability in speed over time. There was just too much variability in the city scenario to rely on the computer to calculate. A different issue existed with lateral control of the vehicle. The simulator can calculate lateral control and steering wheel variability, but this measure gets distorted with tight city turns and can be overly sensitive. The question with these measures becomes what constitutes an actual error. These measures calculated by the simulator make more sense for a highway scenario. Given rater evaluation of speed errors and lane deviations can lead to error and bias, improved simulator technology is needed to obtain more practical and accurate data on average speed, speed variability, and lateral control of the vehicle.

These studies only focused on young participants, some of whom were quite new to driving. Even if other age groups were included in the study, because of the philosophy of the single-study design, group generalizations were not made. For example, if two participants were young, two were middle aged, and two were older adults, one cannot conclude how older adults are affected by distracters, training, and practice, nor how older adults compare to middle aged adults or to young adults.

Older adults are of particular concern with distracted driving. A significant increase in the number of older adults is expected to occur globally (Cavanaugh & Blanchard-Fields, 2011) which will result in an increase in older drivers as well. Not only will many of these older individuals be healthier with medical advances and want to drive to maintain their independence, their interest in engaging in distracting activities such as conversing on cell phones is also likely to increase as a result of changes in the technological culture. Hancock, Lesch, and Simmons (2003) showed that age was a major factor on reaction time in complex dual-task situations. However, Strayer and Drews (2004) determined that although older individuals' performance was worse overall in both conditions (distraction and non-distraction), the amount of performance decline for younger and older individuals did not differ.

Several of the participants indicated that they were not interested in the New York video. This could have had an impact on the phone task, possibly decreasing participant engagement in the phone task and thus affecting validity. However, it seemed that all participants were engaged in the actual phone task and seemed to actively participate. In the future to increase engagement, the video should be something of more interest to all the participants. The texting topics should have been standard across all participants. Instead, there was some variability across what participants would discuss depending on their interests. However this is not uncommon in research with phone distracters, where participants are asked about topics that they would like to discuss to keep the conversation going.

In terms of design, it would be preferable in the future to include baselines pre-training in addition to the initial baseline to have a better comparison of performance between the pre-training distracter phases and the baselines. The disadvantage is adding to the length of the already long study. Having a long study did make it difficult to recruit and keep participants, and therefore in the future it may be necessary to give an individual participant only one type of distracter. Including only one type of distracter has its disadvantages in terms of not being able to compare the results to other distracters, but it could allow for more sessions in phases to obtain a better picture of the performance longer term. This would be particularly useful with the texting post-training, where all participants showed an increase in errors across the sessions. The question is whether the performance would continue to decrease with more sessions or eventually start to improve.

Another limitation is the use of subjective workload, which can introduce individual bias. Participants may have also responded in a desirable way, rating workload higher because they knew they should be experiencing a higher level of workload in a distracter phase. Nevertheless, the NASA TLX is a commonly used instrument to assess subjective workload. Physiological measures of workload may be less biased, but have disadvantages as well such as the impracticality of the instruments and having to generalize from the physiological measures to how the participant is actually feeling about workload.

Future research could also examine other types of distracters. Of course there is a limit to how many distracters can be examined at one time, particularly for a single-subject design study. Global Positioning Systems and other In Vehicle Information Systems could be examined. Passenger interaction has been a well-studied area of driving distraction with mixed results (e.g. Rivardo et al. 2008; Strayer & Drews, 2007). The problem with examining passenger interaction however is the variability in those interactions. This would particularly be a problem for longitudinal studies where it may be difficult to have the same experimenter play the role as the passenger for each condition. Hands-free phones were examined in the Shinar et al. (2005) and Cooper and Strayer (2008) study, and those could be examined in a single subject design as well. Within a phone distracter, different types of tasks could be incorporated like a mathematical computation task or an N-back task.

Different dependent measures can always be incorporated, and depending on the capabilities of the simulator, there may be a wide range of different measures to explore including headway as mentioned earlier. It would be interesting to see if the results of the current studies generalize to other routes in the city scenario, or to other city scenarios, although there is no reason to believe that the skills learned in the training would not generalize. More complex abilities could be trained and examined while the participant is distracted, such as U-turns or merging.

A major variable related to attention to explore would be visual scanning. The research questions that could be asked are whether visual scanning changes with practice in baseline, with practice in distracter phases, and how training of driving performance would impact visual scanning in post-training distracter phases. Also mentioned in Chapter 2 was inattentional blindness. This is a phenomenon that can occur with any distracter, even day-dreaming or fatigue. Although this study did not examine the concept, future research could examine how the occurrence of inattentional blindness changes if any throughout practice of driving in baseline and in distracter phases, and how training impacts the occurrence of inattentional blindness in distracter phases. Combined with visual scanning, an important question could be if over time participants change their scan technique yet still not perceive certain obstacles.

Closing

The usefulness of training was shown in these studies. It is encouraged that other researchers train their participants before collecting data when the participants are distracted while driving. The question is how long will it take to train participants, and that question, much like the question of how long it would take for participants to stabilize with practice on their own, is unknown. However it should take less time to train on average across all participants than having them practice on their own. The training may be able to be conducted in the same day as the actual study, however more than one session may be more practical. It is recommended that researchers do not run hundreds of participants through driving simulator studies due to the vast individual differences possible with length of time to reach adaptation.

Recruiting college freshman and sophomores from a university recruitment pool and having each one come for only an hour session is not the best way to conduct driving simulation research. In fact any study that requires technology or machinery that participants have not used before would benefit from a longer term study. It is argued that researchers should consider driving simulation studies unique and they should not assume that if the participant can drive in the real-world, they can drive with minimal practice on the simulator and do just as well as they would in the real-world. Although it may not be practical to run participants through studies lasting several months, more time should be allocated for adequate training, and performance should be measured for longer than just a few minutes per condition in order to at least determine if performance had reached stability.

Researchers may rebut stating that if they run participants through longer studies, they will not be able to run as many participants in a given amount of time. However it must be noted that the “N” in a study does not necessarily have to be based on the number of participants. Instead it can be based on the number of data collection points. Each participant constitutes his or her own study. Thus if there are six participants, in the true sense of single-subject design, that is six separate studies. Each participant therefore is a replication of the other participant. In the current studies there was quite a large “N” for each participant.

Inferential statistics cannot determine whether the results would or do replicate. The only true method of determining if the results replicate is to actually replicate them. Inferential statistics also do not necessarily indicate internal validity. It is argued because of the added control and in depth analysis of each participant over time, internal validity may be higher in single-subject design research (Johnson & Pennypacker, 2009). Although comparisons among groups are not possible with this type of design, the argument is that in terms of driving distraction behavior is on an individual level (people don’t drive as a group). More may be able to be learned through this design in terms of the actual effects of distraction on driving and how they may vary in different individuals. This is in contrast with averaging scores among individuals, sometimes ignoring or even omitting data for participants who do not “fit the mold”.

These studies showed the usefulness of single subject design in an application where to the best of the author's knowledge it has never been used before.

It is also encouraged that research on driver distraction using simulators focus on more city scenarios. Although it is a more complex environment and more difficult to collect data in, a substantial amount of driving occurs in suburban areas involving many stops and turns. Highway simulated driving is much more often conducted likely because it is more practical as participants are driving on a relatively straight route at a fairly constant speed unless necessary to brake for a vehicle ahead. Drivers may behave very differently in a city scenario due to differences in speed, presence of buildings, turns, traffic and other obstacles. Many crashes among all age groups occur in city environments during maneuvers such as turning and at intersections, particularly for older adults (Bao & Boyle, 2007; McGwin Jr. & Brown, 1999; Ryan, Legge, & Rosman, 1998). These differences also may affect driving with a handheld component more than hands-free device given more reliance on manual control of the vehicle.

If possible, similar to what was done in the current studies, it is recommended that participants learn a relatively simple route. For one, this would keep standardization of the route across participants. Having a route participants memorize also helps to increase realization as this is what they would do in the real-world, learning for instance how to drive from school to their house. Furthermore, the current studies shed light on the effects of distraction on a very familiar route. By the time participants finished training, they were very familiar with the route after having driven a minimum of 12 sessions or about 360 minutes. Alarmingly performance worsened within the post-training distracter phases even after the very strong route familiarity. Thus distraction continues to be dangerous even after knowing the route well and route familiarity does not appear to help driving performance while distracted. In fact it may be possible that the route familiarity leads participants to have more confidence in their driving and thus giving them a false sense of security.

Although this study had several purposes including the effects of practice and training over time, the main purpose was to examine and compare the overall effects of driving distraction with the distracters included in the current studies. As mentioned in Chapter 1, many people drive while doing some distracting activity. With the increase in technological gadgets and the capabilities of these gadgets, this trend is likely to continue. As mentioned, driving distraction as shown in the literature can cause various decrements in driving performance and cause crashes as a result. Many real-world vehicle crashes have also been attributed to distraction. The current studies show that the effects of distraction on driver performance in simulation research in some ways may be underestimated, particularly for texting. Both studies showed the dangerous effects of texting through several means. One was that the error levels both pre and post-training for texting were greater and in most cases much greater than for phone. Also alarming was that for some participants, error levels in texting post-training were higher than in pre-training.

In conclusion, it is hoped that researchers incorporating driving simulation research will see the benefit of training the participants as a possible replacement of participants practicing on their own. It is also recommended that researchers consider single-subject design or at the least more longitudinal research with driving distraction across various demographics as it was shown to be useful in the current studies. It is possible based on the evidence from these studies that the effects of distraction in at least some driving distraction studies may be underestimated, reinforcing the dangers of driving distraction. Thus the current studies have important research and practical implications and make a substantial contribution to the literature, all with the goal of attempting to reduce crash risk and make driving safer.

APPENDIX A: RESULTS OF QUESTIONNAIRES (DEQ, DHQ, CPEQ)

Participant A

a. Much faster
[✓ b.] Somewhat faster
c. About the same
d. Somewhat slower
e. Much slower

8. Over the past year, has anyone suggested that you limit your driving or stop driving? Yes [✓ No]
    a. If Yes, for what reason? ____________________________

9. How would you rate the quality of your driving? (Circle one)
    Excellent Good [✓ Average] Fair Poor

10. In an average week, how many days do you drive? __7__ days per week

11. Over the past year, how many crashes have you been involved in while you were driving? __0__ Crashes

12. Over the past year, how many times have you been pulled over by the police, whether or not you received a ticket? __0__ Times

13. In the past five years, how many traffic tickets (other than parking tickets) have you received, whether or not you were at fault? __1__ Tickets

14. Have you fallen within the last 6 months? Yes [✓ No]

15. Have you fallen within the last 12 months? Yes [✓ No]

16. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes [✓ No]
    a. If so, what visual conditions do you have? ______________

17. Do you currently have any neurological conditions/diseases that might potentially impair your driving ability? NO
    a. If so, what neurological conditions do you have? ____________

18. Do you currently have any mobility conditions that might potentially impair your driving ability? NO
    a. If so, what mobility conditions do you have? ______________

19. For state whether you have a history of each of the following health conditions:

Health Condition	**Yes**	**No**
Arthritis		✓
Heart Problems		✓
High Blood Pressure		✓
Parkinson's		✓
Diabetes		✓
Seizures		✓
Depression		✓
Other: (please specify)		✓

Driving Experience Questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. Do you currently hold at least a valid driver's learning permit? Yes/No

   [✓ Yes] = CONTINUE

   No = EXCLUDE FROM STUDY

2. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes/No. If so, what visual conditions do you have?______________

   Yes = EXCLUDE FROM STUDY

   [✓ No] = CONTINUE

3. Do you have cataracts? Yes/No

   Yes = EXCLUDE FROM STUDY

   [✓ No] = CONTINUE

4. How many years have you been driving? 7

5. Which of the following most closely matches your age?

   (16-18) ☐

   (19-50) ☑

(51-64) ☐

(65+) ☐

7. How often do you drive? (pick one)

Daily ☑

Weekly ☐

Monthly ☐

Less often than above ☐

8. Which of the following do you currently drive or have you driven in the past?

Car ☑

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify _______________

9. Which of the following do you most often drive?

Car ☑

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify ______________

10. Have you ever been involved in a vehicle accident where you were the driver? [✓ Yes]/No

If so, how many? 7

If so, how long ago was your last accident? 4 yrs

If so, were you at fault or was the other motorist at fault for each accident? me

Cell phone use questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. How often do you talk on your hand-held cell phone?

[illegible] twice a day

2. Do you talk on your hand-held cell phone while driving? yes

-If so, how often in a typical day?

once

-Driving where (what type of road environment, for example on the highway)?

highway

-For how long of a duration typically?

5 - 10 minutes

-Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hand-held cell phone?

no

-Are there any times where you avoid talking on your hand-held cell phone while driving?

-If so, when are those times?

yes, during rush hour

-How confident are you about your skills while talking on your hand-held cell phone and driving?

1 2 3 4 5 [✓ 6] 7

Not at all — Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while talking on your hand-held cell phone and driving?

1

-Have you had an accident while talking on your hand-held cell phone and driving?

no

-Have you had more than one accident while talking on your hand-held cell phone and driving?

-If so, describe the situation(s).

no

1. How often do you talk on your hands-free cell phone?

0

2. Do you talk on your hands-free cell phone while driving?

-If so, how often in a typical day?

-Driving where (what type of road environment, for example on the highway)?

-For how long of a duration typically?

-Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hands-free cell phone?

-Are there any times where you avoid talking on your hands-free cell phone while driving?

-If so, when are those times?

-How confident are you about your skills while talking on your hands-free cell phone and driving?

1	2	3	4	5	6	7
Not at all					Extremely confident	

-To the best of your knowledge, how many near-miss accidents have you had while talking on your hands-free cell phone and driving?

-Have you had an accident while talking on your hands-free cell phone and driving?

-If so, describe the situation.

-Have you had more than one accident while talking on your hands-free cell phone and driving?

-If so, describe the situation(s).

1. How often do you text?

daily

2. Do you text while driving? yes

-If so, how often in a typical day?

twice a day

-Driving where (what type of road environment, for example on the highway)?

-For how long of a duration typically?

around town @ stoplights

-Do you ever stop driving (i.e., pull off to the side of the road) to text?

no

-Are there any times where you avoid texting while driving?

-If so, when are those times?

anytime I'm not stationary

-How confident are you about your skills while texting and driving?

1 2 [✓ 3] 4 5 6 7

Not at all Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while texting and driving?

2

-Have you had an accident while texting and driving?

-If so, describe the situation.

no

-Have you had more than one accident while texting and driving?

-If so, describe the situation(s).

no

Participant B

Driving Experience Questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. Do you currently hold at least a valid driver's learning permit? Yes

   Yes = CONTINUE

   No = EXCLUDE FROM STUDY

2. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? No. If so, what visual conditions do you have?_______________

   Yes = EXCLUDE FROM STUDY

   No = CONTINUE

3. Do you have cataracts? No

   Yes = EXCLUDE FROM STUDY

   No = CONTINUE

4. How many years have you been driving? Six years

5. Which of the following most closely matches your age?

(16-18) ☐

(19-50) X

(51-64) ☐

(65+) ☐

7. How often do you drive? (pick one)

Daily X

Weekly ☐

Monthly ☐

Less often than above ☐

8. Which of the following do you currently drive or have you driven in the past?

Car X

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other X please specify SUV

9. Which of the following do you most often drive?

Car X

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify _______________

10. Have you ever been involved in a vehicle accident where you were the driver? Yes

If so, how many? 4

If so, how long ago was your last accident? About 12-18 months ago

If so, were you at fault or was the other motorist at fault for each accident? I was only at fault for one of the accidents; the other motorist was at fault for all the rest.

Driving Habits Questionnaire

Participant #:

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. What is your primary language? English

2. Starting with the first grade, how many years of schooling have you completed? 15 years of schooling.

3. Do you currently drive? Yes

4. Are you the primary household driver? Yes

5. Do you wear glasses or contacts when you drive? Yes

6. Which way do you prefer to get around? (Circle one)
   a. [✓ I prefer to drive myself.]
   b. I prefer to have someone else drive me.
   c. I prefer to use public transportation or a taxi.
7. When compared to the general flow of traffic, do you drive:
   a. Much faster
   b. [✓ Somewhat faster]
   c. About the same
   d. Somewhat slower
   e. Much slower

8. Over the past year, has anyone suggested that you limit your driving or stop driving? No
   a. If Yes, for what reason? ______________________________

9. How would you rate the quality of your driving? (Circle one)

   [✓ Excellent] Good Average Fair Poor

10. In an average week, how many days do you drive? 5-7 days per week

11. Over the past year, how many crashes have you been involved in while you were driving? 0

12. Over the past year, how many times have you been pulled over by the police, whether or not you received a ticket? 0 times

13. In the past five years, how many traffic tickets (other than parking tickets) have you received, whether or not you were at fault? 2

14. Have you fallen within the last 6 months? Yes

15. Have you fallen within the last 12 months? Yes

16. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? No
    a. If so, what visual conditions do you have? _______________

17. Do you currently have any neurological conditions/diseases that might potentially impair your driving ability? No
    a. If so, what neurological conditions do you have? _____________

18. Do you currently have any mobility conditions that might potentially impair your driving ability? No

a. If so, what mobility conditions do you have?_______________

19. For state whether you have a history of each of the following health conditions:

Health Condition	**Yes**	**No**
Arthritis		x
Heart Problems		x
High Blood Pressure		x
Parkinson's		x
Diabetes		x
Seizures		x
Depression		x
Other: (please specify)		x

Cell phone use questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. How often do you talk on your hand-held cell phone? Daily

2. Do you talk on your hand-held cell phone while driving? Yes

-If so, how often in a typical day? Probably at least once in a typical day

-Driving where (what type of road environment, for example on the highway)? Usually just on regular city roads, but I have on the highway before

-For how long of a duration typically? About 5 minutes or a little more.

-Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hand-held cell phone? No.

-Are there any times where you avoid talking on your hand-held cell phone while driving? Yes

-If so, when are those times? When I am on the highway or when I don't know where I'm going.

-How confident are you about your skills while talking on your hand-held cell phone and driving?

1 2 3 4 5 [✓ 6] 7

Not at all Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while talking on your hand-held cell phone and driving? One. I was not at fault; I just happened to be on the phone when I got rear ended at a red light.

-Have you had an accident while talking on your hand-held cell phone and driving?
Yes

-Have you had more than one accident while talking on your hand-held cell phone and driving? No.
-If so, describe the situation(s).

1. How often do you talk on your hands-free cell phone? Never

2. Do you talk on your hands-free cell phone while driving? No.
    -If so, how often in a typical day?

    -Driving where (what type of road environment, for example on the highway)?
    -For how long of a duration typically?

    -Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hands-free cell phone?

    -Are there any times where you avoid talking on your hands-free cell phone while driving?
        -If so, when are those times?

    -How confident are you about your skills while talking on your hands-free cell phone and driving?

1	2	3	4	5	6	7
Not at all					Extremely confident	

    -To the best of your knowledge, how many near-miss accidents have you had while talking on your hands-free cell phone and driving?

    -Have you had an accident while talking on your hands-free cell phone and driving?
        -If so, describe the situation.

-Have you had more than one accident while talking on your hands-free cell phone and driving?
-If so, describe the situation(s).

1. How often do you text? Daily

2. Do you text while driving? Sometimes.
-If so, how often in a typical day? 3-4 texts while moving. Most often sitting at red lights.

-Driving where (what type of road environment, for example on the highway)?
-For how long of a duration typically? Not on highway. Usually just on city roads and usually only at red lights.

-Do you ever stop driving (i.e., pull off to the side of the road) to text? No

-Are there any times where you avoid texting while driving? Yes.
-If so, when are those times? When I'm on the highway or when I am lost.

-How confident are you about your skills while texting and driving?
1 2 3 4 [✓ 5] 6 7
Not at all Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while texting and driving? I'm not sure. 4 maybe?

-Have you had an accident while texting and driving? No.
-If so, describe the situation.

-Have you had more than one accident while texting and driving? No.
-If so, describe the situation(s).

Participant C

Data for the questionnaires was not able to be obtained for this participant

Participant D

a. Much faster

[✓ b.] Somewhat faster

c. About the same

d. Somewhat slower

e. Much slower

8. Over the past year, has anyone suggested that you limit your driving or stop driving? Yes [✓ No]

    a. If Yes, for what reason? ______

9. How would you rate the quality of your driving? (Circle one)

    Excellent [✓ Good] Average Fair Poor

10. In an average week, how many days do you drive? 7 days per week

11. Over the past year, how many crashes have you been involved in while you were driving? 0 Crashes

12. Over the past year, how many times have you been pulled over by the police, whether or not you received a ticket? 1 Times

13. In the past five years, how many traffic tickets (other than parking tickets) have you received, whether or not you were at fault? 0 Tickets

14. Have you fallen within the last 6 months? Yes [✓ No]

15. Have you fallen within the last 12 months? Yes [✓ No]

16. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes [✓ No]

    a. If so, what visual conditions do you have? ______

17. Do you currently have any neurological conditions/diseases that might potentially impair your driving ability?
    a. If so, what neurological conditions do you have? None

18. Do you currently have any mobility conditions that might potentially impair your driving ability?
    a. If so, what mobility conditions do you have? None

19. For state whether you have a history of each of the following health conditions:

Health Condition	**Yes**	**No**
Arthritis		X
Heart Problems		X
High Blood Pressure		X
Parkinson's		X
Diabetes		X
Seizures		X
Depression		X
Other: (please specify) Migraines	✓	

Driving Experience Questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. Do you currently hold at least a valid driver's learning permit? Yes/No

   [✓ Yes = CONTINUE]

   No = EXCLUDE FROM STUDY

2. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes/No. If so, what visual conditions do you have?______________

   Yes = EXCLUDE FROM STUDY

   [✓ No = CONTINUE]

3. Do you have cataracts? Yes/No

   Yes = EXCLUDE FROM STUDY

   [✓ No = CONTINUE]

4. How many years have you been driving? 3

5. Which of the following most closely matches your age?

   (16-18) ☐

   (19-50) ☑

(51-64) ☐

(65+) ☐

7. How often do you drive? (pick one)

Daily ☒

Weekly ☐

Monthly ☐

Less often than above ☐

8. Which of the following do you currently drive or have you driven in the past?

Car ☒

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify ____________

9. Which of the following do you most often drive?

Car ☒

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify ____________

10. Have you ever been involved in a vehicle accident where you were the driver? Yes [✓ No]

    If so, how many? __________

    If so, how long ago was your last accident? ________

    If so, were you at fault or was the other motorist at fault for each accident? ________

Cell phone use questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. How often do you talk on your hand-held cell phone?

No

2. Do you talk on your hand-held cell phone while driving?
-If so, how often in a typical day? No

-Driving where (what type of road environment, for example on the highway)?

—

-For how long of a duration typically?

—

-Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hand-held cell phone?

No

-Are there any times where you avoid talking on your hand-held cell phone while driving?
-If so, when are those times? No

-How confident are you about your skills while talking on your hand-held cell phone and driving?

1 2 3 4 [✓ 5] 6 7
Not at all Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while talking on your hand-held cell phone and driving?

None

-Have you had an accident while talking on your hand-held cell phone and driving?

No

-Have you had more than one accident while talking on your hand-held cell phone and driving?
-If so, describe the situation(s). No

1. How often do you talk on your hands-free cell phone?

Not very.

2. Do you talk on your hands-free cell phone while driving? Yes

-If so, how often in a typical day?

Only when I get calls which is not often

-Driving where (what type of road environment, for example on the highway)? Oviedo

-For how long of a duration typically? 1min

-Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hands-free cell phone?

No

-Are there any times where you avoid talking on your hands-free cell phone while driving?

-If so, when are those times?

No

-How confident are you about your skills while talking on your hands-free cell phone and driving?

1 2 3 4 5 [✓ 6] 7

Not at all — Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while talking on your hands-free cell phone and driving?

None

-Have you had an accident while talking on your hands-free cell phone and driving?

-If so, describe the situation. None

-Have you had more than one accident while talking on your hands-free cell phone and driving?

-If so, describe the situation(s).

None

1. How often do you text?

A lot.

2. Do you text while driving?

-If so, how often in a typical day?

N/A

-Driving where (what type of road environment, for example on the highway)?

-For how long of a duration typically?

N/A

-Do you ever stop driving (i.e., pull off to the side of the road) to text?

N/A

-Are there any times where you avoid texting while driving?

-If so, when are those times? Basically all the time

I usually have texts waiting when I'm done driving

-How confident are you about your skills while texting and driving?

[✓ 1] 2 3 4 5 6 7

Not at all — Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while texting and driving?

None

-Have you had an accident while texting and driving?

-If so, describe the situation.

None

-Have you had more than one accident while texting and driving?

-If so, describe the situation(s).

None

Participant E

a. Much faster
b. Somewhat faster
[✓ c.] About the same
d. Somewhat slower
e. Much slower

8. Over the past year, has anyone suggested that you limit your driving or stop driving? Yes [✓ No]
   a. If Yes, for what reason? ______________________________

9. How would you rate the quality of your driving? (Circle one)
   [✓ Excellent] Good Average Fair Poor

10. In an average week, how many days do you drive? ___7___ days per week

11. Over the past year, how many crashes have you been involved in while you were driving?
    ___0___ Crashes

12. Over the past year, how many times have you been pulled over by the police, whether or not you received a ticket? ___0___ Times

13. In the past five years, how many traffic tickets (other than parking tickets) have you received, whether or not you were at fault? ___0___ Tickets

14. Have you fallen within the last 6 months? Yes No

15. Have you fallen within the last 12 months? Yes No

16. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes [✓ No]
    a. If so, what visual conditions do you have? _______________

17. Do you currently have any neurological conditions/diseases that might potentially impair your driving ability? no
    a. If so, what neurological conditions do you have? ____________

18. Do you currently have any mobility conditions that might potentially impair your driving ability? no
    a. If so, what mobility conditions do you have?_______________

19. For state whether you have a history of each of the following health conditions:

Health Condition	**Yes**	**No**
Arthritis		✓
Heart Problems		✓
High Blood Pressure		✓
Parkinson's		✓
Diabetes		✓
Seizures		✓
Depression		✓
Other: (please specify)		

Driving Experience Questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. Do you currently hold at least a valid driver's learning permit? [✓ Yes]/No

   Yes = CONTINUE

   No = EXCLUDE FROM STUDY

2. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes/No. If so, what visual conditions do you have?_______________

   Yes = EXCLUDE FROM STUDY

   [✓ No] = CONTINUE

3. Do you have cataracts? Yes/[✓ No]

   Yes = EXCLUDE FROM STUDY

   No = CONTINUE

4. How many years have you been driving? 2 years

5. Which of the following most closely matches your age?

   (16-18) ☒

   (19-50) ☐

(51-64) ☐

(65+) ☐

7. How often do you drive? (pick one)

Daily ☒

Weekly ☐

Monthly ☐

Less often than above ☐

8. Which of the following do you currently drive or have you driven in the past?

Car ☒

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify ______________

9. Which of the following do you most often drive?

Car ☒

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify ______________

10. Have you ever been involved in a vehicle accident where you were the driver? [✓ Yes]/No
    If so, how many? 1
    If so, how long ago was your last accident? sep. 13'
    If so, were [✓ you at fault] or was the other motorist at fault for each accident? fault

Cell phone use questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. How often do you talk on your hand-held cell phone?

   sometimes

2. Do you talk on your hand-held cell phone while driving?

   -If so, how often in a typical day?

   maybe once or twice

   -Driving where (what type of road environment, for example on the highway)?

   wherever I'm driving (neighborhood, highway)

   -For how long of a duration typically?

   10 - 20 minutes

   -Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hand-held cell phone?

   no

   -Are there any times where you avoid talking on your hand-held cell phone while driving?

   -If so, when are those times?

   during rush hour/heavy traffic

   -How confident are you about your skills while talking on your hand-held cell phone and driving?

   1 2 3 4 5 6 [✓ 7]

   Not at all — Extremely confident

   -To the best of your knowledge, how many near-miss accidents have you had while talking on your hand-held cell phone and driving?

   none

   -Have you had an accident while talking on your hand-held cell phone and driving?

   no

   -Have you had more than one accident while talking on your hand-held cell phone and driving?

   -If so, describe the situation(s).

   no

1. How often do you talk on your hands-free cell phone?

2. Do you talk on your hands-free cell phone while driving?
   -If so, how often in a typical day?

   -Driving where (what type of road environment, for example on the highway)?
   -For how long of a duration typically?

   -Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hands-free cell phone?

   -Are there any times where you avoid talking on your hands-free cell phone while driving?
   -If so, when are those times?

Front page

~~front~~

-How confident are you about your skills while talking on your hands-free cell phone and driving?

1 2 3 4 5 6 [✓ 7]
Not at all Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while talking on your hands-free cell phone and driving?

none

-Have you had an accident while talking on your hands-free cell phone and driving?
-If so, describe the situation.

no

-Have you had more than one accident while talking on your hands-free cell phone and driving?
-If so, describe the situation(s).

no

1. How often do you text?

not often

2. Do you text while driving?

-If so, how often in a typical day?

not very often
once or twice

-Driving where (what type of road environment, for example on the highway)?

-For how long of a duration typically?

highway / [illegible] neighborhood 10 - 15 seconds

-Do you ever stop driving (i.e., pull off to the side of the road) to text?

no

-Are there any times where you avoid texting while driving?

-If so, when are those times?

rush hour / traffic

-How confident are you about your skills while texting and driving?

1 2 3 4 5 6 [✓ 7]

Not at all Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while texting and driving?

none

-Have you had an accident while texting and driving?

-If so, describe the situation.

no

-Have you had more than one accident while texting and driving?

-If so, describe the situation(s).

no

Participant F

Data for the questionnaires was not able to be obtained for this participant

APPENDIX B: PHONE CONVERSATION QUESTIONS

Cell phone conversation: Part 1

- What did you think of the director’s introduction?
- Who was the discoverer/explorer that they talked about and where was he hoping to get to and why?
- Can all people live together in a single place?
- City founded by whom and why?
- What do you think is the essence of NYC compared to what was said?
- What year did NYC start? What was it called?
- NYC as a place of testing things, what are pros and cons?
- Do you think NYC is greatest city on earth, cultural and economic capital of the world? Why or why not?
- Who was in NY before Hudson got there and how did they act? Why did they act that way do you think?
- What was name of company that was present in NYC in 1624? Why is that name appropriate?
- What did Indians think of deal of sale initially? Why do you think they thought that?
- What troubles did the colony have? How were they improved?
- If you were Dutch and wanted to travel to a colony, would you have gone to new Amsterdam and why?
- What turned things around for the colony?
- What was the feeling about diversity at that time?
- Who took over colony? How did it happen?
- How did city get its name? what year?
- What would have happened do you think if Dutch retained the colony?
- How long did England rule New York? Why was New York so crucial to them?

Cell phone conversation: Part 2

- Summarize what you watched in session 1.
- The natural habitat of NYC was completely replaced by manmade structures. What are pros and cons? What could developers done differently? What was the root for all this?
- What were some of the ways that the native population died off? (There were 3)
- What was Staten Island called? Why?
- How did Queens get its name?
- What was Lord Cornberry made fun of for? Who was he related to?
- How did Wall St. get its name?
- How was diversity tolerated in the 1740s?
- What did the colony need so much of and why?
- Describe the trade routes.
- What were some of the major population groups?
- Describe some of the issues they had with the slaves/
- What happened to some of the slaves?
- What caused some of the hostility between English and merchants?
- Why was Hamilton so pro-war?
- Tell me about Hamilton.
- What was NY so important in revolution?
- Who was general of American forces in NY?
- Why was Brooklyn so important in war?
- What happened to Manhattan in 1776?
- What changed the course in Manhattan?
- Why did the French and Dutch help the American cause?
- How many years did it take for America to get Manhattan?
- Why was it so difficult for Americans to get Manhattan?
- What do you think would have happened if British kept Manhattan for longer?
- Why did British fight so hard for Manhattan?

Cell phone conversation: Part 3

- Summarize what you watched in session 2.
- What was city’s condition after war?
- Why do we not consider NY so historic in architecture?
- Why was Hamilton considered a genius? What was his vision?
- Why was NY not the capital of the country?
- How did Jefferson differ from Hamilton’s views?
- How would NY differ today had it been made the capital?
- How were seeds sown for civil war?
- What was Hamilton’s position with slaves?
- Who shot Hamilton and why? What was the irony? Where was he buried?
- Who was Robert Fulton?
- Who was Astor?
- Who was Irving?
- Who was Gotham?
- Who was Knickerbocker?
- What were two obstacles to NY growth and who did something about it? What was done?
- Why were streets numbered, what was pro?
- What was Hamilton’s view of people being successful in NY?

APPENDIX C: DRIVING EXPERIENCE QUESTIONNAIRE (DEQ)

Driving Experience Questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

1. Do you currently have a valid driver's license? Yes/No

   Yes = CONTINUE

   No = EXCLUDE FROM STUDY

2. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes/No. If so, what visual conditions do you have?_______________

   Yes = EXCLUDE FROM STUDY

   No = CONTINUE

3. Do you have cataracts? Yes/No

   Yes = EXCLUDE FROM STUDY

   No = CONTINUE

4. How many years have you been driving? _______

5. Which of the following most closely matches your age?

   (16-18) ☐

(19-50) ☐

(51-64) ☐

(65+) ☐

7. How often do you drive? (pick one)

Daily ☐

Weekly ☐

Monthly ☐

Less often than above ☐

8. Which of the following do you currently drive or have you driven in the past?

Car ☐

Van ☐

Truck ☐

Motorcycle ☐

Moped ☐

Bus ☐

Other ☐ please specify ________________

9. Which of the following do you most often drive?

Car	☐
Van	☐
Truck	☐
Motorcycle	☐
Moped	☐
Bus	☐
Other	☐ please specify _______________

10. Have you ever been involved in a vehicle accident where you were the driver? Yes/No

If so, how many? ___________

If so, how long ago was your last accident? ________

If so, were you at fault or was the other motorist at fault for each accident? ________

APPENDIX D: DRIVING HABITS QUESTIONNAIRE (DHQ)

Driving Habits Questionnaire

Participant #:___

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

Name:___________________________________ Date:____________

Sex: Male Female Height:___ft___in Date of Birth: ___________

Do you currently own a valid driver's license? Yes No

Have you ever had a motorcycle endorsement? Yes No

Driver's License Number ______________________________

Are there any restrictions on your driver's license? Yes No
If Yes, please specify: ______________________________________

20. What is your primary language? _______________________

21. Starting with the first grade, how many years of schooling have you completed? _____ years of schooling.

22. Do you currently drive? Yes No

23. Are you the primary household driver? Yes No

24. Do you wear glasses or contacts when you drive? Yes No

25. Which way do you prefer to get around? (Circle one)
    a. I prefer to drive myself.
    b. I prefer to have someone else drive me.

    c. I prefer to use public transportation or a taxi.

26. When compared to the general flow of traffic, do you drive:
    a. Much faster
    b. Somewhat faster
    c. About the same
    d. Somewhat slower
    e. Much slower

27. Over the past year, has anyone suggested that you limit your driving or stop driving? Yes No
    a. If Yes, for what reason? ____________________________

28. How would you rate the quality of your driving? (Circle one)

Excellent Good Average Fair Poor

29. In an average week, how many days do you drive? ______days per week

30. Over the past year, how many crashes have you been involved in while you were driving? _______ Crashes

31. Over the past year, how many times have you been pulled over by the police, whether or not you received a ticket? _______Times

32. In the past five years, how many traffic tickets (other than parking tickets) have you received, whether or not you were at fault? ______Tickets

33. Have you fallen within the last 6 months? Yes No

34. Have you fallen within the last 12 months? Yes No

35. Do you currently have any visual conditions/diseases that might potentially impair your driving ability? Yes No
    a. If so, what visual conditions do you have? _______________

36. Do you currently have any neurological conditions/diseases that might potentially impair your driving ability?
    a. If so, what neurological conditions do you have? _____________

37. Do you currently have any mobility conditions that might potentially impair your driving ability?
    a. If so, what mobility conditions do you have?________________

38. For state whether you have a history of each of the following health conditions:

Health Condition	**Yes**	**No**
Arthritis		
Heart Problems		
High Blood Pressure		
Parkinson's		
Diabetes		
Seizures		
Depression		
Other: (please specify)		

APPENDIX E: CELL PHONE EXPEREINCE QUESTIONNAIRE (CPEQ)

Cell phone use questionnaire

The following screener will be administered to all participants prior to participation in the experiment. This screener will be administered via email and/or telephone.

2. How often do you talk on your hand-held cell phone?

2. Do you talk on your hand-held cell phone while driving?
   -If so, how often in a typical day?

   -Driving where (what type of road environment, for example on the highway)?

   -For how long of a duration typically?

   -Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hand-held cell phone?

   -Are there any times where you avoid talking on your hand-held cell phone while driving?
      -If so, when are those times?

   -How confident are you about your skills while talking on your hand-held cell phone and driving?

1	2	3	4	5	6	7
Not at all						Extremely confident

   -To the best of your knowledge, how many near-miss accidents have you had while talking on your hand-held cell phone and driving?

   -Have you had an accident while talking on your hand-held cell phone and driving?

-Have you had more than one accident while talking on your hand-held cell phone and driving?
-If so, describe the situation(s).

2. How often do you talk on your hands-free cell phone?

2. Do you talk on your hands-free cell phone while driving?
    -If so, how often in a typical day?

    -Driving where (what type of road environment, for example on the highway)?
    -For how long of a duration typically?

    -Do you ever stop driving (i.e., pull off to the side of the road) to talk on your hands-free cell phone?

    -Are there any times where you avoid talking on your hands-free cell phone while driving?
        -If so, when are those times?

    -How confident are you about your skills while talking on your hands-free cell phone and driving?

1 2 3 4 5 6 7
Not at all Extremely confident

    -To the best of your knowledge, how many near-miss accidents have you had while talking on your hands-free cell phone and driving?

    -Have you had an accident while talking on your hands-free cell phone and driving?
        -If so, describe the situation.

    -Have you had more than one accident while talking on your hands-free cell phone and driving?
        -If so, describe the situation(s).

2. How often do you text?

2. Do you text while driving?

-If so, how often in a typical day?

-Driving where (what type of road environment, for example on the highway)?
-For how long of a duration typically?

-Do you ever stop driving (i.e., pull off to the side of the road) to text?

-Are there any times where you avoid texting while driving?
    -If so, when are those times?

-How confident are you about your skills while texting and driving?
1 2 3 4 5 6 7
Not at all Extremely confident

-To the best of your knowledge, how many near-miss accidents have you had while texting and driving?

-Have you had an accident while texting and driving?
    -If so, describe the situation.

-Have you had more than one accident while texting and driving?
    -If so, describe the situation(s).

APPENDIX F: OPTEC VISION SCREENER TEST SHEET

DIAL AT 01: *ACUITY - FAR*

LINE/ACUITY		LEFT EYE	BOTH EYES	RIGHT EYE
1	20/200	ZN	RO	HK
2	20/100	RKS	HNC	ZOD
3	20/70	HCDV	SKZO	RNDS
4	20/50	ZROD	NSCH	VZKN
5	20/40	KHSC	OZNR	DNVC
6	20/30	ONRZV	DKHCS	KDSON
7	20/20	SDCHN	VRZKO	HSNRD

DIAL AT 03: *ACUITY - NEAR*

LINE/ACUITY		LEFT EYE	BOTH EYES	RIGHT EYE
1	20/100	SVC	NRK	HZO
2	20/70	RNZH	DOKV	CSZN
3	20/50	CKVD	SNZR	DOHC
4	20/40	VHRN	ODSK	NZCS
5	20/30	HSKRC	NZDOV	ZSHNK
6	20/20	ZONVR	HCSKD	VKCDS

DIAL AT 02: *COLOR PERCEPTION - FAR* A-12 B-5 C-26 D-6 E-16 F-BLANK PASS ___ FAIL ___

DIAL AT 04: *LATERAL PHORIA - FAR*
1 PRISM DIOPTERS

1 2 3 | 4 5 6 | 7 8 9 | 10 11 12 | 13 14 15
ESOPHORIA ORTHO EXOPHORIA

DIAL AT 05: *VERTICAL PHORIA - FAR*
1/2 PRISM DIOPTERS

1 2 | 3 4 5 | 6 7
LEFT HYPERPHORIA ORTHO RIGHT HYPERPHORIA

DIAL AT 06: *DEPTH PERCEPTION - FAR*
SECONDS OF ARC

1-B	2-L	3-B	4-T	5-T	6-L	7-R	8-L	9-R
400	200	100	70	50	40	30	25	20

DIAL AT 07: *FUSION - FAR* 3 cubes BOTH eyes = PASS Other than 3 cubes = FAIL

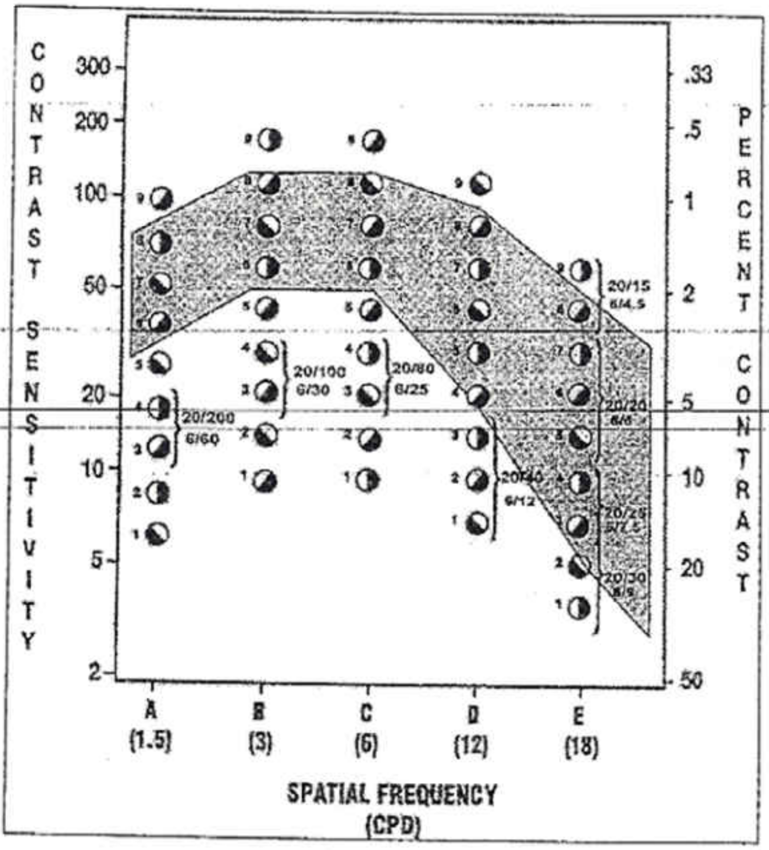
DIAL AT 08: FACT FAR
Row A
Spatial
Frequency

DIAL AT 09: FACT FAR
Row B
Spatial
Frequency

DIAL AT 10: FACT FAR
Row C
Spatial
Frequency

DIAL AT 11: FACT FAR
Row D
Spatial
Frequency

DIAL AT 12: FACT FAR
Row E
Spatial
Frequency

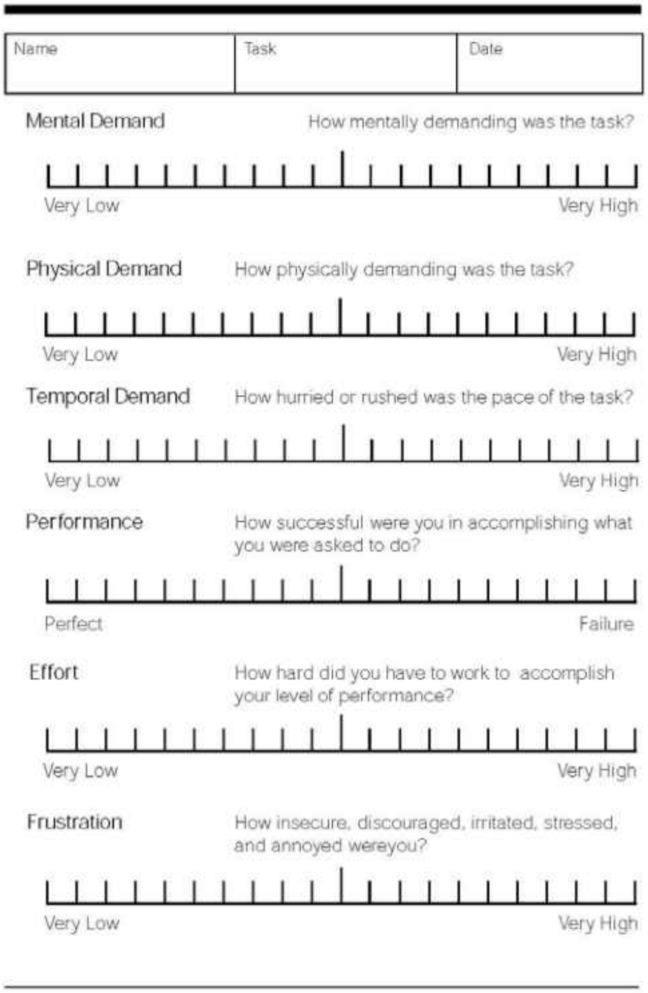


APPENDIX G: NASA TLX

Figure 8.6

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

APPENDIX H: UCF IRB LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Marc Gentzler**

Date: **June 26, 2013**

Dear Researcher:

On 6/26/2013, the IRB approved the following minor modification to human participant research until 06/16/2014 inclusive:

Type of Review: IRB Addendum and Modification Request Form
Modification Type: Participant population will be expanded to include minors. A Parental Consent form has been approved for use.
Project Title: Driving Performance Adaptation through Practice with and without Distracters in a Simulated Environment
Investigator: Marc Gentzler
IRB Number: SBE-13-09436
Funding Agency:
Grant Title:
Research ID: N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 06/16/2014, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 06/26/2013 09:37:38 AM EDT

Joanne Muratori

APPENDIX I: IRB PROTOCOL

1) Protocol Title

Driving Performance Adaptation through Practice with and without Distracters in a Simulated Environment

2) Principal Investigator

Marc Gentzler, M.A., graduate student, Applied Experimental and Human Factors, mgentzler@knights.ucf.edu.

Supervisor

Dr. Janan Smither, Ph.D.
Psychology (PSY 354)
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3) Objectives

The main goal of the study is to examine the effects of driver distraction longitudinally. In other words, to determine whether distracter effects can be mitigated longitudinally with practice. Only a few studies have investigated this subtopic, and of the ones that have been conducted, there have been conflicting results.

The current study will employ a different methodology then has been used before to study this topic called single subject design, which may be better to examine the effects of individual behavior over time, as well as the effects of practice and training, than using the common group design.

Previous studies have a practice session before the study, but do not measure whether the participant has fully adapted to driving the simulator. If the participant has not fully adapted, meaning performance is unstable (increasing/decreasing), this may overestimate or underestimate performance in the distracter condition. Thus the present study will aim to get participants adapted before the distracter conditions.

If practice effects are observed without adaptation to the simulator first, then practice effects may be due to learning to drive in the simulator, as opposed to learning to handle the dual-task condition. The current study will parse out the practice effects from learning to drive the simulator versus handling the dual-task condition.

Even if performance is stabilized, it still may be poor, which may overestimate the error rate in the distracter condition. Further, learning to drive the simulator or having difficulty driving in the simulator may increase mental load, which can also overestimate the effects of distraction on driving. Thus training and feedback will be included in the current study, which could help to reduce the errors to as low of a level as possible to minimize the chances that the performance decrement, if there is one, is not due to difficulty in driving in the simulator. Testing a so called “expert” simulator driver, at least on the route driven, is not done in the literature. Overall, this study desires to enhance the validity of distracted driving effects in simulators, which has important research and practical implications.

Most simulator studies in distracter driving are conducted on a highway scenario, or a city scene without turns. The current study will be examined on a city/suburban scenario that includes turns. The participants will drive the same route from point A to B and from point B to A repeatedly, so that over time participants will become very familiar with the route. This is to simulate what drivers experience in the real-world, driving from home to work every day for example.

Main research questions

10. What level of performance will be reached through the initial baseline? How long will it take to reach steady-state (adaptation), and will there be practice effects in the baseline condition?
11. How will training affect single-task performance? How quickly will performance improve in the training condition (will there be a learning curve)?
12. How will distracter performance compare before training to after training? Will there be practice effects, how much will practice lower errors, and how long does it take to notice practice effects when the distracter is introduced and reintroduced? How stable will performance be? How long does it take to reach steady-state?
13. When going back to baseline in between distracters, will performance go back to a low level of errors?
14. How will performance compare among the distracters (hand-held phone conversation vs. continuous texting)? How will practice effects compare between the two distracters?
15. How does the baseline performance compare to distracter performance in terms of where the performance level starts, how does the performance progress across sessions, and where and when does performance reach a steady-state?

4) Background

Driving is a complex task individuals perform frequently (Hole, 2007). The human factor is still the most important part of safe driving, as about 90% of traffic crashes involve human error (Cai, Lin, & Mourant, 2007). With the driving task, a driver must (1) see or hear a situation developing (stimulus registered and sampled at the perceptual level); (2) recognize it (stimulus recognized at the cognitive level); (3) decide how to respond (make a decision at the cognitive level); and (4) execute the response (at the motor level).

Driving a modern automobile in light traffic on a clear day may not necessarily overtax many drivers. However, driving in heavy traffic, at high speed, or at night on poorly marked roads or at complex intersections can exceed many drivers' abilities (Rinalducci et al., 1993). Attention is required in every phase of the driving task. Although driving can be thought of as a manual task (e.g. turning the steering wheel), a visual task, and somewhat an auditory task, it is also a cognitive task. For instance, improvement over time in driving performance through experience is due to the gradual changes in obtaining and processing of information (Shinar et al., 2005).

As individuals gain experience driving, the task becomes more automated than controlled (Reisberg, 2006). With tasks becoming more automated, drivers should be able to handle other tasks better, as they should be able to allocate more cognitive resources to the secondary tasks. However, automaticity can cause errors by creating “mental reflexes” to various road events since the tasks are not well controlled (Reisberg, 2006).

Driving and distraction

Driver distraction has been a concern for many decades. Regan et al. (2009) defined driver distraction as “a division of attention away from activities crucial for safe driving toward a competing activity” (p. 34). Olson, Dewar, and Farber (2007) defined it as “a mismatch between the attention demanded by the driving task and the attention devoted to it” (p. 472). Researchers have also distinguished between the concepts of distraction and inattention. Distraction is thought of as something external to the driver and compelling like a cell phone or radio, whereas inattention is more internal and not compelling, like daydreaming (Treat et al., 1980; Caird & Dewar, 2007, Olson, Dewar, & Farber, 2007).

Olson, Dewar, and Farber (2007) more specifically stated that the types of distraction are “visual distraction (looking away from the roadway), auditory distraction (e.g. responding to a ringing cell phone), biomechanical distraction (e.g. adjusting the radio volume), and cognitive distraction (e.g. being lost in thought)” (p. 473). Cognitive distraction occurs when drivers shift their attention away from the primary task of driving to focus on a secondary task (Giguere, 2003), which can cause drivers to miss potential hazards (Alm & Nilsson, 1994; Strayer & Drews, 2008, Tornos & Bolling, 2006).

Miles and Vincent (1934) claimed that when drivers are distracted, they tend to have reaction time increases because their attention is diverted to something else. Driver distraction contributes anywhere from 20 to 30 percent to all crashes (Giguere, 2003), and causes about 38% of crashes and 28% of near misses (Klauer et al., 2006). Another study showed that attention failures caused 78% of 69 car crashes and 65% of another 761 car crashes (Lee, 2009). The negative effects of distracted driving may go completely unnoticed by a driver unless they experience a near-miss or crash. Research on distraction and visual scanning indicated that, in general, distracted participants tend to make fewer peripheral scans and more scans in the central area, thus less overall scanning of the visual scene (Atchley & Dressel, 2004; Beede & Kass, 2006; Barkana et al., 2004; Harbluk et al., 2007; Victor et al., 2005).

Harbluk et al. (2002) differentiated between “eyes off the road” and “mind off the road”. If an individual were looking at a text message or dialing a phone, this would most likely require “eyes off the road”. Conversing on the phone while driving would be a form of cognitive distraction and would represent “mind off the road”. In this sense, an individual may not be visibly blind but cognitively blind when conversing on a cell phone. This could be just as dangerous since that could lead to not perceiving an important hazard and could result in what some researchers refer to as “looked but failed to see” crashes (Olson, Dewar, Farber, 2007).

Because cell phone use can serve as a biomechanical, visual, auditory, and cognitive distraction, it is not surprising that it can cause severe detriments in driving performance. For instance, in 2002, the Harvard Center for Risk Analysis roughly estimated that driver cell phone use is responsible for more than 2,500 deaths and greater than 500,000 minor-to-critical injuries in the U.S. each year. Drivers even admit that cell phone use while driving increases the chances of crashing (Giguere, 2003). Strayer and Drews (2004) found that when individuals conversed on the phone while driving, their reaction time declined 18%, it took them 17% longer time to get back to the speed that they were at before they started slowing down, their headway (distance between their vehicle and the vehicle ahead) increased by 12%, and they also had twice as many rear-end collisions. Other research has found that when conversing on a phone and driving concurrently, performance decrements could be as serious as when driving intoxicated (Strayer, Drews, & Crouch, 2006).

Texting (reading and writing) while driving may be more detrimental to driving performance than simply talking on a cell-phone because of the constant visual and manual demands that texting involves (Hosking, Young, & Regan, 2009). Because of the increased demands, it is likely that those who text will look off-road for longer periods than those talking on the phone. This is critical given that the duration of off-road glances longer than two seconds more than doubles crash risk (Klauer et al., 2006). Although good theoretical reasons suggest that texting is a very serious distraction, surprisingly little empirical research exists regarding its effects on driving performance (Hosking et al., 2009). One population that may have greater risk for driving while distracted in general could be older individuals, given the many cognitive and perceptual deficits that come with aging including a decreased ability to allocate attention adequately (e.g. Kramer, Larish, & Strayer, 1995). Since driving requires cognitive and perceptual abilities, deficiencies in these abilities due to aging are likely to cause a decrease in driving performance.

Practice effects on task performance

The human brain needs to adapt to change so that it can cope with variations that occur in the environment (Goldstein, 2010). Although “practice makes perfect” may be difficult to achieve, practice typically can improve performance within limits. The questions then are when does practice improves task performance, which task aspects improve, how much improvement is there, which mechanisms are involved, and does enhanced performance continue over time? Improvements with practice are of particular importance for the complex and potentially dangerous task of driving.

A practiced task requires fewer cognitive resources given that workload is reduced and the spare resources can be allocated to a secondary or emergency task if necessary (Reisburg, 2006). In the beginning, driving necessitates a step-by-step procedure to learn and follow (check the mirrors, press the brake, put the car in drive, check mirrors again, etc.). Each step takes resources, which take up the total amount of resource capacity, to the point where there is little to no extra processing capacity for an out of the ordinary and unexpected situation, such as a car pulling out in front of the novice driver's vehicle (Reisberg, 2006).

Moreover, it is very difficult to combine all the tasks together for the novice (Reisberg, 2006). Because of automation, after practice, the steps are not as demanding cognitively, thus more steps can be dealt with at a given time and more resources are freed up to deal with new steps if necessary (Resiberg, 2006). After substantial driving practice over time, the driver begins to be able to handle the driving task much better, and rather than going through serial processing of all the individual tasks, parallel processing begins to dominate, where the driver combines these steps. With practice, tasks begin to become automatic as opposed to being controlled (Reisberg, 2006), the latter taking more resources, and thus making dual-task performance difficult. Automatic tasks do not require as many resources because they are typically familiar to the individual due to practice, and therefore are easier to conduct concurrently with other tasks.

Practice can help improve performance while driving through trial-and-error as well as memorization (Reisberg, 2006). Drivers learn through past experiences that they have had driving or as passengers. They learn what works well and does not work well for them, and in a way adapt their skills to the task at hand. Memorizing the routine, the route, the way to shift gears, etc., is another way that practice can help improve driving performance partly by reducing the need for executive control. Practice over time allows for this memorization to occur and should make the task easier by making it more automatic.

Once driving is mastered with enough practice over time, an individual still has more learning to do. The “expert” driver still has to conquer new routes, different traffic patterns, and various types of weather. For example, driving in the snow takes practice that will add to the cognitive demand of the driver, thus a novice driver who has little to no spare cognitive capacity because they are all consumed by the ordinary driving task probably would be wise not to drive in such weather conditions. Even the well-practiced driver can find driving in complex conditions such as adverse weather to be too much to handle.

For the novice driver, a distracter task can be easily overwhelming due to not having the spare cognitive capacity. Research has shown that even expert drivers suffer driving performance decrements while distracted (e.g. Caird et al., 2008). It may not be a major problem if the expert driver is having a simple conversation and is not in a complex driving situation. However, the driver may suffer major driving performance decrements if the distracter becomes more complex and thus requires more resources and/or drives in a more complex driving environment. A major question is whether practice can improve dual-task performance while driving, much like practice can improve ordinary driving performance and driving under adverse conditions. If practice can reduce the effects of dual-task interference, it is likely to vary for individuals and certain variables (e.g. age).

Most simulator-based driver distraction studies have participants come in for only one session. Given the vast amount of individual differences, distraction studies would benefit from analyzing participants longitudinally to assess their adaptability and performance changes rather than group participants together by a variable such as age and not observe their reactions to distraction and simulator driving over time. Even within participants there can be differences longitudinally in the method of conducting a task with training and practice (Woodrow, 1939).

As some road studies observe participants over time (Brookhuis et al., 1991), there is also reason to obtain a more reliable and valid picture of various measures of performance longitudinally using simulation. The strategy of the current study is to examine a few participants longitudinally with many data points as opposed to testing as many participants as possible cross-sectionally. In this way, the experimental design allows for more freedom for participants to show learning effects at their own pace, which would not be visible in a typical cross-sectional study.

Novices usually start out driving (before and after obtaining a license) in simple conditions (e.g. little traffic, straight road) rather than attempt to learn to drive in complex driving environments or while distracted so as not to overload their cognitive resources. Inexperienced drivers gain experience through a step-by-step process, gradually increasing complexity and difficulty as the individual successfully handles the previous less difficult step. Thus, beginners could first practice driving in a new environment (i.e. simulator), then practice in gradually more complex situations. Drivers may have to allocate more resources initially to driving in a simulated environment than previously believed. If participants practice first on the simulator before engaging in a more complex driving task or dual-task situation, they may have enough resources spared for the secondary task.

Dual-task interference and practice

Cooper and Strayer (2008) suggested that in terms of dual-task interference, greater amounts typically occur when the tasks have the same resource demands or have a non-preferred stimulus-response modality pairing. Practice in the single or dual-task condition may open up spare cognitive capacity to handle the dual-task condition (Cooper & Strayer, 2008). Practice should reduce the unpredictability in one or both tasks, which then should free up cognitive resources as the task becomes more automatic as opposed to controlled and thus decrease the dual-task interference (Cooper & Strayer, 2008). It is possible that performance on tasks requiring divided attention can be improved with substantial amounts of practice, which is thought to reduce attentional demands, even for older adults (Kramer, Larish, & Strayer, 1995). This may be true even with driving and conversing on a cell phone (Horrey & Wickens, 2003).

However, even a simple, highly practiced task from day to day driving may still not be exempt from dual-task interference. Levy, Pashler, and Boer (2006) had participants press the brake as soon as they perceived the car in front of them slow down. The secondary task consisted of participants having to decide how to respond manually or vocally based on the frequency of a visual or auditory stimulus. Even after practice of tasks that do not compete for resources, the performance when conducting both tasks at the same time tends to be not as quick as performing either task by itself. Further, the limits to practice may be found when predictability disappears in an unfamiliar driving situation for example, as the cognitive demand would increase. The effects of practice can be quite variable, and may affect some aspects of the task but not others. For example, some research has found that practice of tasks does not enhance the individual's accuracy, but does lead to quicker performance across time (Kedzior, Kochhar, Eich, Rajput, & Martin-Iverson, 2011).

Liepelt, Strobach, Frensch, and Schubert (2011) examined whether practice of dual-task conditions can enhance inter-task coordination skill, as well as whether the training would transfer to other dual-task conditions. Participants were trained on a visual-manual task and an auditory-vocal task, and were assigned to either a practice group that focused on single tasks or a hybrid practice group that included practice on the single tasks as well as dual-tasks. When participants were tested in the single and dual-task situations, the hybrid practice group performed better compared to the single-task practice group, although advantages in dual-task performance was reliably seen only for the auditory task.

Other studies have focused on practice or training of dual-task conditions with older adults. Hiyamizu, Morioka, Shomoto, and Shimada (2011) had one physical/motor task combined with a Stroop test as the cognitive task. The older individuals were all over 65 years of age and their training was two times weekly for about 12 weeks. The three months of dual-task practice of the balance and the Stroop task led to better Stroop task performance, showing not only improved cognitive ability but improved ability in dual-task conditions.

Voelcker-Rehage and Alberts (2007), like Hiyamizu et al. (2011) were interested in how motor practice affects dual-task interference with one task that is motor and one that is cognitive with older individuals. They gave younger (19-28) and older (67-75) participants a pretest and a posttest with a total of 100 practice sessions in between. The motor practice led to improved performance on the motor task in both single and dual-task conditions for the older and younger participants, and better cognitive performance when in dual-task situations. Nevertheless, older individuals still had worse motor performance as they went from the single to dual-task condition, even after the practice.

Practice and driving distraction

Only a few studies have focused on longitudinal studies of distracted driving, examining how practicing the dual-task condition affects driving performance over time. It may not be that practice increases the number of resources available to an individual, but that fewer resources would be needed (Green et al., 2008). Brookhuis et al. (1991) conducted a study with participants of all ages who did not have previous experience driving and talking on a cell phone concurrently. Participants drove a car in the real world for one hour every day for roughly two weeks. Certain variables were susceptible to practice such as heart rate variability (indicative of lower workload) and fewer number of math errors on the secondary task. Nonetheless, the participants did not show significant improvement on driving performance when in dual-task conditions.

Chisholm et al. (2008) tested if practicing using an iPod (visual, biomechanical, and cognitive distracter) while driving would help alleviate the demands on the driver and improve driving performance. Drivers ranged from age 18 to 22 and engaged in seven sessions using a simulator. While driving, the authors presented certain hazards to participants such as pedestrians crossing the road, other vehicles pulling out into the road, and a vehicle ahead slowing down. Participants interacting with the difficult iPod task had increased reaction times and number of collisions compared to the control condition and easier iPod tasks. Moreover, the participants scanned significantly more in the vehicle and thus less on the road when in the difficult iPod condition. Nevertheless, in all levels of iPod task difficulty, participants driving performance improved with dual-task practice, including improved reaction time to potential hazards. However, there was still a performance decrement compared to having no iPod interactions after the practice sessions.

Shinar et al. (2005). These authors also wanted to determine whether practice being distracted while driving can improve driver performance, citing that practice and feedback can improve performance as the task becomes more automated, leaving spare capacity for the secondary tasks. They suggested that practice can lead an individual to improve at time-sharing of tasks when distracted while driving. Ten young drivers with less than six months driving experience, 10 drivers ranging in age from 30-33, and 10 drivers aged 60-71 participated in the study. The environment was a simulated straight 2-lane highway having a low level of traffic.

Participants used a hands-free phone device and either engaged in a math task or an emotionally-involving conversation. The design included five sessions over two weeks with at least 1-4 days between sessions. The only practice participants had driving the simulator alone before the practice driving with distracters commenced was a four minute practice session. The participants drove for three minutes during each distracter task, as well as three minutes for the control condition of no distraction. Therefore each experimental session included three 9 minute blocks of driving.

Speed gained across the five sessions when driving in the 65 mph condition across the age groups, and drivers of all age groups drove faster across the training sessions for the two distracter conditions as well as for the control condition. This showed an improvement in handling the single and dual-task condition as distraction typically leads drivers to drive at a slower speed to compensate for the distraction (e.g. Haigney, Taylor, & Westerman; 2000; Liu & Lee, 2006). All age groups experienced less speed variability across sessions, particularly for the oldest group of participants. Speed variability decreased for the two distracter conditions across the sessions, although it decreased mostly for the control condition. Participants made fewer steering wheel deviations across sessions particularly for the oldest group and when conducting the math task. The results for the speed and steering wheel deviations indicate less dual-task interference. There was not a significant main effect of practice on the average lane position, which is not surprising given lane deviation seems not to be as sensitive of a measure to distraction (Caird et al, 2008, Horrey & Wickens, 2006).

As expected, the distracter effects in general were greatest on the first day of training. Practice also significantly decreased the reaction time to peripheral signals. Reaction time appears to be quite sensitive to distraction (Caird et al, 2008, Horrey & Wickens, 2006). Although participants' ratings of subjective workload decreased across sessions, and older as well as younger drivers felt that their driving performance improved over the sessions, the middle aged group actually felt that their driving performance declined across sessions. The most significant finding with the older individuals is that even though their overall driving performance was worse than the middle aged and younger participants, the older individuals showed the most improvement across sessions, sometimes even reaching the same performance level as their younger counterparts.

Cooper and Strayer (2008). These authors conceptually replicated the findings of Shinar et al (2005). The study consisted of 60 participants who reported driving greater than 41 min. per day, talking on their cell phone either less than 5% or greater than 41% of the time. They had highway as well as city scenarios that lasted approximately 18 minutes each. On the highway, participants followed a pace car that periodically braked, whereas in the city scenario participants followed directional arrows inserted in the scenario, which also included various embedded hazards.

All participants practiced driving the simulator without distracters for a standard 20 minutes. Practice was on days 1-4, with day 1 and 4 having single and dual-task driving. On the other hand, days 2 and 3 included dual-task driving only. The distracter was a naturalistic conversation using a hands-free cell phone. After participants practiced on either a highway or city scenario for the four sessions, they would transfer to the scenario they had not practiced on the final day, which the authors termed the transfer condition. They wanted to determine whether the practice effects, if there are any, transfer to a novel driving environment.

Cooper and Strayer (2008) observed that the number of crashes decreased with practice, although it was still greater with dual-task compared to single-task at the end of the training on day 4. The transfer condition to another type of road actually led to increases in crashes. Brake reaction time saw an increase for both single and dual-task conditions across sessions, and was the longest in the transfer condition, with the longer reaction times still for the dual-task. There was a small change in headway across sessions, and even an increased distance in the transfer condition compared to the first day of training. Increased headway typically suggests more dual-task interference as individuals are compensating for the distraction. There was little difference in speed compliance on the first training day for both single and dual-task. However, the authors observed a large difference between single and dual-task between day 4 and transfer, with single task showing better speed compliance than in dual-task conditions. Further, the differences in real-world cell phone use among participants did not show a significant difference in driving performance in dual-task conditions. The authors concluded that the dual-task was never fully automated.

Simulator adaptation

Sahami and Sayed (2010) stressed that participants need time to take their real-world driving skills and apply them to simulator driving. Adaptation to the simulator is essential for the results of a simulator study to be valid (Sahami & Sayed, 2013). Participants need to use what Sahami and Sayed (2013) termed “trial-and-error” and “fine-tuning” to adapt to the simulator and its controls and handling. Initially participants are unlikely to respond as quickly and accurately to the simulator. Once the basics of adapting to the simulator are achieved, the participant can move on to more complicated scenarios and situations (Sahami & Sayed, 2013). Sahami, Jenkins, and Sayed (2009) stated that ideally researchers would be able to determine if participants were in fact fully adapted to the simulator.

Although it is agreed that participants should adapt to the simulator, adaptation can be defined in several ways and thus needs to be specified. Sahami and Sayed (2013) defined it as lasting “until the person knows how the simulator responds to their input and driving becomes automatic” (p. 42). More specifically, in their study, adaptation was when there was no improvement in the measures in the last few trials, where performance was at a "converged to a constant or oscillatory value" (p. 43). When the improvement in performance peaked, the authors claimed this meant that driving the simulator has become automatic and that the performance could not improve any more.

Not only can responses be different initially before adaptation and thus affect validity, the process of getting used to the simulator adds extra mental load on the participant, which can confound the results in a complex driving situation or a dual-task condition (Sahami & Sayed, 2013). Sahami and colleagues argue that adapting to the simulator puts more cognitive demand on the participants and thus making driving, which is the primary task, more difficult and therefore lead to lower driving performance initially. In this sense, the adaptation process becomes another distraction that may confound results and limit validity. If participants are not adapted to the simulator, their performance may not validly represent real-world driving performance. Other research has concurred that the learning process of driving in the simulator, such as learning control and handling, does add to the mental load (Speelman & Kirsner, 2005), which can serve as an added distraction to driving.

Sahami and Sayed (2013) went into detail on what the practice scenario should include. According to them, it should first give the participants the opportunity to learn the controls and how to handle them. They believed that the adaptation is task independent, meaning that it should not take place on any specific task, but instead be a general task that allows the participants to practice overall driving and a large variety of controls and skills. These include, but are not limited to distance perception as well as pedal and steering wheel skills (Sahami & Sayed, 2013). They emphasized that practice scenarios conducted by other researchers which have participants drive on a straight highway or scenario with straight roads at the same speed are not adequate for true adaptation. Nevertheless, the practice scenario should include the same general task over time so that the researchers can monitor changes in performance and thus learning under the same conditions (Sahami & Sayed, 2013).

5) Setting of the Human Research

All data will be conducted at the University of Central Florida Psychology building. Data will be collected in room 303K and 303E.

6) Resources available to conduct the Human Research

Recruitment will be done by word-of-mouth. Participation per participant will last from 9 weeks to 12 weeks, depending on the performance of the participant as well as how long their initial baseline is set to last. There plans to be about 5 participants (an older male and female, two young females, and a young male). All investigators are current with CITI training. Additionally, all investigators were involved with developing this protocol and are well-informed of research-related duties. Each participant will take from 45 minutes to an hour and a half per simulator session, and there will be three simulator sessions per week. It should take 4 to 5 months to collect data for all participants.

Preliminary measures

Before any of the simulator sessions commence, participants will take some preliminary tests. These include the following:

DEQ and DHQ. The driver experience questionnaire (DEQ) and the driving habits questionnaire (DHQ) (Owsley, Stalvey, Wells, & Sloane, 1999) will both be given to participants to obtain basic demographic information. The surveys contain a mixture of closed-ended items such as “yes” or “no” and multiple choice. Although the DHQ is used more for elderly participants, the current study will use it for all participants. Both surveys will be administered by email, phone, or face-to-face.

CPEQ. The cell phone experience questionnaire (CPEQ) was developed by the author to assess the amount and type of participant previous cell phone use, whether using handheld or hands-free, as well as texting behavior. Most of the items are in the form of short-answer written responses, however there are also a few Likert-type items. Individuals do not need to have a certain amount of cell phone use while driving experience to participate in the study. This survey will be administered by email, phone, or face-to-face.

Visual Screener. Participants will take a Snellen far and near visual acuity test using the Optec 5500 visual screener. If the participant has worse than 20/40 corrected with contacts or glasses, they will not be able to continue with the study. Participants will also take a contrast sensitivity test on the Optec. If the participant falls below the normal range for two or more of the frequencies, they will not be able to continue with the study. The normal range is depicted on the score sheet. Also tested on the Optec is far distance color vision using Ishihara type color plates (Goldstein, 2010). The participant must correctly identify four of the five plates to continue with the study.

Auditory Screener. Because part of this study will require the comprehension of speech through phone, it is necessary to test basic hearing, particularly for the older participants. The following website will be used as an online hearing test: http://www.hear-the-world.com/en/hearing-and-hearing-loss/online-hearing-test.html, which can be conducted at a quiet place in the participant's home as long as they have a computer with access to the internet. The test contains 27 sounds /objects being read. They differ in the amount of background noise as the object is being read. After an object is read aloud, the participant selects the object they believe they heard by clicking on the object with their mouse. There is no time limit. The test is computer adaptive, so that if participants select the incorrect object or select unsure with a certain amount of background noise, the amount of background noise remains constant or becomes less. There is no numeric score given with this test. Instead, the test gives a basic explanation of the participant's hearing level, such as an "ok" level, or that there are some problems hearing. Participants are expected to have at least an "ok" level of hearing to participate in the study.

Measures during simulator sessions

SSQ: The Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1992; Kennedy et al., 1993) contains several multiple choice and short answer questions, as well as a checklist of 31 symptoms which the individual self-rates based on a 4 point Likert scale. This will be given immediately before exposure in the simulator for each session as well as after the day's session has concluded. Participants will be recommended to stay until they return to their baseline score.

NASA-TLX: Measures workload on a multidimensional scale consisting of six subscales (Mental workload, Physical workload, Temporal workload, Subjective rating of performance, Effort, and Frustration), each of which the participant rates from 0 to 100 (Hart, 2006).

Participants will also rate these dimensions in a series of pairwise comparisons. Each dimension will be compared against each other, and the participant will decide which of the two dimensions had more impact for each paired comparison. The workload measure may be administered by paper or by computer. Workload will be measured immediately after a driving simulator drive.

Data collection and analysis

Analyses of the dependent measures in driving performance (speed, lane deviations, turns, stops) will be completed through watching a video of the simulation. Investigators will be involved in analyzing the data as the experiment goes, in other words soon after the participant completes the session. Coding one session of data takes approximately 1 hour. The principal investigator is in control of getting IRB approval. Sub-investigators include undergraduate students (about 3 or 4 students). All the sub-investigators are at least upper level students in psychology. All will undergo any training necessary.

Apparatus

The study will use a GE I-SIM PatrolSim Mark-II+ high fidelity driving simulator. The simulator is composed of five computers, including one running the simulator, three separate visual channels corresponding with three separate projector screens, and a computer for the simulator operator interface. The simulator has a built-in dashboard with standard instruments including a speedometer as well as a fuel and oil gauge that operate realistically. Also included is a steering wheel with horn, driver's seat with seatbelt, areas in the dashboard to place a radio or GPS, and dials for air conditioning. The simulator includes one screen for central viewing through the simulated windshield and two screens on the left and right of the driver for peripheral viewing. There are buttons connected to the center of the steering wheel that allow the driver to pan on the left and right screens to the left or right respectively. This is similar to the driver looking further to the left or right, such as when needing to change lanes to check for traffic. The simulation screens contain two side mirrors and a rearview mirror just as in ordinary vehicles. The left and right A pillars of the vehicle are depicted on the screens.

7) Study Design

a) Recruitment Methods

Word-of-mouth. Individuals from the UCF psychology department, or individuals who know the individuals in the psychology department. About 5 participants will be needed.

b) Participant Compensation

If participants finish the entire study, they will be given $100 cash. If they do not finish the study, they will receive a prorated amount. This will be broken down into 25%, 50%, and 75% of the amount of the study. Thus if participants finish about half of the study, they will receive $50.

c) Inclusion and Exclusion Criteria

Our inclusion criteria are the following: Must be at least age 15 (no maximum age), have some driving experience, have 20/40 near and far visual acuity, no color deficiency, have normal contrast sensitivity, and have normal hearing.

d) Study Endpoints

The experiment ends when in the last phase, which will be a baseline, reaches a steady-state.

e) Study Timelines

This study should take anywhere between 9 and 12 weeks, depending on the length of the initial baseline phase and also depending on the length of time within any phase to reach a steady state. There plans to be a total of five participants. It should take 4 to 5 months to collect data for all participants.

f) Procedures involved in the Human Research.

The study plans to include an older female, two young females, a young male, and an older male for participants. The participants will have some flexibility as to when they can come in to the lab; however, ideally they would come for about 3 to 4 sessions a week each week until the study is completed for the participant. Nevertheless, due to participants' schedules and preferences, there will likely be variability in frequency of coming to the lab.

The study will consist of a small-n design. The design will begin with driving on the simulator with no training or distracters. Of the five participants, two will have an initial baseline of three sessions, two will have an initial baseline of six sessions, and one will have an initial baseline of nine sessions. The second phase will be the distracter phases. Two distracters will be used, including the cell phone conversation and the continuous texting for each participant. Once a steady-state is reached for the first distracter, the second distracter phase will occur. The order of the presentation of the distracters will vary across the participants randomly. After a steady-state is reached for the second distracter, the training will begin of driving the simulator without distracters. In the training phase, the experimenter will give real-time verbal feedback and suggestions on how to improve their handling and control over the driving. Following the training, the distracters will be reintroduced. In between each distracter condition after the training will be baseline conditions. The design therefore can be represented as A_1, B, C, D, A_2, B_2, A_3, C_2, A_4. A's represent the baseline conditions. A_1 is the phase consisting of driving in the simulator without any distracter or training. B is the first distracter phase, whereas C represents the second distracter phase. D is the training phase. A_2 is the second baseline. B_2 is the second introduction of the first distracter. A_3 is the third baseline. C_2 is the second introduction of second distracter. Lastly, A_4 is the final baseline measurement. Most of the phases should take 3 sessions or 1 week. For the distracter conditions, the participants will watch a 30 min segment of a documentary on New York before the simulator session commences.

g) Data management

Survey answers and results of the experiment will not be connected to the identity of the participant. To keep data separated, participants will be assigned a number and data will be tracked using that number. So for a particular session and drive, an example would be participant 0007, session A, drive 1.

h) Provisions to monitor the data for the safety of participants

N/A

i) Withdrawal of participants

Participants are free to withdraw from the study at any time, although if they do, they will not be compensated the full amount as if they completed the entire study (see #9). Participants could be terminated without their consent if they are not cooperative or are showing frequent symptoms of sickness.

8) Risks to participants

Participants will not suffer any greater risk in the study than they would experience at most amusement park virtual rides. If the participants feel ill at any time, they will always be allowed to stop and rest, and if they desire, quit the day’s session or even quit the entire study. It is unlikely that this will occur, however, given that participants will try out driving in the simulator for 15 minutes before they actually participate in the study as a screening tool. Participation in this study is voluntary and subjects can terminate their involvement at any time without consequence (see consent form). Participants' responses will be used purely for data collection and their identities will never be revealed. Therefore, it is unlikely these results will be published in a way that affects the participants personally. Participants will be audio and video recorded for the training sessions. These digital files will be kept on a password protected computer. Information gathered from participants in the surveys could be considered somewhat sensitive, such as items covering accident history.

9) Potential direct benefits to participants

If participants finish the entire study, they will be given $100 cash. If they do not finish the study, they will receive a prorated amount. This will be broken down into 25%, 50%, and 75% of the amount of the study. Thus if participants finish about half of the study, they will receive $50. In addition, participants may gain a better appreciation for the effects of distracted driving. They will also get to practice driving in the simulator, which may benefit novice drivers.

10) Provisions to protect the privacy interests of participants

Participants' names will not be in any way associated with the surveys and data collected. Emails and/or phone numbers will be acquired from the participants; however, these will only be available to the PI. Further, these will not be connected to the data.

11) Provisions to maintain the confidentiality of data

Surveys will not be linked to the identity of participants in any way, shape, or form. Surveys will be identified by number. The paper surveys will be kept in a locked cabinet. Electronic data will be kept on a computer without a password as no participant identification will be kept there. Only lab investigators will have access to the data. Data will be stored indefinitely.

12) Medical care and compensation for injury

If participants become ill from driving in the simulator, they will be allowed to rest and given water and snacks. If needed, they can be recommended to the health center. They will be recommended to not leave the lab until they feel better.

13) Cost to participants

The only costs will be transportation to the lab site. For this reason, only participants in the nearby area will be selected.

14) Consent process

18 and over: Upon beginning the study, all participants will read an informed consent form regarding the study. This will be given to them electronically. They will be given a week to give their consent. This study presents minimal risks to participants and thus qualifies for a "waiver of written documentation of consent." Therefore, consent forms will not be signed. Completing the consent process in this way also helps to protect against breach of confidentiality. The participant will be prompted to read the consent. This should only take

the participant a few minutes to complete. The informed consent is written in a simple manner so that it is easy to understand.

Under 18: A parental consent form will be administered to the parent of the participant. The parent will be required to read and sign the form to approve that their child can participate in the study. The assent of the participant will also be required, where they will have to give their verbal approval of participation in order to participate in the study. Both the signature of the parent on the parental consent form as well as the assent of the child will be necessary for the child to participate. Only one parent signature is needed given that there is a minimal risk involved in the study.

15) Process to document consent in writing

18 and over: We have created a consent form that participants will read in order to obtain any information pertaining to this study. It will be shown to them to review upon beginning the study, but before their actual participation. They will have an electronic copy of the consent form to keep with them.

Under 18: The assent of the child will not require their signature in order for them to participate. However, for the child to participate, the signature of one of the child’s parents will be needed on the last page of the parental consent form.

16) Vulnerable populations

The only vulnerable population that will be included in the study will be individuals under the age of 18. For these particular individuals, a parental signature will be necessary for the individual to participate, in addition to the individual's assent.

17) Drugs or Devices

N/A

18) Multi-site Human Research

N/A

19) Sharing of results with participants

If any participants contact us or express interest, we will share their results the after they have concluded the study. If the participant is a child and they express interest in their results, we will ask them if they would like their parents to see their results as well.

APPENDIX J: IRB CONENT FORM

University of
Central
Florida

Driving Performance Adaptation through Practice with and without Distracters in a Simulated Environment

Informed Consent

Principal Investigator(s):	Marc Gentzler, M.A.
Faculty Supervisor:	Janan Smither, Ph.D.
Investigational Site(s):	University of Central Florida, Psychology Department, room 303e

Introduction: Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study which will include about 5 people from the Orlando area. You have been asked to take part in this research study because you have driving experience. You must be 18 years of age or older to be included in the research study, have 20/40 corrected near and far visual acuity, normal contrast sensitivity, normal far distance color vision, and normal hearing.

The person doing this research is Marc Gentzler of the University of Central Florida Psychology Department. Because the researcher is a graduate student, he is being guided by Janan Smither, Ph.D., a UCF faculty supervisor in the Psychology Department. UCF students learning about research are helping to do this study as part of the research team.

What you should know about a research study:

- Someone will explain this research study to you.
- A research study is something you volunteer for.
- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.

UCF University of Central Florida IRB
IRB NUMBER: SBE-13-09436
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- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

Purpose of the research study: To examine the effects of driver distraction longitudinally. In other words, to determine whether distracter effects can be mitigated longitudinally with practice. Only a few studies have investigated this subtopic, and of the ones that have been conducted, there have been conflicting results. The current study will employ a different methodology then has been used before to study this topic called single subject design, which may be better to examine the effects of individual behavior over time, as well as the effects of practice and training, than using the common group design.

What you will be asked to do in the study:

- Vision tests.
- Several questionnaires that can be filled out at home, assessing demographics, driving habits and history, and cell phone use while driving.
- A hearing test, which can be done at home on the internet.
- Preliminary driving simulator session.
- Three sessions of simulator driving per week. Some conditions will include watching a documentary video on New York, which will take 30 minutes, and will take place before the simulator session starts.
- You will be interacting with an experimenter who may be the principle investigator or an undergraduate research assistant.

You do not have to answer every question or complete every task.

Location: The study will be conducted at the psychology building in room 303e, which is where the driving simulator is located. Some tasks may be conducted in room 303k as well.

Time required: We expect that you will be in this research study for 9 to 12 weeks. You will be expected to attend 3 sessions per week, and each session should last between 45 and 75 minutes.

Audio or video taping: You will be audio taped during a portion of this study. If you do not want to be audio taped, you will still be able to be in the study. Discuss this with the researcher or a research team member. If you are audio taped, the tape will be kept in a locked, safe place. Tapes will be kept indefinitely. Furthermore, you will be video taped during a portion of this study. If you do not want to be video taped, you will still be able to be in the study. Discuss this with the researcher or a research team member. If you are video taped, the tape will be kept in a locked, safe place. Tapes will be kept indefinitely.

Risks: There is a small risk that people who take part will develop what is ordinarily referred to as simulator sickness. It occurs once in awhile to people who are exposed to prolonged continuous testing in simulated enviroments. Symptoms consist of nausea and a feeling of being light- headed. The risk is minimized as a result of the short duration of each session in the simulator. If you experience any of the symptoms mentioned, please tell the researcher and remain seated until the symptoms disappear. It is unlikely that this will occur, however, given that you will try out driving in the simulator for 15 minutes before you actually participate in the study as a screening tool. Your responses will be used purely for data collection and your identity will never be revealed. Therefore, it is unlikely these results will be published in a way that affects you personally. The digital files for audio/video recording will be kept on a password protected computer. Information gathered from participants in the surveys could be considered somewhat sensitive, such as items covering accident history. Survey answers and results of the experiment will not be connected to the identity of the participant. To keep data separated, participants will be assigned a number and data will be tracked using that number.

Benefits: We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include gaining a better appreciation for the effects of distracted driving. Also practicing driving in the simulator may help improve your driving skills and abilities in the real world. The goal of this study is to better understand the effects of distracted driving, which can help improve road safety.

Compensation or payment: Compensation for your participation if you finish the entire study will be $100 cash. If you do not finish the study, you will receive a prorated amount. This will be broken down into 25%, 50%, and 75% of the amount of the study. Thus if you finish about half of the study, you will receive $50.

Confidentiality: We will limit your personal data collected in this study to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of UCF. Surveys will not be linked to the identity of participants in any way, shape, or form. Surveys will be identified by number. The paper surveys will be kept in a locked cabinet. Electronic data will be kept on a computer without a password as no participant identification will be kept there. Only lab investigators will have access to the data. Data will be stored indefinitely. Emails and/or phone numbers will be acquired from the participants; however, these will only be available to the principle investigator. Further, these will not be connected to the data.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, talk to Marc Gentzler, Graduate Student, Psychology Program, College of Sciences, mgentzler@knights.ucf.edu or Dr. Janan Smither, Faculty Supervisor, Department of Psychology at (407) 823-5859 or by email at janan.smither@ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.

- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

Withdrawing from the study: Participants are free to withdraw from the study at any time. If you decide to leave the research, you will be paid for the amount that you participate (see compensation section above). The person in charge of the research study can remove you from the research study without your approval. Possible reasons for removal include not following directions, not taking the task seriously, or if the principle investigator feels it is in your best interest for health reasons to withdraw. We will tell you about any new information that may affect your health, welfare or choice to stay in the research.

Results of the research: The results of your performance may be shared to you soon after you complete the study. This will be done by the principle investigator.

APPENDIX K: IRB PARENTAL CONSENT FORM

University of
Central
Florida

Driving Performance Adaptation through Practice with and without Distracters in a Simulated Environment

Informed Consent from a Parent for a Child in a Non-Exempt Research Study

Principal Investigator(s):	Marc Gentzler, M.A.
Faculty Supervisor:	Janan Smither, Ph.D.
Investigational Site(s):	University of Central Florida, Department of Psychology, room 303e

How to Return this Consent Form: This signed form will need to be handed to the primary investigator only, before the actual study commences.

Introduction: Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being asked to allow your child to take part in a research study which will include about 5 people from the Orlando area. Your child is being invited to take part in this research study because he or she is under 18 years of age and has minimal driving experience, has 20/40 corrected near and far visual acuity, normal contrast sensitivity, normal far distance color vision, and normal hearing.

The person doing this research is Marc Gentzler of the University of Central Florida Psychology Department. Because the researcher is a graduate student, he is being guided by Janan Smither, Ph.D., a UCF faculty supervisor in the Psychology Department. UCF students learning about research are helping to do this study as part of the research team.

What you should know about a research study:

- Someone will explain this research study to you and your child.
- A research study is something you and your child volunteer for.
- Whether or not your child takes part is up to you and your child.
- You should allow your child to take part in this study only because you and your child want to.
- You can choose to not let your child take part in the research study. Your child can choose to not take part in the research study.
- You and your child can agree to take part now and later change your minds.
- Whatever you and your child decide it will not be held against you or your child.
- Feel free to ask all the questions you and your child want before you decide.

UCF University of Central Florida IRB
IRB NUMBER: SBE-13-09436
IRB APPROVAL DATE: 6/26/2013
IRB EXPIRATION DATE: 6/16/2014

Permission to Take Part in a Human Research Study

Purpose of the research study: To examine the effects of driver distraction longitudinally. In other words, to determine whether distracter effects can be mitigated longitudinally with practice. Only a few studies have investigated this subtopic, and of the ones that have been conducted, there have been conflicting results. The current study will employ a different methodology then has been used before to study this topic called single subject design. This design may be better to examine the effects of individual behavior over time, as well as the effects of practice and training than using the common group design.

What your child will be asked to do in the study:

- Vision tests.
- Several questionnaires that can be filled out at home assessing demographics, driving habits and history, and cell phone use while driving.
- A hearing test which can be done at home on the internet.
- Preliminary driving simulator session.
- Three sessions of simulator driving per week. Some conditions will include watching a documentary video on New York, which will take 30 minutes, and will take place before the simulator session starts.
- Your child will be interacting with an experimenter who may be the principle investigator or an undergraduate research assistant.

Your child does not have to answer every question or complete every task.

Location: The study will be conducted at the Psychology Building in room 303e, which is where the driving simulator is located. Some tasks will be conducted in room 303k as well.

Time required: We expect that your child will be in this research study for 9 to 12 weeks. Your child will be expected to attend 3 sessions per week, and each session should last between 45 and 75 minutes.

Audio or video taping: Your child will be audio taped during this study. If you do not want your child to be audio taped, your child will be able to be in the study. Discuss this with the researcher or a research team member. If your child is audio taped, the tape will be kept in a locked, safe place. The tape will be kept indefinitely. Your child will be video taped during this study. If you do not want your child to be video taped, your child will be able to be in the study. Discuss this with the researcher or a research team member. If your child is video taped, the tape will be kept in a locked, safe place. The tape will be kept indefinitely.

Risks: There is a small risk that people who take part will develop what is ordinarily referred to as simulator sickness. It occurs once in awhile to people who are exposed to prolonged continuous testing in simulated enviroments. Symptoms consist of nausea and a feeling of being light-headed. The risk is minimized as a result of the short duration of each session in the simulator. If your child experiences any of the symptoms mentioned, please instruct your child to tell the researcher and remain seated until the symptoms disappear. It is unlikely that this will occur, however, given that your child will try out driving in the simulator for 15 minutes before he/she actually participate in the study as a screening tool. Your childs' responses will be used purely for data collection and his/her identity will never be revealed. Therefore, it is unlikely these results will be published in a way that affects your child personally. The digital files for audio/video recording will be kept on a password protected computer. Information gathered from participants in the surveys could be considered somewhat sensitive, such as items covering accident history. Survey answers and results of the experiment will not be connected to the identity of the participant. To keep data separated, participants will be assigned a number and data will be tracked using that number. Taking part in this research study may lead to added costs to you and/or your child in terms of traveling to the university lab where the research study will take place.

Benefits: We cannot promise any benefits to you, your child, or others from your child taking part in this research. However, possible benefits include gaining a better appreciation for the effects of distracted driving. Also practicing driving in the simulator may help improve your childs' driving skills and abilities in the real world. The goal of this study is to better understand the effects of distracted driving, which can help improve road safety.

Compensation or payment: Compensation for your child's participation if he/she finishes the entire study will be $100 cash. If your child does not finish the study, he/she will receive a prorated amount. This will be broken down into 25%, 50%, and 75% of the amount of the study. Thus if your child finishes about half of the study, he/she will receive $50.

Confidentiality: We will limit your child's personal data collected in this study to people who have a need to review this information. We cannot promise complete secrecy. Efforts will be made to limit your child's personal information to people who have a need to review this information. Organizations that may inspect and copy your child's information include the IRB and other representatives of UCF. Surveys will not be linked to the identity of participants in any way, shape, or form. Surveys will be identified by number. The paper surveys will be kept in a locked cabinet. Electronic data will be kept on a computer without a password as no participant identification will be kept there. Only lab investigators will have access to the data. Data will be stored indefinitely. Emails and/or phone numbers will be acquired from the participants; however, these will only be available to the principle investigator. Further, these will not be connected to the data.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt your child talk to: Marc Gentzler, Graduate Student, Psychology Program, College of Sciences, mgentzler@knights.ucf.edu or Dr. Janan Smither, Faculty Supervisor, Department of Psychology at (407) 823-5859 or by email at janan.smither@ucf.edu.

IRB contact about you and your child's rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

Withdrawing from the study: You may decide not to have your child continue in the research study at any time without it being held against you or your child. Also, your child may decide to not continue in the research study without it being held against you or your child. If you decide to have your child leave the research, or your child decides to leave the research, your child will be paid for the amount that he/she participates (see compensation section above). The person in charge of the research study can remove your child from the research study without your approval. Possible reasons for removal include not following directions, not taking the task seriously, or if the principle investigator feels it is in your child's best interest for health reasons to withdraw. We will tell you and your child about any new information that may affect your child's health, welfare or your choice to have your child stay in the research.

Results of the research: The results of your child's performance may be shared to you and your child soon after he/she completes the study. This will be done by the principle investigator.

Your signature below indicates your permission for the child named below to take part in this research

DO NOT SIGN THIS FORM AFTER THE IRB EXPIRATION DATE BELOW

Name of child participant

Signature of parent or guardian*

Date

☐ Parent
☐ Guardian (See note below)

Printed name of parent or guardian*

If signature of second parent not obtained, indicate why: (select one)
☐ IRB determined that the permission of one parent is sufficient

Assent
☐ Obtained verbally

Signature and Printed name of person obtaining consent and assent

My signature and date indicates that the information in the consent document and any other written information was accurately explained to, and apparently understood by, the participant or the participant's legally authorized representative, and that informed consent was freely given by the participant or the legally authorized representative.

***Note on permission by guardians:** An individual may provide permission for a child only if that individual can provide a written document indicating that he or she is legally authorized to consent to the child's general medical care. Attach the documentation to the signed document.

University of Central Florida IRB
IRB NUMBER: SBE-13-09436
IRB APPROVAL DATE: 6/26/2013
IRB EXPIRATION DATE: 6/16/2014

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