# Driving Distractions and Multi-tasking: An Investigative Study

Hoon S. Choi
choihs@appstate.edu

Jason Xiong
xiongjj@appstate.edu

B. Dawn Medlin
medlinbd@appstate.edu

Computer Information Systems & Supply Chain Management
Walker College of Business
Appalachian State University
Boone NC, 28608 USA

## Abstract

Mobile distractions in driving can be defined as any activity that diverts a person's attention away from the primary task of driving. Therefore, texting, calling, messaging, and taking selfies are all forms of driver distractions. In order to understand the dangers of mobile distractions, this paper investigates the impact of various types of distractions and their effects on driving performance, as well as the level of potential dangers imposed by each distraction. Adopting the use of a driving simulator, which has rarely been used in prior experiments, this study found that each mobile distraction causes a different level of complexity related to driving performance. For instance, texting and using a Social Network Service (i.e., Snapchatting) created the largest distraction to driving.

**Keywords:** Distracted Driving, Multitasking, Mobile Distractions, Mobile Applications, Mobile Phones

## 1. INTRODUCTION

Distracted driving has been a part of the history of driving automobiles that began in the mid-1800s. Throughout history, other people, playing music, and performing other activities in an automobile setting have diverted driver's attention away from the task of driving and paying close attention to that one activity - driving. Driving has been shown to be a complex task that requires drivers to perform various cognitive, physical, sensory and psychomotor skills (Young, Regan, & Hammer, 2007). 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 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 and opportunities for distraction through cell phone use has increased the opportunity for multitasking which may include more than the action of driving and texting and talking, it also can 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.

When switching from one task to another, a driver may not only be less efficient, but they can also make more mistakes. Therefore, simple distractions from one task to another 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. Through the use of the theory of multitasking, we can examine the potential threats posed by distractive driving.

## 2. LITERATURE REVIEW

### Distracted Driving

The National Highway Traffic Safety Administration (NHTSA) defined 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 can be classified as distracted driving. Furthermore, distractions can be classified into four categories, 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 overlaps do exist between those categorizes. Playing mobile games while driving (Postelnicu, Machidon, Girbacia, Voinea, & Duguleana, 2016) is one of the examples that includes 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 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 is not a new phenomenon. Historically, drivers have multitasked while driving as they attempted to tune into their favorite radio station, apply make up on the way to work and simultaneously eat and drive. With more than 266 million cell phone users in the United States as of 2017 (PYMNTS, 2017), technology is playing an important role in all aspects of human life . The amplified use of mobile phones along with the increased triggers and pressures of work and family life have transformed multitasking from occasional usage to a habit (Adler & Benbunan-Fich, 2015), which can invite enormous dangers into the driving environment.

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

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 fundamentally different forms of hazards. The first form is the "driver distraction," which occurs when the primacy of the social role "driver" affects the person's on-road behavior. The second form is "distracted driving," which occurs when circumstances act to divert attention from the driving task. This study focuses on the second form of distracted driving. 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 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 on video recording analysis that included 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 the 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 will increase when stimulus onset asynchrony (SOA) was reduced. Similar results were found in a later study (Levy & Pashler, 2008). However, while the majority of individuals will experience decreased performance in driving while talking on a cell phone, a small portion (2.5%) of the participants may not have any performance decrease due to performing dual tasks at the same time (Watson & Strayer, 2010). 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 performing 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 truly enough to explain a realistic behavior of the driver using their mobile phone for various activities. To fill in the gaps, this study investigates the impact of various mobile distractions by adopting the use of a driving simulator. We attempted to 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

Benbunan-Fich (2012) introduced the theory of multitasking behavior, which consisted of three main components. 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 polychronic 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. Although technology-mediated driving is not unusual anymore, people may feel the pressure to use mobile phones and other technologies while driving. 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 as it is connected to the vehicle’s music player.

As interdisciplinary research, this study utilizes the theory of multitasking as the theoretical lenses, as individuals are generally undertaking more than one task when using a mobile phone while driving. Multitasking can be defined as “performing two or more tasks at once” (Salvucci & Taatgen, 2008). With the recent emerging development in information technologies, including autonomous vehicles, machine learning, augmented reality, virtual assistants, and deep learning (Panetta, 2017), multitasking may be shown to increase work efficiencies. Multitasking activities using technology while driving are not new. As discussed, however, multitasking using the technology can be a double-edge sword as it relates to driving.

### Hypothesis Development

Four scenarios were selected, including driving with no disruption, snapchatting while driving, texting while driving, taking a selfie while driving, and talking over the phone and driving. Those combinations are the most common multitasking activities while driving (AT&T, 2015).

According to the central-bottleneck (CB) theory, certain central 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 tend to decrease. The level of the 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.

Concerning SNS, snapchat is selected to represent a social network service. Snapchat is a multimedia social messaging application that allow users to share pictures and messages to friends, which will be only available for a short amount of time. There are about 191 million daily active users of Snapchat in 2018 (@StatistaCharts, 2018). While Snapchat is one of the most popular social network services, many people, 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 an unique feature, which allows user to post a picture with current speed, which is called a Geofilter (Atchley & Strayer, 2017). This potentially motivates drivers to use Snapchat while driving (Boudette, 2016; McNabb & Gray, 2016).

Snapchatting generates multiple distractions, including visual distractions, cognitive distractions, and manual distractions (Martell, 2018). Visual distractions mean that people will have to look at their screen when Snapchatting, which takes their vision away from the road. Cognitive distractions suggest that drivers will think about the content received or sent via Snapchat, which creates distractions from driving. Manual distractions suggest that in order to use Snapchat, drivers will have to type and hold the phone, which means at least one of the hands will be free and off of the steering wheel. Compared to other mobile distractions, therefore, Snapchatting would impose more danger to the driver. 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, and imposes 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, rather than calling is a substantially more diverse task, than calling, which simply imposes 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). While little extant literature concerning distracted driving has been discussed, taking a selfie while driving would create a significant distraction as the driver will have to look at the mobile phone screen and focus in order to take the selfie. Actually, this sis a simplification of the process. Compared to calling, the drivers more frequently look at the screen to operate and see the camera while less frequently to see it while texting, suggesting 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. Calling while driving would create an additional task in a driving situation because they have to listen to, understand, and prepare their answers (i.e., cognitive distraction) and 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

The researchers 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 a general car simulation video game that emphasizes unrealistic racing components for fun. In the software, the users had to follow all traffic rules such as speed limit adherence and signaling lane changes. The subjects reported that the simulator provided a realistic driving environment (3.6 out of 5.0).

Before the experiment, a pilot test was conducted to detect potential issues in the experiment design with six subjects. Based on the feedback from the pilot test, the researchers 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 without distractions in order to measure the impact of mobile distractions on driving performance. Each session took approximately 60 minutes to complete. The driving environment was set to a highway environment with moderate traffic entering the highway, but where few external distractions existed. This allowed the researchers to measure the impact of mobile distractions on driving performance, excluding the other distractions.

**Figure 1.** Driving Simulator

We employed a within-subject experimental 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 different 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 to participate in the final study. Each participant 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. 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 beginning 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 administered to rule out possible time effect. Because subjects can be more proficient at a task as they complete more instances, they tend to present superior performance in the later sessions (Gravetter & Forzano, 2018). In the driving experiment, it is possible that they performed better at the end of the experiment due to the fact that they had 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 included, "What did you eat for dinner last night?" which is a far simpler question than "What is the biggest challenge in your life right now and why?" 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 to 10 selfies that required approximately four minutes according to their proficiency of taking selfies. 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 due to the length and/or complexity of the captions. It was expected that in-depth captions may cause an undue influence on their driving performance.

After all five tasks were completed, 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 the 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 such as the type and the number of violations and accidents. 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. The difference is measured by the amount of a monetary fine for the violation. In order to measure driving performance, 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 allowed the researchers to test for measuring 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 the hypothesis testing, 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 on driving performance. 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.

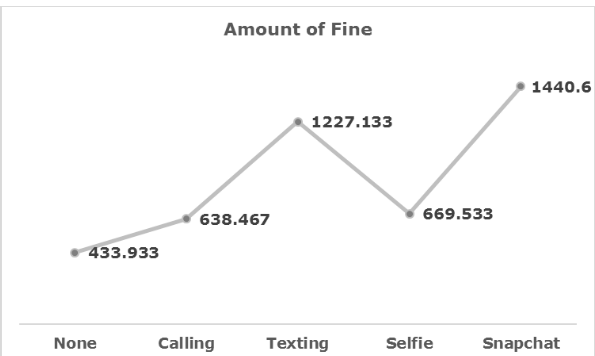
**Figure 2.** Means for Number of Violations


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.

We tested the hypotheses, adopting 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, $\eta^2$=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).

**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 Support ed** |
| **H4** | Calling while driving is more dangerous than driving with no distractions. | **Not Supported** |

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.

## 5. DISCUSSION AND CONCLUSION

This study investigated the impact of various mobile distractions on driving performance adopting the multitasking theory. Particularly, it examined 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, the researchers found that this activity statistically 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 the other distractions. 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, which is also a part of Snapchatting, is a highly distractive action in comparison to the other mobile distractions. In the interview conducted after completion of the experiment, most subjects mentioned that typing in both texting and Snapchatting was the most difficult, and was distractive to their driving. This activity required each subject to physically hold their mobile phone so that they could see the screen while they were typing. 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 would cause 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, and may be somewhat proficient in completing simple multitasking activities (Willingham, 2010).

Compared to other activities with mobile phone usage, such as texting and Snapchatting, calling is substantially simple; once clicking an icon on the screen, they can conduct the activity 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 they would have had to pay attention too, 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 should provide more realistic results than a survey instrument, it is very 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, the researchers may consider a similar study with 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 expected to be somewhat 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 had not considered (e.g., Snapchatting and selfie), there are popular and newer 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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