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Journal of Information Systems Applied Research

Dangers of Distracted Driving by Mobile Phone Users: An Experimental Approach

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Abstract

Using mobile phones while driving has been dramatically increasing for the last years, causing fatal accidents on roads. Although prior studies on mobile distraction while driving have investigated this issue, they focused on the relationship between using texting or calling and safe driving based on self-reported survey data. In order to fill the gap, this research investigates the impact of various distractions, including voice calling, texting, social network service (SNS), and selfie, on the level of potential dangers imposed by each distraction, employing a driving simulator which has rarely been used in the prior studies. The major findings include that each mobile distraction imposes a different level of potential dangers to drivers: using SNS causes the largest danger in driving, followed by texting, calling, and selfie.

Keywords: Distracted Driving, Multitasking, Mobile Distractions, Safe Driving, Mobile Phones

1. INTRODUCTION

Driving is a complex task that requires drivers to perform various cognitive, physical, sensory and psychomotor skills (Young, Regan, & Hammer, 2007). Distracted driving has been a part of the history of driving automobiles that began in the mid-1800s. However, mobile phones enabling drivers to perform multiple tasks, which is called mobile distractions, have added a new chapter to the history. Mobile distractions can be defined as any activity that diverts a person's attention away from the primary task of driving. This definition therefore includes any activity that occurs while a driver is using a mobile phone. As smart phone's capabilities have increased and advanced technologies have been introduced more than texting and receiving telephone calls, drivers have increased opportunities for deadly results. Notably, as smartphone functions expand and social media platforms become more widely adopted and regularly used, some drivers cannot seem to turn away from their apps and phones while behind the wheel.

With today's pervasive use of mobile cell phone devices, multitasking behavior has become commonplace at work, in the classroom, and everywhere else, including even on the road (González & Mark, 2004; Kraushaar & Novak, 2010; Stephens & Davis, 2009). Technology through cell phone use has increased the opportunity for multitasking, which may include more than the action of driving and texting and talking, it can also include multiple actions on the phone such as calling and texting, sending pictures, and preforming other activities which would include multiple multitasking functions or activities. However, when using mobile phone while driving, a driver may not only be less efficient but also can make more risky mistakes. Therefore, simple distractions from using the phone can create dangerous actions such as speeding up and slowing down, lane changes that result in collisions with other vehicles, and even fatal car crashes.

This research investigates the potential impact of mobile distractions based on the theory of multitasking, which has been widely used in various behavioral studies (Salvucci & Taatgen, 2008) and provides a theoretical lens to examine how using mobile phone affects driving performance and causes dangerous situations on the road.

2. LITERATURE REVIEW

Distracted Driving

The National Highway Traffic Safety Administration (NHTSA) defines distracted driving as "any activity that diverts a driver's attention away from the task of driving" (Ranney, Mazzae, Garrott, & Goodman, 2000). Thus, any distraction in driving can be classified as distracted driving. The distractions can be categorized into four groups, which are visual distractions, auditory distractions, biomechanical distractions, and cognitive distractions (Ranney et al., 2000). Visual distraction includes looking at anywhere else other than the road ahead. It also includes looking at the screen of the mobile phone. Auditory distraction includes actions like responding to a cell phone and turning off an alarm clock. Biomechanical distraction includes using hands to turn on/off the radio, rolling down a window, and adjusting the mirror. Finally, cognitive distraction includes thinking about other things while driving (Ranney et al., 2000). It is obvious that one distraction can have more than one distractions. For example, playing mobile games while driving (Postelnicu, Machidon, Girbacia, Voinea, & Duguleana, 2016) can cause all the aforementioned distractions. These distractions have been a primary reason for accidents on roads. According to the National Traffic Safety Administration, 37,461 lives were lost on the U.S. roads in 2016, an increase of 5.6 % from 2015. Of these, 3,450 were reportedly due to distracted driving (NHTSA, 2018).

Mobile Distractions

Human multitasking behavior while driving is not a new phenomenon. Historically, drivers have multitasked as they attempted to tune into their favorite radio station, apply make up on the way to work and simultaneously eat and drive. However, the impact of mobile distractions are far more substantial than the traditional ones. Currently, there are 266 million cell phone users in the United States as of 2017 (PYMNTS, 2017). The amplified use of mobile phones along with the increased triggers and pressures of work and private life have transformed multitasking from occasional usage to a habit (Adler & Benbunan-Fich, 2015) even while driving, which can invite enormous dangers into the driving environment. Even for experienced drivers, the risk of a crash or near-crash increased significantly if they were dialing on a cell phone (Klauer et al., 2014).

Driving is a highly complex task that involves many sensory functions as well as psychomotor skills (Young et al., 2007). Therefore, texting and calling as well as performing other mobile distractive activities are a significantly dangerous behavior. According to research by AT&T's "It Can Wait,"(AT&T, 2018) campaign, however, 7 in 10 people are engaging in smartphone activities while driving, and the distracted driving has become a "habit," for 1 in 3 drivers.

The significance of mobile distractions has attracted attention from researchers in both practice and academia. Regan, Lee, and Young (2008) suggested that distracted driving results in two different forms of hazards. The first is the "driver distraction," which occurs when the primacy of the social role "driver" affects the person's on-road behavior. The second is "distracted driving," which occurs when circumstances act to divert attention from the driving task. Nemme and White (2010) utilized an extended theory of planned behavior (TPB) to predict the factors that could lead to the reading of and sending of text messages. They identified that driver's attitude is the most important predictor in sending and reading text messages. Caird, Johnston, Willness, Asbridge, and Steel (2014) conducted a meta-analysis and found that typing and reading text messages while driving adversely affected a series of activities related driving, including eye movements, reaction time, lane positioning, and speed. Haddington and Rauniomaa (2011) utilized video recording analysis that includes mobile phone usage while driving, particularly in the pre-beginning stage of answering the phone. They reported that the mobile phone activity could be a potential danger to safe driving. Adopting an experimental approach, Hancock, Lesch, and Simmons (2003) found that in-vehicle technologies erode performance safety margins and could potentially distract drivers from controlling their vehicles. Nasar, Hecht, and Wener (2008) extended Hancock and colleagues' study and further confirmed that usage of mobile devices are dangerous for both drivers as well as pedestrians. Based on their survey data from 40 students, Levy, Pashler, and Boer (2006) identified that the break reaction time increases when stimulus onset asynchrony was reduced. Similar results were found in a later study (Levy & Pashler, 2008). Watson and Strayer (2010) found that although the majority of individuals would experience decreased performance in driving while talking on a cell phone, some people might not have any performance decrease due to performing dual tasks. It has also been found that the performance of conducting dual tasks may be increased with proper training (Gugerty, 2011).

Although many prior studies investigated diverse aspects of mobile distractions while driving, few focused on comparing the level of potential dangers by different mobile distractions. In addition, they mainly considered calling and texting but did not examine new mobile activities with smartphones, such as taking a selfie and using social network services (SNS). In terms of research methodology, they mostly used self-reported survey data, which may not be enough to explain a realistic behavior of the driver using their mobile phone for various activities. To fill in the research gaps, we investigates the impact of various mobile distractions by adopting the use of a driving simulator. W compare the significance of the distraction to understand which mobile distractions imposed the more or most danger to the driving environment.

3. CONCEPTUAL FORMATION

Multitasking Theory

Multitasking can be defined as "performing two or more tasks at once" (Salvucci & Taatgen, 2008), which are composed of three dimensions (Benbunan-Fich, 2012). The first component are causal antecedents, which includes individual preferences and situational demands. Individual preferences include the way people perceive and think about the specific tasks and a specific way to solve the issues. Temporal perception can be divided into monochronic and polychromic (Hall, 1959). People who have polychromic time will more likely engage in multitasking behaviors (Benbunan-Fich, 2012). In the context of driving, thus, monochronic drivers may prefer to drive without doing anything else, while polychronic drivers tend to do other tasks such as mobile phone use while driving. Situational demands are the second component. While driving people may feel the pressure to use mobile phones and other technologies. For instance, drivers must ask themselves on a regular basis if they are going to miss their best friend's message regarding plans for the weekend or preform other activities like immediately posting a selfie and information while driving. Finally, patterns of enhancement shift is the third component of the theory. It suggests that multitasking behaviors will happen if there are internal or external triggers. In driving situations, there may an internal desire to use mobile phones. The driver may want to play a video game or send a text. Individuals in the car can create an external trigger, asking the driver to change a music selection on their smartphone, which is connected to the vehicle's music player.

Hypothesis Development

This study adopts the theory of multitasking as its framework for developing hypotheses: as individuals are obviously undertaking more than one task when using a mobile phone while driving. According to the theory, multitasking generally decreases processing speed for a principal tests and increase errors (Spink, Cole, Waller, & technology, 2008) as well as increasing a psychological stress, which may be an additional distraction to deter processing of the principal task. One of the reasons that multitasking decreases task performance is frequent switching between tasks. People need to set up a different cognitive set when switching to another task. The switching negatively affects working memory of the people, which is known as the most important factor to predict performance on multitasking (Otto, Wahl, Lefort, & Frei, 2012). Another influential factor is task complexity. As people process more diverse, complex tasks simultaneously, they perceive more difficulties in multitasking (Czerwinski, Horvitz, & Wilhite, 2004) and therefore, taking more time to process but making more mistakes. The central-bottleneck (CB) theory lends support to the aforementioned discussion. According to the theory, certain mental operations cannot be performed at the same time (Levy et al., 2006).

Therefore, when people are in multitasking situations, their performance including accuracy and speed tends to decrease.
As discussed, it is expected that the level of the performance decrease is determined by diversity and difficulty of tasks. As people have to conduct more diverse and difficult tasks, they are more likely to make more mistakes and take more time to complete the entire tasks. In the context of mobile distractions while driving, it is expected that the four mobile distractions have different level of diversity and difficulty.

In this study, five scenarios were selected, including driving with no distraction, snapchatting while driving, texting while driving, taking a selfie while driving, and talking over the phone and driving. Those combinations are the most common mobile phone activities while driving (AT&T, 2015). Concerning SNS, Snapchat is selected to represent the activity. Snapchat is a multimedia social messaging application that allows users to share pictures and messages to friends. There are about 191 million daily active users of Snapchat in 2018 (@StatistaCharts, 2018). Especially, college students use that while driving and thus, has been shown to be a major reason for car accidents (Vaysberg, 2015). One of the reasons for using Snapchat while driving is its unique feature, which allows user to post a picture with current speed, which is called a "Geofilter" (Atchley & Strayer, 2017), potentially motivating drivers to use Snapchat while driving (Boudette, 2016; McNabb & Gray, 2016).

Snapchatting requires frequent switching between various tasks, causing multiple distractions while driving such as visual distractions, cognitive distractions, and manual distractions (Martell, 2018). For example, drivers have to look at their screen when Snapchatting, which takes their vision away from the road (i.e., visual distraction). In addition, drivers need to think about the content received or sent via Snapchat, which creates another distraction (i.e., cognitive distractions). In order to use Snapchat, lastly, drivers have to type holding the phone, which means at least one of the hands will be off the steering wheel (i.e., Manual distractions). Therefore, Snapchatting would impose more diverse distractions than any other mobile distractions and consequently, creating more dangers. Thus, we propose the following hypothesis:

H1: Snapchatting while driving is more dangerous than other mobile phone activities while driving.

Prior studies commonly reported that texting while driving adversely affects the reaction time and lane positioning in driving (Caird et al., 2014). In addition, they illustrated that the negative effect is more significant than making a phone call (Nelson, Atchley, & Little, 2009; Owens, McLaughlin, & Sudweeks, 2011). In terms of multitasking theory, texting is more difficult than calling, imposing more visual and manual distractions. For example, a drive in order to read something must divert their eyes from the vehicle windshield and use multiple keys to manually type in texts. Typing is a substantially more diverse task than calling, which simply creates cognitive distraction for conversation and the manual distraction of holding a mobile phone. Thus, we propose the following hypothesis:

H2: Texting while driving is more dangerous than calling while driving.

Many drivers take selfies while driving and then post the pictures on their SNS (Chae, 2017; Qiu, Lu, Yang, Qu, & Zhu, 2015). Although little extant literature concerning distracted driving discussed about its effect on driving performance, taking a selfie while driving would create a significant distraction because the driver will have to look at the mobile phone screen and focus in order to take the selfie. Compared to calling, the drivers more frequently look at the screen to operate and see the camera while less frequently to see it when texting. This discussion suggests the following hypothesis:

H3: Taking a selfie while driving is more dangerous than calling, but less dangerous than texting while driving.

As many prior studies have found, making phone calls while driving creates a distraction (Collet, Guillot, & Petit, 2010; Tison, Chaudhary, & Cosgrove, 2011; K. M. White, Hyde, Walsh, & Watson, 2010; M. P. White, Eiser, & Harris, 2004). These findings correspond to the concept of multitasking. For example, calling creates an additional task in a driving situation because they have to listen to someone they talk with, understand, prepare their answers, and answer (i.e., cognitive distraction) as well as hold the phone while talking (i.e., manual distraction). Therefore, the following hypothesis is proposed.

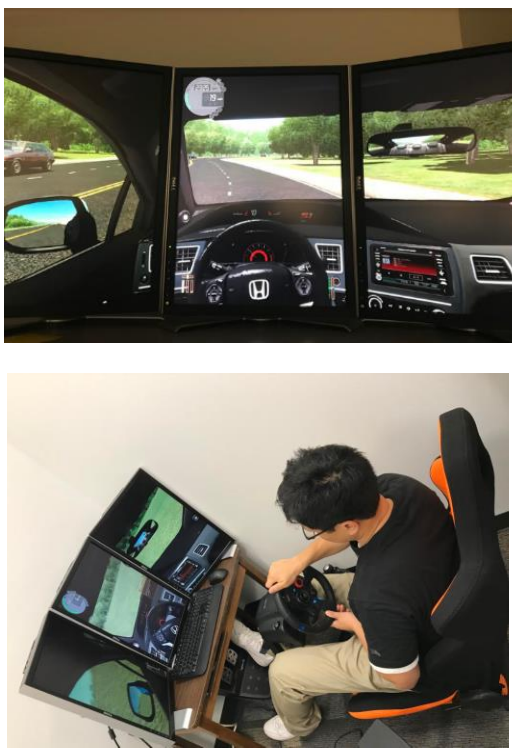
H4: Calling while driving is more dangerous than driving with no distractions.

4. METHODOLOGY

Experimental Design

We conducted a laboratory experiment to test the proposed hypotheses. We constructed a driving simulator using a Logitech G29 racing wheel and City Car Driving software, which is a car simulation game (Figure 1). The software provided a more realistic driving environment than general car simulation video games that emphasize unrealistic racing components for fun. In the software, users had to follow all traffic rules such as speed limit adherence and signaling lane changes. Subjects participated in the experiment reported that the simulator provided a realistic driving environment (3.6 out of 5.0).

Figure 1. Driving Simulator



Before the experiment, a pilot test was administered to detect potential issues in the experiment design with six subjects. Based on the pilot test, we revised the experiment's design in terms of session time, driving difficulty, driving environment (e.g., town or highway), weather, vehicle types (e.g., sedan or SUV), and traffic conditions. The experiment is composed of five sessions with the four mobile distractions (i.e., stimulus) in the hypotheses and one session without distractions in order to measure the impact of mobile distractions on driving performance. Each experiment with the five sessions took approximately 60 minutes to complete. The driving environment was set to a highway environment with moderate traffic entering the highway but the environment where few external distractions existed. This allowed us to measure the impact of mobile distractions, minimizing the other distractions.

The experiment adopted a within-subject design to test the different effects of mobile distractions on driving performance. This is an adequate design for our study in that it can rule out individual differences in subjects and test the effect of treatment conditions, which are the four mobile distractions.

Subjects

From December 2017 to January 2018, a pre-screening survey was initially administered, and eighty-eight samples were collected at a state university. In order to select adequate subjects, the researchers controlled relevant factors to driving performance, such as gender, age, driving experience, car accident experience, and smartphone use experience while driving. Thirty subjects who had similar demographics and driving experience were selected for the final study. All participants had experience in the use of mobile phones while driving for calling, texting, selfies, and SNS with no car accident experiences. They were also Snapchat users, which is one of the most popular SNSs in the U.S. and used for the experiement. Table 1 illustrates their profile.

Table 1. Subject Profile

Category	Group	Frequency	
Gender	Males		15
	Females		15
-	Average	Min	Max
Age	21.4	20	27
Driving Experience	5.87	3	11

Experiment Procedure

Before the driving simulation session, a practice session was held to train the participants on how to use the simulator and the driving wheel. After the practice session, five tasks were randomly administered to rule out possible time effect, which experiment subjects can be more proficient at a task as they complete more instances and thus, tend to present superior performance in the later sessions (Gravetter & Forzano, 2018). In the driving experiment, it is possible that they performe better at the end of the experiment because they may become more proficient by experiencing the same driving environment.

In the *no distraction session*, subjects were asked to drive the simulator without any mobile phone use, fully focusing on driving. In the *calling session*, they talked with one of our researchers and were asked several simple questions. All subjects received the same questions in order to control for possible external effects on driving performance. One example of the questions asked includes, "What did you eat for dinner last night?". In the *texting session*, one of our researchers asked several questions via texts. In the *selfie session*, subjects took several selfies when the session leader asked. After taking each selfie, they set their mobile phone back to their home page. They took 5 selfies that required approximately four minutes. Lastly, the subjects were asked to post some of the selfies on their Snapchat Story section with short comments in the *snapchat session*. The subjects typed the same caption on each of the pictures to control the length and/or complexity of the captions.

After all five tasks had been completed, post interviews were conducted to collect quantitative data about their feelings and opinions of the experiment. In the interview, particularly, the researchers focused on the relationship between mobile distractions and driving performance.

Measurement

In the five task sessions, the distractions were implemented for the same amount of time which was approximately four minutes in length. The time factor is important because as the subjects might face a mobile distraction for a longer time, they would likely make more mistakes. Since the purpose of our study was to understand the impact of different mobile distractions, we controlled the time of each distraction.

The simulation software, City Car Driving, used in the experiment provided data concerning driving performance and safe driving such as the types and the number of violations and accidents. The significance of each violation is measured by the amount of a monetary fine for the violation. As an example, driving in the opposite lane is defined as a far more significant violation than not turning on a direction light when changing lanes. In order to measure the distractions, we considered both the number of violations (i.e., frequency) and the total amount of monetary fines due to the violation (e.g., significance).

Analysis Results

The proposed hypotheses were tested using a repeated measure ANOVA design. This is adequate to test behaviors of the same individuals over different conditions (Brady, Bourdeau, & Heskel, 2005).

First, the hypotheses were tested using the number of violations as the dependent variable. Before testing the hypothesis, we examined violations of sphericity with Mauchly's test of sphericity. Mauchly's test was significant (p=0.04) and thus, we applied the correction factor epsilon (ε) to the degree of freedom. Because the Greenhouse-Geisser estimate of sphericity (ε =0.768) was larger than 0.75, we employed the Huynh-Feldt correction. The main effect of mobile distractions was significant ($F_{3.616,\ 101.249} = 16.179$, $p < 0.01$, $\eta^2=0.366$), indicating a statistically meaningful difference in the number of violations across different mobile distractions. As illustrated in Figure 2, using Snapchat while driving caused more violations than any other mobile distraction (*M*=7.500, *SD*=1.241). This corresponds to Hypothesis 1, which predicted the largest distraction of using Snapchat. In the post hoc comparisons performed with Bonferron, adjustment for multiple comparisons, however indicated that the difference between using Snapchat and texting is not statistically significant, while its differences from the rest of the distractions are significant ($p < 0.001$). This result partially supports Hypothesis 1.

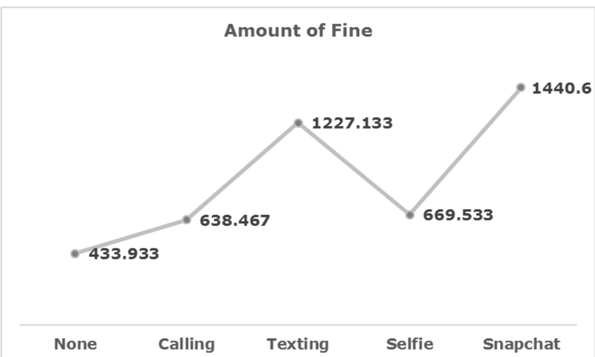
Figure 2. Means for Number of Violations

Concerning Hypothesis 2, the subjects experienced more violations in the *texting session* (*M*=6.267, *SD*=0.922) than the *calling session* (*M*=3.200, *SD*=0.714). This difference was statistically significant in the post hoc comparisons ($p<0.01$). Therefore, Hypothesis 2 is supported.

Testing Hypothesis 3, taking a selfie (*M*=3.100, *SD*=0.712) caused fewer violations than calling (*M*=3.200, *SD*=0.714) and texting (*M*=6.267, *SD*=0.922). In the post hoc comparisons, the difference between taking a selfie and texting is statistically significant (p<0.01) but not between taking a selfie and calling (p>0.05). This result partially supports Hypothesis 3, predicting that taking a selfie imposes more distractions than calling, but less than texting. Lastly, although subjects committed more violations when they were calling (*M*=3.200, *SD*=0.714) than when they had no mobile distraction (*M*=2.033, *SD*=0.357), the difference was not statistically significant (p>0.05).

In addition, we tested the hypotheses based on the amount of fines in U.S. dollars caused by the violations. The Mauchly's test of sphericity for this analysis indicated no violation of sphericity (p = 0.524). The main effect of different mobile distractions was significant ($F_{4,\ 15.389}$ = 15.389, p <0.001, η^2=0.355). Figure 3 presents the means for the amount across the five tasks.

Figure 3. Means for Amount of Fine



The amount of the fines caused by using Snapchat (*M*=1440.600, *SD*=2347.541) is the largest followed by texting (*M*=1227.133, *SD*=181.990), taking selfie (*M*=669.533, *SD*=151.610), calling (*M*=638.467, *SD*=158.500), and no distraction (*M*=433.933, *SD*=75.782).

Although there are differences across the five task sessions, some differences were not found to be statistically significant. For instance, using Snapchat and texting imposed statistically more distractions than calling and taking a selfie in terms of the fine amounts. However, the difference between calling and taking a selfie was not statistically significant in the post hoc comparisons (p>0.05). In addition, the amount of the fine caused by calling and taking a selfie was not statistically higher than driving without a mobile distraction (p>0.05). Table 2 summarizes the hypothesis test result.

Table 2. Hypothesis Test Result

Hypo.	Prediction	Result
H1	Snapchatting while driving is more dangerous than other mobile phone activities while driving.	**Partially Supported**
H2	Texting while driving is more dangerous than calling while driving.	**Supported**
H3	Taking selfie while driving is more dangerous than calling but less than texting while driving.	**Partially Supported**
H4	Calling while driving is more dangerous than driving with no distractions.	**Not Supported**

5. DISCUSSION AND CONCLUSION

This study investigated the impact of various mobile distractions on driving performance and safe driving adopting the multitasking theory and a driving simulator. Particularly, it examined the mobile distractions that prior studies had barely considered, such as Snapchatting and taking selfies, which have become a popular activity.

Concerning the impact of using Snapchat while driving, we found that it imposes more dangers (i.e., more violations and fines) than the other distractions. Although the difference from texting is not statistically significant, the actual number of violations and the dollar amount of the fines are higher than any other distractions in the experiment. As previously noted, texting is a highly dangerous mobile distraction. Although texting caused fewer violations (*M*=6.267) than Snapchatting (*M*=7.5), the difference between the two is not statistically significant. This implies that texting is a highly distractive, dangerous action compared to the other mobile distractions. In the post-interview, most subjects mentioned that typing in both texting and Snapchatting was the most difficult and distractive to their driving because it requires them to hold, look at, and type on their mobile phone. Accordingly, texting is found to be more dangerous than calling while driving, corresponding to the extant literature (Nelson et al., 2009; Owens et al., 2011).

The experiment result concerning the impact of taking a selfie is mixed in the comparisons using the number of violations and the amount of fines. Although the subjects committed slightly fewer violations (*M*=3.1) than calling (*M*=3.2), the amount of the fines were higher (*M*=669.533) than calling (*M*=638.467). This indicates that taking a selfie causes serious violations such as crossing over into other driver's lanes. However, taking a selfie is less distractive than both texting and Snapchatting.

Although the subjects committed more violations when they were calling (*M*=3.2) than no distraction (*M*=2.033), the difference was not statistically significant in the post hoc comparisons (p>0.05). This does not correspond to the extant literature (Collet et al., 2010; Tison et al., 2011; K. M. White et al., 2010; M. P. White et al., 2004). One of the possible explanations for this unexpected finding is that the subjects are young, who are somewhat proficient in completing simple multitasking activities (Willingham, 2010). Compared to other mobile phone activities, such as texting and Snapchatting, calling is substantially simple; once clicking an icon on the screen, they can perform the task without additional distractions. In the post interview, most subjects stated that it was easy to talk on their phones during the experiment because they have more experience with calling than other mobile phone activities while driving. This is supported by the finding of Gugerty (2011), reporting that the performance of conducting dual tasks may be increased with proper training and experience. Another explanation can be that the driving environment was that of a highway with controlled entrances, and thus relatively simpler than a busy downtown area or city where many other vehicles such as buses and taxis would have been involved. A statistically significant difference may have been found if there were more external factors that the subjects had to pay attention to, such as traffic signals, signs, and other vehicles entry and exit points.

6. LIMITATIONS AND FUTURE RESEARCH

This study has several limitations, mainly concerned with research design and subjects used in the experiment. First, although this is one of the first attempts to examine the impact of mobile distractions using a driving simulator, which can provide more realistic results than a survey instrument, it is different from a real driving situation. As some subjects indicated, for example, the driving wheel of the simulator was smaller and thus, more sensitive than a real driving wheel. In the future, researchers who investigate this issue may consider preparing a more realistic driving simulator with advanced technologies (e.g. virtual reality).

Second, the subjects did not include a diverse group in terms of their demographics. Some unexpected findings (e.g., no significant difference between calling and no distraction) may be derived from the characteristics of the subjects who are highly young and proficient at multitasking. Future studies may investigate diverse groups in the area of demographics in order to compare how mobile distractions are affected by age and other demographic factors.

Lastly, future studies may consider additional mobile distractions, such as emailing and web browsing that drivers frequently conduct while driving. Although this study considered novel distractions that extant literature did not consider (e.g., Snapchatting and selfie), there are more mobile phone activities that might be considered. According to a survey conducted by AT&T (2015), for instance, 33% and 28% of drivers respectively have used email and web browser while driving. The comparisons among various mobile distractions would extend the spectrum of multitasking theory and the understanding of the distractions while driving.

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