Understanding Volitional and Habitual Facilitators of Drivers’ Handheld Cellphone Use

by

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for the degree of Master of Applied Science in Mechanical and Industrial Engineering.

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Abstract

Despite increased media attention and legislation, many drivers continue to engage in illegal cellphone distractions. Various constructs of the Theory of Planned Behavior (TPB), e.g., attitudes, have been found to explain drivers' intention to engage in distractions; however, the role of cellphone habits has rarely been considered. This thesis reports the results of two online survey studies conducted in North America and China in 2015/2016. In addition, the design of a follow-up survey study is introduced; this study could not be conducted due to the impact of COVID-19. Overall, it was found that cellphone habits predicted self-reported frequency of engagement in a selection of handheld cellphone distractions while driving, after controlling for the TPB. Further, several TPB constructs were found to be significant, with patterns of significance differing across the two geographies. Results from this thesis can inform the development of countermeasures in both North America and China.

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Chapter 1

1 Introduction

1.1 Motivation

Traffic crashes have been identified as the 8th leading cause of death worldwide, with an estimated 1.35 million traffic fatalities occurring in 2016 (World Health Organization, 2018). One of the major contributors to traffic fatalities is distracted driving (National Highway Traffic Safety Administration [NHTSA], 2019a), which can be defined as: “the diversion of one’s attention away from activities critical for safe driving toward a competing activity” (Lee et al., 2008, pp 34). In the U.S., 7.8% of fatal crashes in 2018 were reported as distraction-affected (NHTSA, 2019a). Similar statistics were found in Canada (10% of all fatal crashes in 2014; Canadian Automotive Association, 2018), France (11.3% of all fatal crashes in 2016; The Local, 2018), and Australia (5% of all fatal crashes in 2017; Budget Direct, 2019), with distraction appearing to account for a bigger proportion of traffic fatalities in China (44.3% of traffic fatalities for the Zhejiang province; Xiaofeng, 2017).

Driver distraction includes a broad range of activities secondary to driving (e.g. talking to passengers, adjusting climate controls), however, one type of distraction, handheld cellphone related distractions, have attracted significant attention from the transportation research community. This attention has been due to the high prevalence of handheld cellphone distractions - for example Schroeder, Wilbur, and Pena (2018) found 56% and 63% of drivers (N = 6,001) reported making and answering calls, while 25% and 20% reported reading and sending texts/emails at some point while driving in the past year. Further, handheld cellphone use has been found to be associated with a number of performance decrements for driving (Caird, Simmons, Wiley Johnston & Horrey, 2018; Caird, Johnston, Willness, Asbridge & Steel, 2014) and to increase the odds of being involved in a vehicle crash by 3.6 times (Dingus et al., 2016).

In order to combat handheld cellphone distracted driving, initiatives and countermeasures have been developed that include legislative bans (Governors Highway Safety Administration [GHSA], 2017), media campaigns/educational programs (print and television; Philips, Ullberg & Vaa, 2011; Buckley, Chapman & Sheehan, 2014) and technological alternatives/constraints (Reagan &

Cicchino, 2018). While measures have been put in place, national reports show that distracted driving is still highly prevalent (Schroeder et al., 2018; NHSTA, 2019b); therefore, to better inform countermeasure efforts, it is important to understand the motivating factors or facilitators behind why drivers engage in cellphone use while driving.

Previous studies examining the reasoning behind drivers' cellphone use have focused on measuring their volitional engagement using the Theory of Planned Behavior as a guiding framework (TPB; Ajzen, 1991). The TPB states that intentions are the main determinant of behavior, and that intentions to behave are influenced by an individual's attitude (i.e. positive/negative evaluations of a given behavior), perceived subjective norms (i.e. approval/disapproval from important others – otherwise known as injunctive norms), and perceptions of behavioral control (PBC; i.e. ease or difficulty of engaging in a behavior). Studies utilizing the TPB have found that these three constructs explain a statistically significant portion of the variance (11-48%) in drivers' intentions/willingness to engage in handheld cellphone distracted driving, after controlling for demographic variables (Walsh, White, Hyde & Watson, 2008; Rozario, Lewis & White, 2010; Nemme & White, 2010; Waddel & Wiener, 2014; Bazargan-Hejazi et al., 2016; Przepiorka, Blachnio & Sullman, 2018).

While the TPB framework has been useful in understanding intentional behaviors, such as using a cellphone while driving, it does not address the role of habitual behavior. Habitual behavior can be defined as: "a specific action or behavioral tendency that is enacted with little conscious awareness or reflection, in response to a specific set of associated conditions or contextual cues" (Hagger, 2019, pp. 119). This differs from volitional engagement (as measured through TPB), in that habits bypass intentions; thus, habits may be a direct predictor of behavior in certain settings (Gardner, de Bruijn & Lally, 2011; Triandis, 1977). Certain handheld cellphone interactions have been found to be habitually conducted, including checking the home screen of a cellphone and specific apps for notifications (Oulasvirta, Rattenbury, Ma & Raita, 2012). If these habits carry over to the vehicle environment, it may explain why individuals persist in using cellphones, despite the fact it is illegal to do so. Such a finding would have implications for countermeasure development. Currently, many countermeasures appeal to drivers' volitional decision-making processes (e.g. educational messages, legislation) – these countermeasures are sometimes informed by research, with some studies utilizing the TPB. However, if habits also facilitate drivers' handheld cellphone use, then countermeasures that solely target drivers' volitional use may be ineffective. Instead, countermeasures that also directly target cellphone habits, such as technological constraints (e.g. driver mode on cellphones), may offer enhanced effectiveness.

To date, only a limited number of studies have examined the role of habits in cellphone related distracted driving. One of these studies found that general texting habits predicted self-reported frequency of texting while driving after controlling for measures of the TPB (Bayer & Campbell, 2012). Another study found that general habits surrounding monitoring/reading social interactive technology on smartphones (e.g. Facebook) did not predict self-reported frequency of this behavior while driving (Murphy, Gauld & Lewis, 2020). The issue with both of these prior studies is that they only examined a narrow range of cellphone behaviors, and their sample was composed entirely of university students. Further, both of these studies adopted a cross-sectional design and did not examine the interaction between intentions and habits in predicting handheld cellphone use while driving; this is an effect that has been found in the habit literature (Gardner et al., 2011). Thus, there is a need to further examine the role of cellphone habits and their relationship to volitional factors in facilitating drivers' handheld cellphone use while driving, specifically for a wider range of cellphone distractions (e.g. social media use) within a more diverse sample of drivers.

1.2 Research Questions and Study Summaries

This thesis aims to investigate the role of volitional and habitual facilitators in predicting self-reported frequency of engagement in handheld cellphone distractions while driving. To do this, this thesis analyzed data from two online survey studies conducted in 2015/2016 in North America and China; they are reported in Chapter 3 and 4, respectively. Our results for the former are currently in press in *Transportation Research Record*, and our results for the latter are currently under review by another journal (reviews have not been received yet). In addition, a new survey study was developed, with a plan to run it from April 1st – May 1st, 2020; however, due to the outbreak of COVID-19, this survey was delayed. The design of this survey, as well as results from an initial preliminary survey, are discussed in Chapter 5.

To assess drivers' volitional use of handheld cellphones, the Theory of Planned Behavior was adopted for all three studies. The TPB is a widely used social-cognitive framework that has been found to predict a wide variety of both self-reported and observed behaviors (Armitage & Conner, 2001). In this thesis, a number of additional constructs were also examined beyond the original TPB constructs of attitude, injunctive norms, and perceived behavioral control. Specifically, two additional social norms constructs were examined - descriptive norms, which are perceptions of what others do, were examined in Chapters 3 and 4, while moral norms, which are perceptions of the moral rightness/wrongness of action, were included in the proposed study in Chapter 5. A distinction was also made between the two sub-constructs of perceived behavioral control: perceived control (i.e. amount of control felt over engaging in a behavior) and self-efficacy (i.e. confidence in one's ability to engage in a behavior). Research has found that these two sub-constructs are distinct, but related components of PBC. To date, only one other distracted driving related TPB study has made the distinction between self-efficacy and perceived control. The lack of distinction made between the constructs may explain the somewhat inconsistent predictive capacity of PBC in the distracted driving literature; for this reason, perceived control and self-efficacy were measured and analyzed separately in this thesis.

Constructs of TPB were captured by different versions of the Susceptibility to Driver Distraction Questionnaire (SDDQ; Feng, Marulanda & Donmez, 2014; Marulanda, Chen & Donmez, 2015; Marulanda, 2015). The SDDQ is a validated North American survey which was designed to study drivers' engagement in a variety of distractions (Feng et al., 2014). Three different versions of the SDDQ were used in this thesis. Chapters 3 and 4 employed a revised version of the SDDQ as found in Marulanda (2015). Chapter 3 used an English version of the questionnaire, while Chapter 4 used a Mandarin translation. The upcoming study (Chapter 5) employs an updated version of Marulanda's (2015) SDDQ.

To measure drivers' cellphone habits, the Self-Report Habit Index (Verplanken & Orbell, 2003) was used in the two survey studies reported in Chapters 3 and 4. The SRHI is a popular validated questionnaire that has been used to study habits for a number of health behaviors (Gardner et al., 2011). The proposed survey study presented in Chapter 5 employs a validated, short-item questionnaire, the Self-Report Behavioral Automaticity Index (SRBAI), which is based on the SRHI (Gardner, Abraham, Lally, & de Bruijn, 2012). A number of additional habit questions were also developed to measure different aspects of habit for the upcoming study.

Overall, results from the first two online survey studies support the idea that both volitional and habitual facilitators predict drivers' self-reported frequency of handheld cellphone engagement while driving. In the North American study (N = 227; see Chapter 3), hierarchical-linear regression was used, and it was found that notification-related cellphone habits (developed outside of the vehicle) accounted for significant unique variance in drivers' self-reported frequency of engagement in a selection of handheld cellphone distractions behind the wheel, while controlling for volitional factors (i.e. TPB constructs). In this study, it was found that attitudes, perceived control, self-efficacy and habits were significant predictors of self-reported frequency of use; neither perceived social norm constructs (descriptive and injunctive norms) were significant. Results from these studies have implications for distracted driving related countermeasure development for North American drivers (e.g. educational messages which highlight social disapproval may be ineffective in decreasing handheld cellphone use amongst the general driving population, while countermeasures that specifically target notification-related habits may be effective).

The Chinese survey study (Chapter 4) had a much larger sample size (N = 1,016), which afforded the use of structural equation modeling; the role of the driving environment (i.e. rural highway vs downtown urban) was also explored. It was again found that notification-related cellphone habits (developed outside of the vehicle) predicted self-reported frequency of cellphone use in a selection of cellphone distractions behind the wheel, while controlling for the TPB. In this Chinese sample, it was found that notification-related habits were either the strongest, or one of the strongest, predictors of self-reported cellphone use while driving. A number of TPB constructs were also significant, with an interesting difference being that both types of social norms (descriptive and injunctive) were significant in this sample. Although no direct comparison was performed between the North American and the Chinese samples, there appear to be cultural/societal differences between the samples, with an implication being that educational messages highlighting social disapproval may be effective in China. Further, the driving environment was found to moderate the influence of certain TPB constructs (i.e. attitude and self-efficacy) on drivers' self-reported frequency of engagement in cellphone distractions. This demonstrates that the driving environment should be taken into consideration when examining psycho-social facilitators of drivers' cellphone use.

Finally, a third study was developed to further explore the role of cellphone habits, as well as to address some methodological limitations with the prior two studies (Chapter 5). Specifically, the studies reported in Chapters 3 and 4 examined whether notification-related cellphone habits predicted engagement in cellphone distractions while driving – no other types of cellphone habits, such as reading a text message or scrolling through social media, were examined. Given that notification-related habits predicted frequency of engagement in a number of other cellphone distractions (e.g. reading a text) while driving, it would be interesting to examine whether these distractions themselves are carried out habitually, and if so, to what extent they predict frequency of engagement while driving. The third study plans to accomplish this through directly measuring the habitualness of different types of cellphone distractions (e.g. scrolling through social media) via self-reports and examining their role in predicting cellphone use behind the wheel, while controlling for volitional factors relating to those same distractions. In addition, the influence of different types of habit cues (i.e. associated contexts or stimuli which elicit habitual behavior) and their influence in predicting self-reported engagement in cellphone distractions will be examined. Previous studies have not considered the role of habit cues for cellphone distractions, and thus, these studies' measurement of habit may be incomplete. A further benefit of examining the predictive strength of different habit cues is that results from this approach may lend themselves to the development of habit-specific countermeasures, which can directly target the cues which elicit habitual behavior.

The studies reported in Chapters 3 and 4 did also not measure drivers' intentions or counter-habitual intentions to engage in handheld cellphone distractions; these studies rather captured self-reported prior frequency of engagement. Previous research has found that there exists an interaction between habits and intentions in predicting behavior, such that when habits for a behavior are strong, intentions to engage in a behavior do not predict actual behavior (Gardner et al., 2011). Such an interaction for handheld cellphone related distracted driving would have further implications for countermeasure development, as it would indicate that there may exist a subset of drivers for which current countermeasures are ineffective (i.e. countermeasures that target drivers' volitional decision-making such as legislation and educational messages). This finding would differ from the results in Chapters 3 and 4, as the results from these studies merely suggest that notification-related habits account for unique variance in the frequency of cellphone use while driving, while controlling for volitional factors (i.e. a portion of participants' frequency of cellphone use can be attributed to their notification-related cellphone habits). If habits do interact with intentions in predicting frequency of cellphone use while driving, then habit-specific countermeasures may be required to ultimately reduce the prevalence of handheld cellphone use behind the wheel driving.

1.3 Thesis Overview

- **Chapter 2** provides an overview of the relevant literature on distracted driving, as well as a brief introduction to TPB and a summary of TPB's application to handheld cellphone related distracted driving. It also provides an overview of habit research within the social/health psychology field and its applications/relevance to cellphone related distracted driving.

- **Chapter 3** presents the first survey study, which was conducted in North America in 2015. These results are currently in press in Transportation Research Record.

- **Chapter 4** presents the second study, which was conducted in China in 2016. These results are currently under review in another transportation journal (reviews have not been received yet).

- **Chapter 5** discusses the limitations and methodological issues with the previous studies and proposes the new survey. Results from a preliminary study are also presented.

- **Chapter 6** provides a conclusion to this thesis.

Chapter 2

2 Literature Review

This chapter summarizes a number of topics related to handheld cellphone use while driving. First, the performance detriments of handheld cellphone use on driving performance and its influence on crash risk will be discussed. Second, several large-scale survey studies will be reviewed, which assessed the prevalence of a variety of handheld cellphone distractions, as well as drivers' reasons for engaging in them. Third, a number of countermeasures and their effectiveness in curbing handheld cellphone use behind the wheel will be discussed. Fourth, a comprehensive summary of the TPB's application to the distracted driving domain will provided. Finally, a discussion of the concept of habit, and its relation to conscious intentions and inhibition, will take place. This will be followed by a discussion of the application of habits to handheld cellphone use, and a summary of the research studying the role of habits in predicting cellphone use while driving.

2.1 The Effects of Handheld Cellphone Use on Driving Performance

The performance decrements of handheld cellphone distractions on driving have been well studied, with several comprehensive meta-analyses finding a negative impact of cellphone use on driving performance; these findings hold across laboratory (e.g. driving video clips), simulator and on-road studies (Caird et al., 2018; Caird et al., 2014). Specifically, Caird et al. (2018) examined the effects of talking on a handheld cellphone and dialing a phone number on a keypad, while Caird et al. (2014) examined the effects of reading and sending text messages (see **Table 1** for a complete reporting of significant effects). Overall, talking on a handheld cellphone was found to negatively affect driving performance, with effects such as increased reaction time to both emergency events and targets (e.g. signs, secondary probes), as well as increased rates of vehicle collisions. Distractions that have larger visual-manual components, such as reading/sending text messages (both separately, and in conjunction) and dialing a phone number on a keypad, were found to have a larger negative effect on baseline driving performance (i.e. normal attentive driving) than talking. Specifically, dialing a phone number was found to increase target detection reaction times (e.g. signs or probes), worsen vehicle lateral control (i.e. keeping the vehicle within the lane) and increases off-road glances, compared to baseline driving. Reading and sending text messages (both separately, and in conjunction) were found to result in more eyes off road time, longer reaction times to roadway hazards, and worse lateral control of the vehicle compared to baseline driving, while doing both in conjunction was found to result in increased vehicle collisions. Reading texts had a smaller effect on driving performance than sending texts or doing both in conjunction, which aligns with the hypothesized difficulty of the tasks (i.e. sending texts involves more visual/manual elements, such as searching for and manually pressing keys).

An interesting finding from Caird et al. (2018) and Caird et al. (2014) was that drivers had increased headway distance and variance to lead vehicles, as well as lower vehicle travel speeds for conditions in which participants read/sent text messages and dialed a phone number on a keypad, as opposed to talking on a handheld device. Some previous studies have interpreted this finding as drivers engaging in compensatory behaviors while performing visually/manually demanding distractions (e.g. "*If my eyes are off the road, I will slow down and increase headway to the car in-front of me"*). However, both meta-analyses noted that the benefits of increased headway and reduced vehicle speed were probably not enough to compensate for the other negative effects of visual-manual distractions (e.g. dialing or texting), including increased eyes off road time and reaction time to targets or roadway hazards. This may explain why increased collision rates were found for both reading and sending text messages, as well as dialing a phone number on a keypad. Taken together, it appears that engaging in distractions that are visual-manual in nature results in larger performance detriments to the driving task, with visual-manual distractions resulting in higher rates of vehicle collisions, as compared to baseline, normal attentive driving.

Table 1. Summary of significant effects for handheld cellphone use vs baseline, attentive driving from two meta-analyses (Caird et al., 2018; Caird et al., 2014).

Study Findings	**Measures**
Caird et al. (2018)	
Talking on a handheld cellphone	
Increased RT to hazards	Brake pedal response to emergency events (e.g. pedestrian incursion, car-pull out event)
Decreased target detection and increased detection RT	% of targets detected and reaction time to targets (e.g., signs, secondary probes in detection tasks)
Increased vehicle collisions	Collisions with vehicles, pedestrians and infrastructure
Decreased headway	Time to collision (seconds) and distance (meters) from a lead vehicle
Dialing on a handheld cellphone	
Decreased detection RT	To targets - e.g. signs, secondary probes
Worse lateral control	E.g. standard deviation of lane position (SDLP), number of lane exceedances (centerline and edge)
Lower speed	Mean vehicle travel speed
Increased headway variance	Headway variance (time or distance) to lead vehicles
Increased number of off-road glances	Proportion of glances made off road (e.g. speed-odometer, mirrors, phone)
Caird et al. (2014)	
Reading and typing a text (separately)	
Poorer eye movements	E.g. proportion and length of glances made off road
Increased RT to hazards	E.g. pedestrian incursion, car-pull out event
Worse lateral control	E.g. SDLP and lane exceedances
Typing and reading texts (in conjunction)	
Poorer eye movements	E.g. proportion and length of glances made off road
Increased RT to hazards	E.g. pedestrian incursion, car-pull out event
Increased rate of collisions	Collisions with vehicles, pedestrians and infrastructure
Worse lateral control	E.g. SDLP and lane exceedances
Lower speed and increased variance	Mean vehicle travel speed and speed variance
Increased headway to a lead vehicle	Mean headway, minimum headway and headway variance (time or distance)

While the above meta-analysis findings primarily focused on examining the specific effects of cellphone distraction on driving performance, several landmark naturalistic driving studies have examined the impact of distraction engagement on crash and near-crash involvement. Naturalistic driving studies are observational on-road studies, where cameras (e.g. forward road facing, driver facing) and sensors (e.g. accelerometers, global positioning systems) are installed into a driver's vehicle to continuously monitor the driver state and vehicle performance. Naturalistic driving studies are considered a gold standard approach to collecting driver behavior data, as drivers can be observed and recorded unobtrusively for long periods of time. Two early North American naturalistic driving studies were the Naturalistic Teenage Driving Study (NTDS; Klauer et al., 2014) and the 100-Car Naturalistic Driving Study (100-Car NDS; Klauer et al., 2014), which will be reviewed below.

In the NTDS and 100-Car NDS, 42 newly licensed drivers' vehicles and 109 experienced drivers' vehicles were set up with NDS equipment to observe their driving behavior over a period of 12-18 months. An outcome of these studies was to examine the impact of driver distraction on vehicle crash/near crash events. Over the course of the data collection, 167 crashes/near crash events were observed for young drivers (NTDS), and 518 crashes/near crash events were observed for experienced drivers (110-Car NDS). In these studies, a near-crash event was defined as any driving circumstance that required a last-moment physical maneuver, which challenged the physical limitations of the vehicle, to avoid a crash. A crash was defined as any physical contact between the vehicle and another object for which the driver was at fault or partially at fault.

Looking specifically at handheld cellphone use, Klauer et al. (2014) found that for novice drivers, the odds of getting involved in a crash/near crash increased significantly when dialing a cellphone, reaching for a cellphone (including locating and answering it), and sending a text message/using the internet to read e-mails or browse web content (see **Table 2** for estimates of odds ratios). For experienced drivers, dialing a cellphone was associated with a significant increase in crash/near crash risk, while reaching for a cellphone was not. Texting/web browsing was not assessed in the experienced driver population, as it was not a widespread activity at the time of data collection (i.e. 2006). Interestingly, talking on a handheld phone was not found to significantly increase the odds of being in a crash/near-crash for either novice or experienced drivers; however, this non-significant finding may have been a by-product of including both hands-free and handheld interactions in the analysis.

A more recent naturalistic driving study, the Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS), may more accurately capture the impact of handheld cellphone distractions on crash risk. The SHRP 2 NDS is the largest NDS of its kind, and it captures more than 35 million miles of continuous naturalistic driving data from more than 3,500 participants from the years 2010 to 2013. One of the benefits of the SHRP 2 NDS over its predecessors, the NTDS/100- Car NDS, is that it contains a larger number of participants, and thus, contains more crash events (905 injurious and property damaging crashes). A higher number of crash events allows for odds ratio estimates to be based solely on crash events, and not on a combination of crash/near crash events (similar to Klauer et al., 2014). Combining crash/near crash events may affect the accuracy and validity of the odds estimates, as near-crash events may be fundamentally different, and have different causes, than crash events (Guo, Klauer, Hankey & Dingus, 2010).

From the data, Dingus et al. (2016) found that the use of handheld cellphones, in general (i.e. any manipulation), increased the odds of being involved in a crash by 3.6 times. This estimate is in line with another large-scale epidemiological study performed in Australia (odds ratio = 4.9; McEvoy et al., 2005). Dingus et al. (2016) also examined the odds ratio for specific cellphone distractions (see **Table 2**). They found that dialing a phone number on a handheld cellphone was associated with the biggest increase in crash risk, followed by texting and then reaching for a cellphone. In this study, talking on a handheld cellphone was found to significantly increase the odds of being involved in a vehicle crash – this was likely because only handheld phone conversations were considered. Out of the 19,732 baseline epochs randomly sampled from the data (i.e. 6 seconds snippets of normal driving conditions), Dingus et al. (2016) found that drivers engaged in cellphone distractions in 6.40% of epochs. This result aligns with findings from the National Occupant Protection Use Survey (NOPUS), which is a nationally representative roadside observed survey study conducted annually by NHTSA. In 2018, it was estimated that approximately 3.2% of American drivers talk on a handheld device at any given daylight moment (with another 1-2% visibly manipulating their handheld cellphone; NHTSA, 2019b).

In conclusion, cellphone distractions have been found to have significant detriments on safe driving performance (Caird et al. 2014 and Caird et al. 2018), with naturalistic driving studies showing that engaging in handheld cellphone distractions increases the risk of being involved in a crash or near crash event while driving (Dingus et al., 2016, Klauer et al., 2014). In addition, data from NOPUS and the SHRP-2 NDS estimate that at any given daylight moment, a significant portion of drivers engage in cellphone distractions while driving (NHTSA, 2019b; Dingus et al., 2016). For these reasons, it is important to understand the frequency of engagement in different types of cellphone distractions (e.g. social media use) as well as drivers' self-reported reasons for using handheld cellphones while driving. These will be examined in the next section of this chapter (Section 2.2**)**. Further, it is also important to examine whether any countermeasures (e.g. increased negative media coverage, laws against cellphone related distracted driving) have been successful in reducing handheld cellphone use while driving. This will be examined in Section 2.3 of this chapter.

Table 2. Crash odds ratios from naturalistic driving studies for different kinds of cellphone distractions while driving.

Study Findings	Distraction	Odds Ratio
Klauer et al. (2014)		
Novice Drivers		
	Dialing a number on a keypad	8.32*
	Reaching for a cellphone (locating and answering it)	7.05*
	Sending a text/browsing the internet	3.87*
	Talking on a handheld phone	0.61
Experienced drivers		
	Dialing a number on a keypad	2.49*
	Reaching for a cellphone (locating and answering it)	1.19
	Talking on a handheld phone	0.76
Dingus et al. (2016)		
	General cellphone use	3.6*
	Cell browsing	2.7*
	Dialing a number on a keypad	12.2*
	Reaching for a cellphone (locating and answering it)	4.8*
	Texting	6.1*
	Talking on a handheld phone	2.2*

** Indicates that the 95% confidence internal for an odds ratio estimate did not cross 1, and thus, the odds ratio estimate was significant.*

2.2 Survey Reports of Driver Handheld Cellphone Use

Based on self-reports, it has been noted that handheld cellphone distractions have, for the most part, remained steadily common in the U.S. (Schroeder et al., 2018). This trend has persisted, despite increased media attention on the issue, as well as an increase in the number of states banning handheld cellphone use. To determine what sort of handheld distractions drivers engage in, as well as their reasoning for such engagement, a number of large scale nationally representative surveys have been conducted within the United States. The National Survey on Distracted Driving Attitudes and Behaviors conducted by NHTSA is an American survey study which has undergone three iterations (delivered in 2010, 2013 and 2015). The survey inquires about drivers' self-reported frequency of engagement in a variety of distractions (i.e. not just related to handheld cellphone use), as well as their attitudes and opinions regarding distracted driving. Results from the 2015 survey (N = 6,001) showed that handheld cellphone use is still a common occurrence. For example, it was found that 56% and 63% of drivers reported making and answering calls on a handheld device, respectively, while 25% and 20% reported reading and sending texts/emails, respectively, at some point while driving in the past year (Schroeder et al., 2018). Further, 16% of participants indicated that they used a smartphone app (not related to navigation) at some point within the past year (see *Figure 1* for the percentage of participants who used a given app at least rarely).

What is concerning about these statistics is that a number of people continue to drive while engaging in handheld cellphone distractions. For example, 56% of the 3,704 respondents who indicated they answered their phone at least rarely while driving, stated that they continued to drive while talking, as opposed to 12% who indicated they pulled over to the side of the road. Less people seemed willing to continue to drive and engage in visual manual distractions. For example, 44% of the 1,044 respondents who sent text messages while driving indicated they waited until they reached a red light to do so, compared to 14% who continued to drive. Results seem to corroborate findings from a recent observational study, which noted five times the number of drivers' text at red lights as compared to while the vehicle is moving (Bernstein & Bernstein, 2015). Smartphone app usage (non-navigation related) while driving was more common than texting, with 35% of the 960 respondents who used smartphone apps continuing to drive while doing so, compared to 36% who waited for a red light. Taken together, a significant portion of drivers appear to be willing to use handheld cellphones while continuing to drive, although this behavior is more common for auditory based distractions. This finding may be linked to drivers viewing visual manual distractions as riskier (Walsh et al., 2008); thus, they may be more willing to wait for more opportune times to engage in these distractions (e.g. stopped at a red light).

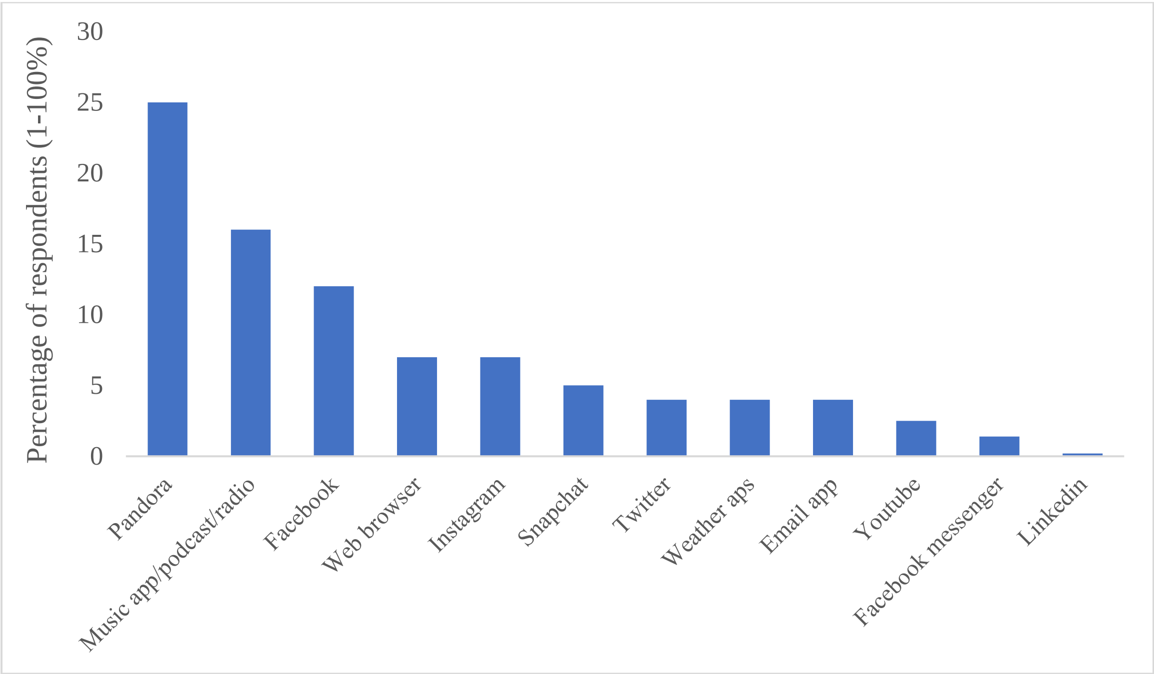


Figure 1. Percentage of respondents indicating that they used a particular **s**martphone app at least rarely while driving within the past year (n = 460; Schroeder et al., 2018). Respondent**s** offering more than one response (n = 102).

Schroeder et al. (2018) also examined respondents' reasons for using handheld cellphones while driving. They found that sending texts was a distraction that was more associated with logistic/necessity reasons (e.g. believing the message was important, reporting an emergency, inquiring about directions, schedule/planning), while app usage was more associated with entertainment or social purposes. The implications of this are that sending texts while driving may be easier to address through technological countermeasures, such as hands-free technology. This is because drivers appear to have a specific goal in mind when sending text messages, and as such, they may be more willingly to use hands-free technology if it meets their current goals in an acceptable manner. On the other hand, app use seems to be driven by under stimulation (i.e. boredom, need for entertainment or social interaction). This may result in app related distractions being harder to address through technological countermeasures, since many apps are not supported, or compatible (i.e. they are visual manual in nature) with hands-free technologies.

In addition to the extensive survey conducted by Schroeder et al. (2018), a similar survey study was conducted within the U.S. by AT&T in 2015 (AT&T, 2015). This survey focused more on visual-manual distractions (e.g. texting, social media use) and examined drivers aged 16 to 65 who owned and operated a smartphone and drove at least daily. Results from the survey (N = 2,067) showed that most drivers (62%) kept their smartphones within easy reach while driving (e.g. in their cup holder, passenger seat, or on their lap). The most common visual-manual smartphone distractions were texting, emailing, and browsing content on the internet (see *Figure 2* for a breakdown of app usage by reading/actively engaging). Social media and smartphone app use was surveyed separately, and it was found that 38% of respondents admitted to using social media/smartphone apps while driving. The most frequently used apps were Facebook, Twitter, Instagram and Snapchat (see *Figure 2* for full reporting of apps).

One concerning finding in the AT&T survey, was that 19% to 40% of the respondents who used particular social media apps while driving did so “all the time” (percentages varied for specific social media apps). Pinterest and LinkedIn were particularly bad offenders, with 40% and 39% of respondents who used these apps while driving indicating they actively engaged with the app “all the time”. While these high percentage estimates may be a byproduct of those apps having smaller sample sizes (87 and 81 respondents indicated they use Pinterest and LinkedIn while driving, respectively), this finding points to the importance of considering more modern smartphone functions/apps when conducting distracted driving research. While the overall percentage of drivers who use these apps may be lower than the percentage who use more traditional functions (38% used smartphone apps vs 61% who texted in AT&T, 2015), those drivers who do use smartphone apps appear to do so with high frequency (AT&T, 2015).

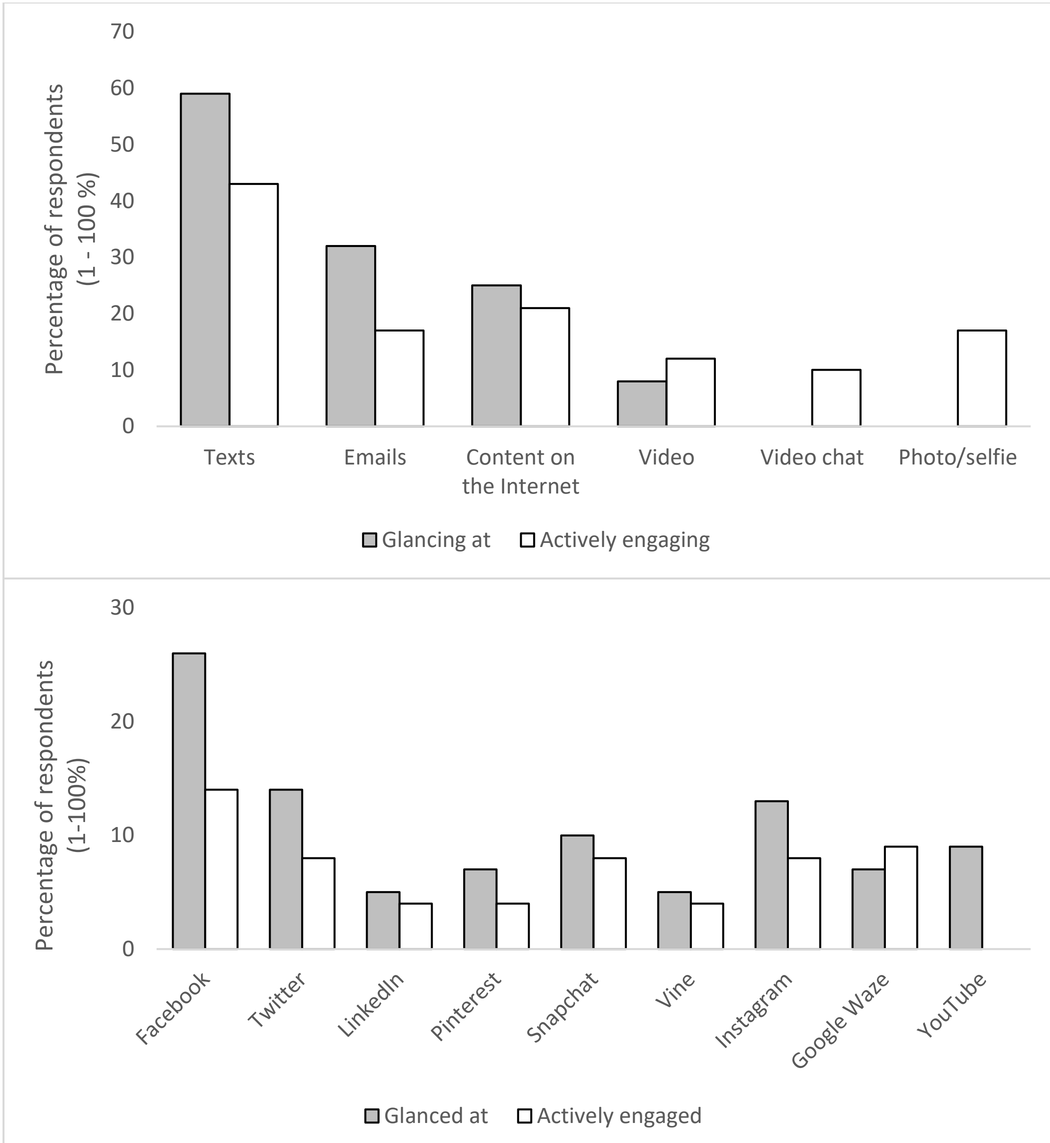


Figure 2. The top figure is the percentage of respondents (n = 2,067) indicating that they either glanced at, or actively engaged in, a smartphone activity while driving. The bottom figure is the percentage of participants (n = 2,067) indicating that they engaged in different social media apps while driving. From AT&T (2015).

In conclusion, two large, nationally representative U.S. surveys found that handheld cellphone distractions are still prevalent, despite talking and texting bans now being common within the U.S. Results from AT&T (2015) align with an Ontario survey study (N = 2000), which found that 55% and 44% of young drivers (aged 18-24) read and sent text messages while driving, respectively (Berebaum et al., 2015). Estimates from Schroeder et al. (2018) appear to be low in comparison to both AT&T (2015) and Berebaum et al. (2015). Specifically, 25%/20% of respondents in Schroeder et al. (2018), indicated they read/sent texts in the past year, while 59%/43% read/sent texts in the AT&T (2015) and 55%/44% read/sent texts in Berebaum et al. (2015). This discrepancy may be attributable to Schroeder et al. (2018) examining a larger proportion of older drivers in their study (e.g. over 51% of their sample was over 45, with 17% over the age of 65). Berebaum et al. (2015) examined drivers 16-24 years old, whereas AT&T (2015) examined drivers aged 16-65 (no mean age was reported). When solely looking at drivers under 24, Schroeder et al.'s (2018) estimates seem to be approach estimates from the other survey studies (i.e. the percent of young drivers [under 24] who sent/read texts was 34% and 43%, respectively). Thus, it appears handheld cellphone use may be more common in younger age groups, a finding that has been noted in other studies (Walsh et al., 2008; Rainie, 2012; Australian Associated Motor Insurers, 2012).

2.3 Countermeasures for Handheld Cellphone Related Distracted Driving

In order to combat cellphone related distracted driving, initiatives and countermeasures have been developed that include legislative bans and enforcement (GHSA, 2017), media campaigns (print and television; Philips et al., 2011), and technological constraints (e.g. driver mode; Reagan & Cicchino, 2018). The effectiveness of each of these countermeasures is discussed in depth in **Appendix A** – a summary of the findings will be provided below.

As of 2015, 131 countries have prohibited handheld cellphone use while driving (WHO, 2015). In Canada, handheld cellphone use is prohibited in all 13 provinces/territories (see **Table 3**). Despite widespread bans, research regarding the effectiveness of legislative bans has been somewhat inconclusive, with some studies finding a positive effect of legislation (i.e. decreased use), and others finding no effect. Several studies from the United States have shown that states who enact state-legislation against handheld cellphone use experience a significant decline in the frequency of cellphone related distracted driving, compared to states that do not (McCartt, Hellinga, Strouse & Farmer, 2010; Braitman & McCartt, 2010; Rudisill & Zhu, 2017); this trend does not appear to hold for younger drivers (Goodwin, O'Brien & Foss, 2012). Legislation has been found to be more effective when high-visibility enforcement (HVE) campaigns are used (Cosgrove, Chaudhary, & Reagan, 2011; Schick, Vegega, & Chaudhary, 2014); however, HVE campaigns are associated with significant state costs (e.g. law enforcement and media/advertising expenses). For this reason, it is important to consider other types of countermeasures which may be similarly effective, but have lower costs associated with them.

Table 3. Fines and penalties for distracted driving in the different provinces of Canada.

Province	**Fine**	**License Suspension**
British Columbia	$368	Two or more convictions within a year can result in a 3-12-month prohibition.
Alberta	$287	NA
Saskatchewan	$280	Second offences result in a 7-day vehicle impoundment
Manitoba	$672	3-day for initial & 7-day suspension for subsequent offences.
Ontario	$615-$1000 for 1st conviction Up to $2000 for 2nd Up to $3000 for 3rd	3-day suspension for 1st conviction 7-day for 2nd 30-day for 3rd
Quebec	$300-$600	3 days suspension for 1st conviction 7 days for 2nd 30 days for 3rd
Newfoundland and Labrador	$300-$1000	NA
Prince Edward Island	$500 - $1200	NA
Nova Scotia	$233.95 for 1st conviction $348.95 for 2nd $578.95 for subsequent	NA
New Brunswick	$172.50	NA
Yukon	$500	NA
Northwest Territories	$322	Suspension for second offence
Nunavut	No fine	No penalties

Information obtained from CAA (2020).

One such type of countermeasure are technological countermeasures. “Driver / Do Not Disturb Modes” and hands-free alternatives to handheld cellphone use (e.g. vehicle voice recognition systems) are both examples of technological countermeasures that have shown promise in reducing drivers’ handheld cellphone use behind the wheel (Reagan & Cicchino, 2018; Schroeder et al., 2018). Despite this, these countermeasures have limitations, including a lack of driver access to such technologies (e.g. Apple’s driver mode was released on iOS11 in Fall 2017), as well as a lack of use (given driver access). Reagan and Cicchino (2018) found that only a small portion of drivers (~20%) with access to built-in driver modes set it to automatically activate when driving. Similarly, only ~20% of drivers without built-in driver modes downloaded any sort of third-party driver mode app. Of those drivers that reported downloading a third-party driver mode app, 38% indicated they never used the app while driving within the past thirty days – these results existed despite almost half of participants indicating they thought using driver mode was a good idea. Thus, there appears to be a gap between drivers' intentions/willingness to use such a technology and their actual use. Some reasons drivers gave for not wanting to use the feature was that they felt they needed to access their phone while driving and that they had concerns about missing important information.

Voice recognition systems seem to be a better technological alternative to driver mode. Recent advances in natural language communication have resulted in voice recognition systems having enhanced accuracy, with drivers preferring voice recognition technologies for certain types of cellphone interactions while driving (e.g. talking on the phone; Schroeder et al., 2018). Despite this, voice recognition technologies seem less popular for other types of cellphones interactions, including sending text messages and interacting with smartphone apps (Schroeder et al., 2018). This lack of preference may be due to the still somewhat limited accuracy of speech-to-text translations, as well as the fact voice recognition systems cannot access or are not compatible with certain kinds of cellphone interactions (i.e. interactions that are visual-manual tasks in natures, such as scrolling through social media).

Educational messages (publicized messages that encourage refrain from a unwanted behavior) and road safety/social marketing campaigns (more elaborate behavior change campaigns) have also had some success in altering the public's perception on distracted driving – drivers now admit that engaging in handheld cellphone distractions is an extremely risky activity (Schroeder et al., 2018; AAA, 2020). In addition, survey studies have found that drivers have low intentions to use handheld cellphones while driving (e.g. Walsh et al., 2008), and have negative attitudes towards their use, as well as perceive disapproval from others (e.g. Walsh et al., 2008). While no specific study (to the best of this author's knowledge) has examined the effect of educational messages and road safety/social marketing campaigns on the prevalence of handheld cellphone use while driving, it is unlikely that such countermeasures have had no effect on cellphone use rates. Drivers indicate they have negative attitudes/low intentions towards handheld cellphone distractions; these constructs have in turn been found to predict lower self-report frequency of engagement (Nemme & White, 2010). Further, educational messages and safety campaigns have been effective in reducing other unwanted transportation behaviors (e.g. drunk driving; Tay, 1999; Benson, McLaughlin, & Giles, 2015). As such, it is likely that messages and campaigns related to distracted driving have had some effect on decreasing cellphone usage rates.

To ensure educational messages and road safety / social marketing campaigns are more effective, their development should be guided by scientific theory; else, these types of countermeasures may be ineffective. For example, messages such as “U Drive. U Text. U Pay”, may be ineffective, since drivers believe the risks of getting caught are low (e.g. Schroeder et al., 2018). Previous research has found that interventions guided by scientific theory are more effective in changing health behavior than non-theory based interventions - TPB has been found to be a particularly effective guiding framework for intervention development (Webb, Joseph, Yardley & Michie, 2010). In the context of distracted driving, TPB can be used to examine the psycho-social factors which predict drivers’ cellphone use behind the wheel – these factors can then be targeted with message and campaigns, with the hope that these efforts can challenge drivers’ beliefs and alter the psycho-social which predict use.

In conclusion, a combination of all three countermeasures are recommended to reduce the prevalence of handheld cellphone use while driving. Legislation has been found to reduce observed and self-reported rates of handheld cellphone use while driving – although this may not apply to all types of drivers (e.g. young drivers; Goodwin et al., 2012). HVE campaigns can enhance the effect of legislation, however, they are associated with significant costs. Recently, several technological countermeasures have become viable, however, their effectiveness may be limited by the fact not all drivers will have access to such technology or be willing to use them. A promising countermeasure approach that addresses weaknesses in both the legislative and technological approaches is the use of scientifically guided educational messages and road safety / social marketing campaigns. While these efforts may be associated with their own costs, they may have a lasting impact on individuals through altering their beliefs about handheld cellphone related distractions. Individuals may in turn comply with the law to a greater extent, or seek out technological countermeasures to help address their use of handheld cellphones while driving. As such, the development of such countermeasures should be of high priority to all government / non-governmental organizations with a stake in distracted driving – however, it is important to first understand the underlying psycho-social factors which predict handheld cellphone use. Only then can effective messages and campaigns be designed.

2.4 The Theory of Planned Behavior and Its Application to Handheld Cellphone Use While Driving

2.4.1 Overview of TPB

One approach researchers have utilized to understand the underlying psycho-social reasons behind why drivers engage in handheld cellphone distractions is the Theory of Planned Behavior (TPB; Ajzen, 1991). The TPB states that intentions (i.e. motivation) are the main determinant of behavior, and that intentions themselves are influenced by an individual’s attitude (i.e. the positive or negative beliefs associated with a behavior), perceived subjective norms (i.e. the perceived approval from important/significant others), and perceived behavioral control (PBC; i.e. the ease or difficulty one feels over executing a certain behavior). Underlying each of these global constructs (i.e. attitude, subjective norms, PBC) are a set of salient beliefs (i.e. attitudinal beliefs, normative beliefs and control beliefs), which are the determinants of the global constructs. By salient beliefs, Ajzen (1991) noted that persons may hold many individual beliefs about a given behavior, but that only a small number of “salient beliefs” (eight or nine at a maximum; Miller, 1965) are responsible for determining whether a behavior is performed.

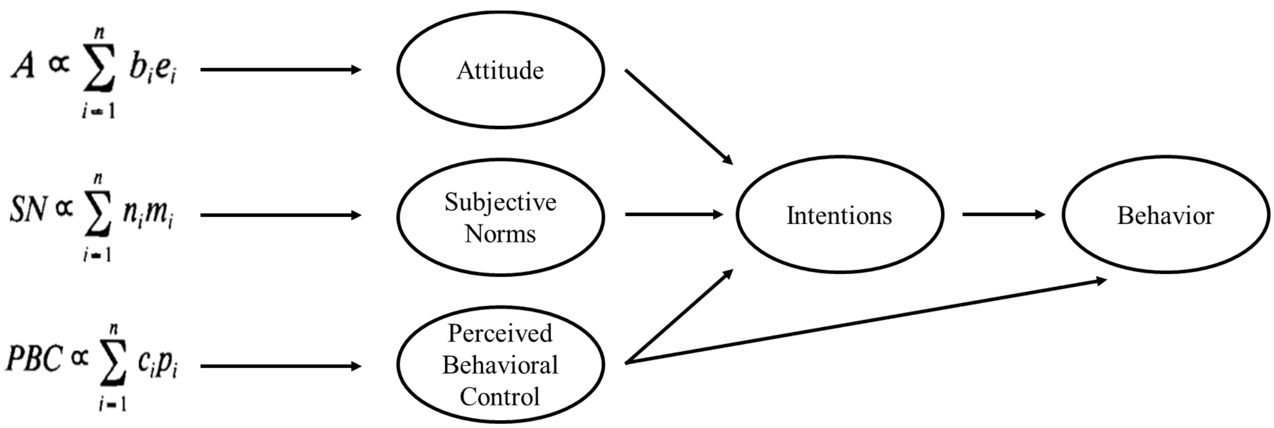


Figure 3. The Theory of Planned Behavior as posited by Ajzen (1991).

The relationship between the global constructs of attitude, subject norms and PBC, and their corresponding beliefs are outlined below. Attitude towards a given behavior is directly proportional to the perceived probability of a belief outcome (i.e. the likelihood of a belief outcome occurring – b_i), multiplied by the outcome’s subjective value (i.e. how good or bad the outcome is – e_i), which is summed over all relevant beliefs for a behavior (n; see *Figure 3*). Subjective norms are directly proportional to the perceived probability that important referent individuals or groups will approve/disapprove of a given behavior (n_i), multiplied by a person's motivation to comply with a specific referent group (m_i), summed over all relevant referent groups (n). Finally, PBC over a given behavior is directly proportional to the relevance of particular control beliefs (i.e. how applicable the control belief is – c_i), multiplied by the perceived power of the control belief to facilitate or inhibit performance of the behavior (p_i), summed over all relevant control beliefs (n). Ajzen (1991) stated that it was possible to measure either global constructs, or belief-based measures of the constructs, with global measures being ideal when the researcher's question concerns the constructs as a whole, and belief-based measures being ideal when further understanding of the motivational foundations of a behavior are of interest.

In the TPB application to distracted driving, researchers have mainly focused on measuring driver's attitudes, subjective norms and PBC via global construct measures in order to determine which constructs predict driver's intentions/handheld cellphone use while driving. While this approach allows researchers to infer what psycho-social factors influence a driver's decisions to use a handheld cellphone behind the wheel, it does not easily lend itself to the development of educational materials, which normally target specific beliefs drivers hold about engaging in handheld related distractions. To do this, specific beliefs must be elicited from drivers who engage in such distractions – this can be done through qualitative techniques, such as interviews and focus groups. Elicited beliefs can then be tested within a larger sample to obtain quantitative insights regarding the wide-spread prevalence of the belief, as well as whether the belief predicts either its own construct (e.g. attitude) or driver's intention to use a handheld cellphone. Such methods allow for the identification of significant beliefs, which organizations can then challenge via educational messages/social marketing campaigns. For example, if drivers believe that using their handheld cellphone is a good use of time, or that they need to respond to someone after receiving a message, then educational messages that challenge this belief (e.g. "It Can Wait") can be an effective method in drawing drivers' attention to their beliefs, with the hopes that they will reevaluate them and stop engaging in the undesired behavior.

Despite the benefits of identifying the underlying beliefs associated with the TPB constructs, very few studies have taken this approach in the distracted driving domain (see White, 2010; Gauld, Lewis, White, & Watson; 2016a; 2016b; Gauld et al., 2017, for studies that have taken this approach). The majority of TPB's application to handheld cellphone related distracted driving has focused on using global measures of the TPB constructs to discover which constructs predict cellphone use. The findings of these studies should ideally then be used to direct future research efforts to examine what underlying beliefs predict significant constructs, and/or driver's intentions to use a cellphone; however, this next step is often not undertaken, with the result being that educational messages based on these findings may be under tailored, compared to if a belief-based approach was taken. Thus, future research should focus on examining the underlying beliefs associated with each construct, to help aid practitioners or public health officials in designing more effective educational messages/social marketing campaigns. The exception to this is when a new construct is being added to the original or expanded TPB model, then, the significance of the new construct in predicting handheld cellphone use must be examined while controlling for other constructs (Ajzen, 1991).

2.4.2 Summary of Studies Applying TPB to Handheld Cellphone Use

Despite the practical limitations in purely assessing global TPB constructs, a number of studies have applied TPB to understand why drivers engage in a variety of handheld cellphone distractions while driving. The first TPB-cellphone related study was published in 2008 in Australia (Walsh et al., 2008). Since then, a number of TPB papers on cellphone use have been published (see **Appendix B** for a summary of their results), with a majority of studies being conducted in Australia (specifically within Queensland), and other studies being conducted in North America (i.e. Canada and the United States), China, and Poland. While each study shares a similar methodology (similar items and statistical analysis – i.e. stepwise hierarchical regression), most studies examine different types of cellphone distractions (e.g. talking, reading/sending texts, initiating/responding on cellphones). In addition, almost every study has attempted to expand the original TPB model by including a variety of other constructs, which may account for additional variance in drivers' intentions and/or actual cellphone use while driving. These additions to the model have been welcomed by Ajzen (1991), who has stated that additional predictors could be included in the TPB if their inclusion enhanced the prediction of behavior and/or intentions, above and beyond the original constructs. In that vein, researchers have examined measures of risk perception (Walsh et al., 2008; Przepiorka et al., 2018), personality (Chen & Donmez, 2016; Rozario et al., 2010), additional social norms (Nemme & White, 2010; Waddel & Wiener, 2014; Gauld et al., 2017; Nemme & White, 2010), and habits (Nemme & White, 2010; Bayer &

Campbell, 2012; Gauld et al., 2020). Below, a number of the above papers and their methodologies/findings will be summarized.

2.4.2.1 Early Findings and the Addition of Risk Perceptions

Walsh et al. (2008) used the TPB to examine the role attitudes, social norms, PBC and risk perceptions played in predicting driver's (N = 796) intentions to use a cellphone while driving in four different scenarios, which varied on time pressure (late / not late) and vehicle speed (100 km/hr / stopped at a traffic light). Notably, Walsh et al. (2008) added the variable of risk perception to the TPB, given that cellphone use while driving is associated with two major risks: (1) an increased crash risk (Dingus et al., 2016) and (2) an increased risk of apprehension (Queensland Transport, 2007). They found that after controlling for gender, age and driving purpose (i.e. business vs personal), attitude and subjective norms significantly predicted drivers' intentions to use a cellphone in general (i.e. for both texting and calling); PBC was not significant. Furthermore, they found that attitude was a significant positive predictor across all four driving scenarios for both texting and calling (i.e. the more positive one's attitude, the more intention they had to engage), while subjective norms were only significant for calling in scenarios where the driver was late. Thus, it appeared that norms only played a role when drivers felt they were late and potentially had to reach out to someone to explain why (i.e. they perceived more approval from important others to do so). Risk perceptions (crash and apprehension risk) were mostly non-significant across scenarios, with the only exception being apprehension risk, which was significant for texting (i.e. drivers who had an increased awareness of the risks of apprehension texted more frequently). This counterintuitive finding may represent the fact that drivers who are more likely to text are also more aware of the consequences (i.e. apprehension risks), which is a concerning finding.

A similar study to Walsh et al. (2008) was conducted by Przepiorka et al. (2018) in Poland, in which they used the same TPB measures and control variables, as well as the same driving scenarios (time pressure X driving speed). Instead of looking at calling and texting, this study specifically looked at reading/sending text messages while driving. They found that after controlling for demographic variables (age, gender, driving purpose), attitude and PBC were the only significant predictors of drivers' (N = 298) intentions to use a cellphone in general; this differed from Walsh et al. (2008) where attitude and subjective norms were the only significant predictors for general cellphone use (i.e. both calling and texting). Similar to Walsh et al. (2008), they found that attitude was the strongest predictor of driver's intentions to read/send texts across all four driving scenarios. Also, they found that risk perceptions were a weak predictor of intentions to text. Specifically, they found that perceptions of crash risk were a negative predictor of intentions to read texts for two scenarios (travelling 100 km/hr and running late; waiting at traffic lights and not in a hurry) and intentions to send texts for one scenario (waiting at traffic lights and not in a hurry). Thus, increases in the perceptions of being involved in a crash were associated with a significant decrease in drivers' intentions to use a phone for reading/sending texts. While this negative relationship makes sense for the highway travel/late scenario, it is surprising that crash risk predicted decreases in driver's intentions to send/read texts while waiting at a traffic light and not in a hurry. It is arguable that the crash risk associated with waiting at a traffic light is lower than while traveling at high speed. Therefore, it may be that drivers believed they would be likely to be involved in a minor-fender bender if they were to send/read texts in this environment, which might explain this finding.

2.4.2.2 The Addition of Different Measures of Personality

In addition to risk perceptions, a number of studies have examined the influence of personality on driver's engagement in cellphone related distractions. Rozario et al. (2010) looked at drivers' "behavioral willingness" to use a handheld cellphone while driving across four different scenarios (Passenger presence [Alone or with friends] X Time Urgency [Low or high]). Behavioral willingness was used instead of intentions because it was believed to capture an element of behavioral spontaneity relevant to cellphone use (Walsh, White, Watson & Hyde, 2007). Rozario et al. (2010) found that measures of neuroticism and extroversion (as measured by the extraversion and neuroticism subscales of the NEO-FFI; Costa & McCrae, 1989) did not significantly predict drivers' willingness to engage in cellphone distractions, after controlling for sex, age and the traditional TPB variables (i.e. attitude, subjective norms and PBC). It was found that attitude and PBC were significant predictors across all four driving scenarios (Passenger presence x Time urgency), while subjective norms were only significant in scenarios that involved passengers being present. It should be noted that the mean age for Rozario et al.'s (2010) experiment was ~22 (SD = 5.52), thus for young drivers, it appears that perceived normative pressure to use a cellphone may be greater while driving in the presence of friends who approve of such behavior. Surprisingly, time urgency was only a significant moderator of subjective norms for one condition, which weakens the findings from Walsh et al. (2008) that lateness may increase the influence of subjective norms on intentions. However, a younger sample was examined than in Walsh et al. (2008; M = 36.80, SD = 14.33), which may partially explain this finding – older drivers may feel more perceived social approval when they feel they have to reach out to someone when they are late.

Chen and Donmez (2016) also examined the influence of personality, as measured through the Eysenck Impulsiveness Questionnaire (both the venturesome and impulsiveness scale; Eysenck & Eysenck, 1978) and Arnett Inventory of Sensation Seeking (Arnett, 1994). In this study, Chen and Donmez (2016) specifically looked at three types of distractions, two of which specifically related to handheld cellphone use (i.e. having phone conversations and manually interacting with a phone). They found that personality, as measured by impulsiveness, venturesome and sensation seeking, significantly predicted drivers' self-reported frequency of engagement in technology-based distractions, such that those individuals with a more risk /sensation seeking personality had a higher frequency of engagement in technology-based distractions. This effect was found when controlling for other components of the TPB. Further, when age was considered as a moderating variable, it was found that effect of risk/sensation seeking on technology-based distraction engagement varied by age group, with risk/sensation seeking predicting distraction engagement for older drivers (over 30), but not younger drivers (under 30). This result may seem somewhat surprising, however, it may be that the influence of risk / sensation seeking on technology-based distractions is mediated by other variables, such as positive attitudes towards distracted driving, for younger drivers.

2.4.2.3 The Addition of Multiple Social Norm Constructs

Most notably, a number of alternative/additional social norm constructs have been added to TPB to make up for the fact that subjective norms have been identified as a weaker predictor of intentions/willingness - both within the larger TPB literature (Armitage & Conner, 2001), as well as within the driver distraction based TPB research (e.g. Walsh et al., 2008; Rozario et al., 2010). Armitage and Conner (2001) stated that the reason subjective norms may not fully capture the influence of social norms (Armitage & Conner, 2001) is because it only considers the influence of what "important/significant others" may think, and it does not capture elements of what is commonly done at large (i.e. descriptive norms), or within specific referent groups (i.e. group norms). These types of social normative influences may guide individuals' behavior, as individuals may use other people's behavior as a benchmark to guide their own behavior (e.g. "*I see others engage in handheld cellphone distractions; therefore, it is okay if I continue to do so*"). To date, a number of studies have examined the influence of descriptive norms (i.e. perceptions of what others do; Waddell & Wiener, 2014; Chen et al., 2016; Chen & Donmez, 2016), group norms (i.e. the perceived expectations and behavior of a specific referent group; Nemme & White, 2010; Bazargan – Hejazi et al., 2017) and moral norms (i.e. the perceived moral rightness or wrongness of a behavior; Nemme and White, 2010; Bazargan – Hejazi et al., 2017; Gauld et al., 2017). These studies will be reviewed below.

Nemme and White (2010) examined the efficacy of an expanded TPB in predicting young drivers' (17-24 years old; N = 169) intentions and subsequent behavior of sending and reading text messages while driving. The study was a prospective design, with measures of the TPB (i.e. attitude, subjective, group and moral norms and PBC), past behavioral frequency of and drivers' intentions to send/read texts taken at one point in time, and driver's self-reported texting frequency (for both sending and reading) taken one week later. They found that attitude, subjective norms, PBC, group norms, and moral norms, all significantly predicted drivers' intentions to send text messages while driving, after controlling for gender and past behavior – all effects were in the expected direction (e.g. the more morally wrong an individual felt about sending texts while driving the less frequently they intended to do it). Further, they found that attitudes, group norms, and moral norms, significantly predicted drivers' intentions to read text messages – again, all effects were in the expected direction (e.g. the more frequently an individual's peer group read texts and approved of reading texts while driving, the more an individual self-reported intentions to do the same). Intentions were found to significantly predict frequency of sending/reading text messages one week later, however, PBC was not. Moral norms and past behavior were also found to have a direct effect on actual behavior one week later. The finding that moral and group norms significantly predicted drivers' intentions to send and read text messages while driving showed that additional types of social normative pressure should be examined within the TPB framework related to driver distraction. Also, the finding that moral norms directly predicted self-reported behavior above and beyond intentions is noteworthy, as this indicates that the moral aspect of a behavior may have a direct, non-mediated influence on self-reported behavior measured at a later date.

Two other studies have confirmed the findings that moral and group norms should be added to TPB, with Bayer and Campbell (2012) finding that a composite measure of social norms (including subjective, group and moral norms) was the strongest predictor of self-reported sending/reading text messages, and Gauld et al. (2017) finding that moral norms significantly predicted driver's intentions to initiate and monitor/read social interactive technology on smartphones (e.g. communicating via social networking sites, e-mails, texting and/or calling). However, one study from North America (Bazargan-Hejazi et al., 2017) found that only group norms (and not moral norms) was significant in predicting driver's intentions to send a text message. Further, both group and moral norms were not significant in predicting driver's intentions to read text messages. It is not clear why moral norms failed to predict reading/sending texts here, but it may be that there were sample differences between the studies (Nemme and White, 2010 and Gauld et al., 2017 were Australian studies). Alternatively, it may be that the effects of both group and moral norms were suppressed by the significance of subjective norms in Bazargan-Hejazi et al.'s (2017) regression analysis. In their analysis, subjective norms had a larger than usual standardized beta-weight (approximately twice as large as a number of other similar studies; see **Appendix B**).

One other type of norm that has been added to TPB must be noted - descriptive norms. Descriptive norms are perceptions of what is typically done and considered normal within a population, which can then influence how individuals act themselves (Moan & Rise, 2011; Rivis & Sheeran, 2003). The addition of descriptive norms to TPB has been studied by several different researchers. Waddel and Wiener (2014) found that descriptive norms were one of the strongest predictors of initiating and responding to text messages and calls while driving. Only PBC was a stronger predictor of initiating and responding behavior. Chen and Donmez (2016) also examined the role of descriptive norms in predicting drivers' self-reported frequency of engagement in technology-based distractions (2 of 3 related to handheld cellphone use) and found that it was a significant predictor; however, they found that the effect of descriptive norms was moderated by age group, such that descriptive norms were marginally significant for younger drivers (under 30), while they were not significant for older drivers (over 30). Thus, it appears that age plays a factor when considering the influence of descriptive norms; this aligns with the idea that younger drivers are more susceptible to normative pressure than adults (Costanzo & Shaw, 1966).

In conclusion, it appears that adding additional social norm constructs to the TPB is valid. There appears to be many different types of perceived social normative pressure, with each type having a unique influence and relationship with drivers' intentions/willingness to behave. For this reason, it is important to include multiple different types of social norms measures when conducting TPB research for cellphone related distracted driving. Making these distinctions can help organizations create more effective educational messages/social marketing campaigns by highlighting the different routes perceived social pressure can influence a driver's decision-making. Further, research has shown that social norm constructs, such as moral norms, have a direct influence on behavior, unmediated by intentions (Nemme & White, 2010). Thus, educational messages which specifically target moral norms may be directly effective in reducing driver's actual self-reported handheld cellphone use.

2.4.3 The Effectiveness of the TPB in Predicting Driver's Handheld Cellphone Use

Overall, the TPB has been found to be an effective framework for understanding driver's intentions and self-reported behavior regarding handheld cellphone use behind the wheel. Depending on the cellphone distraction, driving environment and control variables considered, the original TPB constructs (attitude, subjective norms and PBC) as a whole have been found to account for, on average, 37% of the variance in driver's intention/willingness and self-reported engagement in handheld cellphone distractions (range: 11%-77%; see **Appendix B** for studies). Furthermore, when additional TPB constructs are considered, the expanded TPB has been found to account for, on average, 42% of the variance, in driver's intention/willingness and self-reported engagement (range: 13% to 93%; see **Appendix B**). Attitudes have been identified as being one of the strongest significant predictors across cellphone distractions and driving environments (mean standardized estimate = 0.41; see **Appendix B**), while the influence of subjective norms and PBC has varied. Further, several expanded TPB constructs have shown promise in predicting driver's handheld cellphone use - notably, different kinds of social norms (e.g. moral norms). Therefore, researchers engaging in future TPB research in the domain of distracted driving should consider using an expanded version of the TPB, in order to enhance the theory's predictive validity in accounting for handheld cellphone use behind the wheel.

Another important point to note is that there has been a general lack of distinction made in the TPB-related distracted driving literature between the two sub-constructs of perceived behavioral control: self-efficacy and perceive control. Self-efficacy can be defined as the perceived difficulty of engaging in a given behavior, while perceived control can be defined as a person's self-assessment of how much personal control they feel over the behavior (Trafimow, Sheeran, Conner, & Finlay, 2002; Armitage & Conner, 2001). Early TPB research did not draw a distinction between these two sub-constructs when measuring or defining perceived behavioral control, however, studies from Trafimow et al. (2002) and Armitage and Conner (2001) found that self-efficacy and perceived control represent two distinct, but inter-related elements of PBC. The lack of distinction made between these two sub-constructs may explain why PBC has been somewhat of an inconsistent predictor within TPB's application to cellphone related distracted driving (Walsh et al., 2008; Rozario et al., 2010; Waddel & Wiener, 2014; Nemme & White, 2010; Przepiorka et al., 2018). Certain studies outside of the distracted driving domain have found self-efficacy to a better predictor of behavioral intention than perceived control (Trafimow, Sheeran, Conner, & Finlay, 2002), which is something that has been mimicked within the distracted driving literature. For example, Zhou, Wu, Rau and Zhang (2009), Rozario et al. (2010), and Waddel and Wiener (2014) all had PBC measures which resembled measures of self-efficacy as specified in Traffimow et al. (2002); standardized beta weights in these studies were considerably larger than standardized beta-weights in studies where PBC measures resembled perceived control (Walsh et al., 2008; Przepiorka et al., 2018; Nemme & White, 2010; Bayer & Campbell, 2012). A recent study by Murphy, Gauld and Lewis (2020) is the only study to date which has separated the constructs of self-efficacy and perceived control – they found that self-efficacy was a considerably stronger predictor of intentions to monitor/read social interactive technology on handheld cellphones. For this reason, future studies applying the TPB within the distracted driving domain should examine these constructs separately, so that a clearer picture of each construct's relationship with intentions/self-reported behavior can be obtained.

2.5 Habitual Cellphone Use and Cellphone Related Distracted Driving

While the TPB framework has been useful in understanding intentional behaviors, and willingness to behave, it does not address the role of automatic habitual behavior. It has been posited that cellphone use, in general, may not be entirely intentional (Oulasvirta et al., 2012), with certain interactions being habitual in nature. Further, a study from Bayer and Campbell (2012) found that texting habits, as measured through a self-reported questionnaire (i.e. the SRHI), predicted self-reported frequency of texting while driving, after controlling for volitional measures as captured through TPB. It appears that cellphone use is at least partially habitual, with habits influencing the extent to which drivers self-report using their cellphone behind the wheel. This finding may help partially explain the intention-behavior gap noted in Nemme & White (2010) (i.e. habits may explain residual variance in behavior, after intentions have been taken into account). Habits may also explain why drivers persist in engaging in handheld cellphone distractions, despite the fact it is illegal to do so, and the fact drivers are aware of the risks (e.g. Schroeder et al., 2018).

This section serves three purposes. The first is to define the concept of habit, as well as briefly review a wider body of literature examining the relationship between habits, intentions and inhibition. Through this, the aim is to give the reader a better understanding of what a habit is, how it is formed and how it interacts with intentions and inhibition mechanisms in producing/predicting behavior. The second purpose of this section is to examine whether the concept of habit applies to cellphone use in general, as well as if habitual use can be extrapolated to cellphone use behind the wheel. Studies will be reviewed, which have examined the types of cellphone interactions which appear to be habitual, as well as the extent to which a chain of cellphone interactions can become habitual. Finally, a summary of the research examining the role of habits in predicting cellphone use behind the wheel will be presented. To date, very few studies have examined the role of cellphone habits within this context.

2.5.1 General Review of Habit and its Relation to Intentions and Inhibition

For this thesis, habit will be defined as a psychological construct (Gardner et al., 2015; Verplanken & Orbell, 2003; Wood, 2017), and not as repetitive behavior (Sutton, 1994; Trandis, 1977). Viewing habit as repetitive behavior, by itself, has substantial limits, including a lack of explanatory value when it comes to predicting future behavior (see Ajzen, 2002 and Verplanken & Orbell, 2003 for a discussion). With this in mind, habit can be defined as: “a specific action or behavioral tendency that is enacted with little conscious awareness or reflection, in response to a specific set of associated conditions or contextual cues” (Hagger, 2019, pp. 119). A key characteristic of this definition is that habits are based upon paired cue-behavior associations, which have developed over time (e.g., Neal, Wood, Labrecque, & Lally, 2012; Orbell & Verplanken, 2010; Wood & Neal, 2007) in response to repeated past pairings. Further, once an associated cue has been perceived, an impulse to act is automatically generated (Gardner, 2015), which unless sufficiently imposed (i.e. self-control/inhibition), results in behavior being conducted with a high degree of automaticity (e.g., Aarts & Dijksterhuis, 2000; Orbell & Verplanken, 2010; Verplanken & Orbell, 2003). Automaticity is defined as the performance of behavior, which proceeds in the absence of awareness, conscious control, cognitive effort or deliberation (Bargh, 1994).

What is immediately apparent from this definition of habit is that it differs from the rational decision-making processes (e.g. TPB) discussed in Section 2.4. To date, a number of studies within the health/social psychology domain have examined the differences between habit and rational decision making in predicting behavior and attempted to statistically model it. Two main approaches have been used (Gardner et al., 2011), with the first approach examining whether habits predict behavior above and beyond the influence of intentions, and the second approach examining whether there is an interaction between habits and intentions, such that when habits are strong, intentions do not predict behavior (and vice versa). The second approach to modelling the habit – intention relationship is more interesting, as the first approach simply reveals whether behavior is partially attributed to habit, while the second may more closely resemble cognitive processes (at least in the highest, most abstract sense; Trandis, 1977).

A meta-analysis from Gardner et al. (2011) found that habits, as measured by a popular self-report questionnaire (the Self-Report Habit Index; Verplanken & Orbell, 2003), predicted a wide variety of behaviors (e.g. fruit consumption, exercise, dieting), after controlling for intentions. However, they also found that an interaction between habits and intentions was prevalent, such that when habits were strong (as measured by the SRHI), intentions did not predict behavior (or did so very weakly). The opposite situation was true when habits were weak (i.e. intentions strongly predicted later behavior; Gardner et al., 2011). These findings confirm results from an earlier meta-analysis (Oullette & Wood, 1998), which used a frequency in context measure of habit (i.e. how frequent a behavior is X how consistent the performance context is). This meta-analysis found that habits moderated intentions to behave only when the behavior was performed frequently in a consistent context. This makes sense, since performing a behavior in a consistent context provides ample opportunity for cues within the context, or the context itself, to be consistently paired with the behavior. The implication of both of these meta-analyses (Gardner et al., 2011; Oullette & Wood, 1998) is that habit is an alternate pathway for the generation of health behavior. Thus, only considering rational decision-making in predicting people's health behaviors has severe limitations, if the health behavior itself can be partially habitual. These findings can be reasonably extrapolated to the use of handheld cellphones, specifically while driving, which will be discussed in Section 2.5.2.

The finding of an interaction between habit and intention (Gardner et al., 2011; Oullette & Wood, 1998) aligns with a dual-process model view of cognition (Trandis, 1977). While dual-process models have many different representations in social-cognitive psychology, a heavily cited model within the habit literature is the Reflective-Impulsive Model of Cognition (RIM; Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). RIM states that behavior is generated through two pathways: an impulsive pathway (e.g. habits) and a reflective pathway (i.e. conscious deliberations, such as the TPB). In the impulsive pathway, behavior is generated via the perception of environmental cues, which activate low-level context/cue-behavior associations in implicit memory (one type of long-term memory). This activation prompts behavior to be carried out rapidly, efficiently and with minimal conscious forethought (Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). On the other hand, the reflective pathway is captured by reasoned cognition (e.g. as captured by the TPB). Here, perceived cues initiate rule-based deliberation, which result in behavior being enacted in a more slow, effortful manner.

In line with the findings of Oullette and Wood (1998), the RIM predicts that the impulsive pathway (e.g. habit) will consistently elicit behavior, as long as associated cues/contexts are encountered and perceived. In this situation, conscious intentions do not need to be formed, and thus, the reflective pathway remains inactive. In this scenario, action control has been transferred to the environment, and behavior is driven based on established cue-behavior associations (Lally, Wardle, & Gardner, 2011). When cues are not encountered, either because no behavior has been frequently paired with it in a stable environment, or because the cue has been paired with a number of other behaviors, it is more likely that the reflective pathway takes over and behaviors are selected based on conscious deliberation (e.g. intention formation). Thus, habits can act as baseline for guiding behavior, which can free up individual's cognitive resources to perform other activities (Wood et al., 2002).

Are we then a slave to our habits, forced to involuntarily carry out behavior after behavior when encountering paired cues? Research has shown that this is not the case. People are at least aware of their current habits (Wood, Quinn, & Kashy, 2002; Quinn et al., 2010), with empirical evidence suggesting that some habitual responses can be consciously inhibited or overridden. For example, Quinn et al. (2010) found that participants in an observational diary study reported some success in inhibiting unwanted habits. In their study, they had participants record situations in a diary where they felt the need to employ self-control to limit engagement in an unwanted habitual behavior, as well as report what strategies they used to control it. A behavior was classified as habitual if participants performed the behavior frequently in the past, and often performed it in the same location. They found that vigilant monitoring (i.e. increased attentional focus on not performing a response) was the most commonly used and effective method employed by participants to block habitual behavior (Quinn et al., 2010). This finding was echoed in a laboratory task, where participants successfully employed vigilant monitoring to limit habits established in the lab. In their experiment, participants were trained to respond to stimulus words with two specific response words. Weak habits were formed in a training session by presenting response words with a stimulus word in equal proportions (i.e. 50/50 pairing between the stimulus and two response words), while strong habits were formed by presenting response words with stimulus words in a 75/25 split (i.e. strong habits were formed for the stimulus-response pair presented in 75% of training trials). Following habit formation, participants underwent another shorter training session where they formed new stimulus-response word associations for both weak and strong habitual pairs. It was found that participants who used a vigilant monitoring strategy during the experimental phase (i.e. after both training rounds) were better able to employ self-control/inhibitory mechanisms to override their strong habitual impulse to respond to a stimulus word with its associated response word - they were able to correctly state the alternate word on significantly more trials than those not trained with a vigilant monitoring strategy.

Alternatively, Adriaanse et al. (2010) showed that habitual behavior can be reduced by planning to carry out an alternative response when encountering habitual cues (i.e. mental contrasting with implementation intentions; Stadler, Oettingen, & Gollwitzer, 2009). Mental contrasting with implementation intentions (MCII) involves thinking about an important wish regarding behavior change (e.g. to stop texting while driving), imagining a positive future in the event of a successful behavior change (e.g. not being involved in a distracted driving related accident), and then mentally contrasting this positive future state with the negative realities that stand in the way of the desired future state (i.e. habitual cues - e.g. having a tendency to text message while driving and being bored). Once potential cues associated with an unwanted behavior have been identified with mental contrasting, individuals can form implementation intentions around these cues, so that they can perform an alternative behavioral response in regard to a cue, rather than the associated habitual behavior. Implementation intentions take the form of: ‘‘If I encounter cue Y (e.g. being bored) and I feel like doing behavior X (e.g. texting while driving), then I will engage in behavior Z (e.g. change the radio station).

Instead of relying on limited cognitive resources, such as performing vigilant monitoring and employing inhibition, MCII works to override habits by forming a new cue-alternate behavior association in memory, with the hopes that this new association will become stronger than existing cue-behavior associations, which drive unwanted habits. Adriaanse et al. (2010) examined participants' unhealthy snacking habits and found that those participants who engaged in MCII reported a lower intake of unhealthy snacks one week later than those who engaged in alternative control strategies. Further, the effects of MCII on unhealthy snack intake were not moderated by habit strength, goal importance, or expectations of method success, indicating that MCII was effective for individuals with both weak and strong snacking habits, as well as for individuals with differing levels of motivation to change behavior and belief in the effectiveness of MCII.

Thus, we may not be slaves to our habits, rather, habits can be inhibited and overridden – albeit sometimes with difficulty – given sufficient will-power, motivation to change behavior, and self-regulatory resources (Neal, Wood, & Drolet, 2013; Adriaanse et al., 2010). In regard to inhibition or self-control, this can be expressed in the RIM as the reflective pathway effectively inhibiting, or overriding a habitual impulse to act (Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). However, it should be noted that the reflective pathway is heavily reliant upon cognitive capacity, and as such, habitual behavior will proceed when spare capacity is depleted (i.e. either from cognitively demanding tasks, Neal et al. 2013, or through continuously employed self-control, Hagger, Wood, Stiff, & Chatzisarantis 2009). This limitation in monitoring and overriding habitual impulses points to the benefit of MCII, as new established behaviors can be paired with cues previously established with unwanted habits, thus potentially altering the cue-behavior associations in long-term memory responsible for habits (Adriaanse et al., 2010). This approach to changing habits is not reliant upon self-control or inhibition, which depend on cognitive capacity.

2.5.2 The Role of Habits in Handheld Cellphone Use

Now that habit, and its relation to conscious decision making (e.g. intentions) and inhibition, has been defined, the habitualness of cellphone use, and its relation to cellphone related distracted driving, will be examined. To date, most of the studies that have examined why drivers use cellphones have strictly focused on the intentional (i.e. volitional) mechanism. A common approach has been to use TPB (Ajzen, 1991). However, if cellphone use can be considered habitual, then the TPB cannot fully account for drivers' cellphone use. Instead, certain cellphone interactions, as well as sequences of cellphone interactions, may simply be learned behavioral responses to associated cues/contexts. The following section will discuss what kinds of cellphone interactions have been identified as being habitual. It will then outline the extent to which a sequence of cellphone interactions can become habitual. Finally, it will discuss what kind of cues/contexts may be associated with cellphone habits, and how these cues/contexts can be carried into the driving environment to influence handheld cellphone related distracted driving.

The habitualness of cellphone use was examined by Oulasvirta et al. (2012), who examined cellphone usage data and found that two types of cellphone interactions appeared to be habitual – cellphone touching (i.e. very briefly checking the home screen of the phone) and checking individual apps for app-specific notifications. In their study, Oulasvirta et al. (2012) defined habit as any cellphone usage that was brief in time (<1s) and occurred with high behavioral frequency. In this study, the automaticity of cellphone usage was impossible to determine, as the mind-set of an individual could not be inferred from cellphone usage data. In their first study, they found that approximately 18% of cellphone use sessions qualified as being habitual – these interactions involved briefly accessing a single application, and then quickly locking the phone. They termed this type of interaction checking habits, with checking habits being most common for a phone's contact book, e-mail, social media apps, and news apps. In their second, larger, study, Oulasvirta et al. (2012) found that touching the cellphone (i.e. unlocking and quickly relocking it) was an interaction that could qualify as being habitual - 35% of 30,295 usage sessions qualified as touching behavior, with interaction lasting <= 1 second. Oulasvirta et al. (2012) inferred that individuals in this scenario were quickly accessing the home screen to check for general notifications or to access specific information (e.g. time).

Overall, Oulasvirta et al. (2012) identified three different types of checking habits, each associated with their own rewards: (1) Informational, (2) Awareness, (3) Interactional. Informational checking habits revolved around accessing dynamically updated, but non-interactive information (e.g. looking at the clock on the home screen). Awareness was a specialized form of information value, where the purpose was to maintain an awareness of a dynamically changing external reality (e.g. checking messages to see if anyone had contacted you). Interactional habits revolved around accessing information that the user could act upon, such as social interactions (e.g. check out the latest updates, so a user can respond). Oulasvirta et al. (2012) found that checking habits, specifically those associated with interactional and awareness rewards, could act as gateways to the use of other cellphone applications. In their study, users would start by opening apps to check something (e.g. new messages – i.e. informational/awareness reward) or to acquire some stimulus for diversion or entertainment purposes (interactional reward). These sometimes led to a series of follow-up actions being performed (e.g. one user viewed the news, followed by Facebook, and then Gmail in a sequence in 31 of the 73 reported instances). Interestingly, these sequences of actions were tied to a specific context (i.e. ‘‘killing time’’ in lectures or transit); indicating that the pattern of usage may have been habitual. This chunking of individual behaviors into one overall action sequence is known as behavioral chunking, which is a phenomenon associated with habit formation (Graybiel, 1998). As such, a sequence of behaviors may become habitual, and behaviorally chunked, if they are frequently repeated together in the same sequence, in response to the same initiating contextual cue (e. g. boredom).

An example of behavioral chunking can be seen below in *Figure 4*. In *Figure 4*, checking a handheld cellphone can either be done intentionally, or habitually, with habitual checking occurring via a response to an associated cue (e.g. notification from the phone). From this point, checking may automatically lead to reading a message, which in turn may prompt an individual to automatically type and send a reply (the grey path in *Figure 5*). In this pathway, preceding actions automatically elicit a subsequent behavioral response. However, as the figure shows, at any point in the action sequence, the reflective pathway may take over (i.e. conscious decision making). Two different outcomes can happen here: either an individual can voluntarily choose to engage in a subsequent behavior (i.e. switch to the white path) or an individual can terminate an action sequence using self-control/inhibition (i.e. halt the action sequence). The intervention of the reflective pathway will depend on the extent to which a sequence of cellphone interactions is habitual (i.e. frequently carried out together in response to a given cue), with shifts to intentional interactions or termination of action sequences being harder with increasing habit strength.

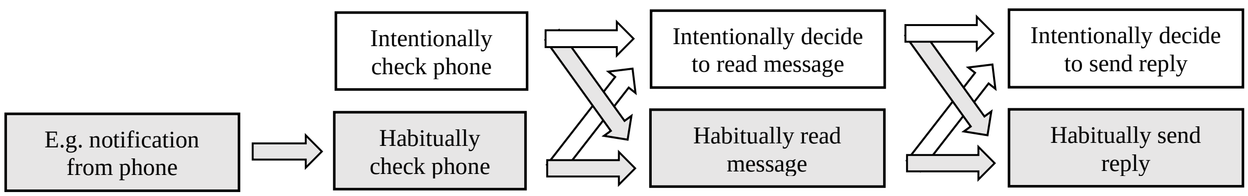


Figure 4. A diagrammatic representation of the extent to which a sequence of cellphone interactions can be carried out habitually or intentionally.

While *Figure 4* applies to cellphone use in general, it may very well apply to cellphone use while driving. Well not empirically proven, it is conceivable that once a sequence of cellphone behaviors has become highly habitual (i.e. frequently repeated in the same sequence) in general, it may become activated also while driving. This would be especially risky, as certain sequences of behavior could take the driver's eyes off the road for longer than two seconds, a threshold that has been found to significantly increase a driver's crash risk (Rockwell, 1988; Klauer et al., 2014). Furthermore, it is possible that drivers may be unable to stop habitual sequences of action via self-control/inhibitory mechanisms, since these mechanisms are reliant upon cognitive capacity (Neal et al. 2013). Research has shown that the task of driving is associated with decreases in driver's cognitive capacity (Schweitzer & Green, 2007; Miura, 1992), and as such, the driving task itself may inadvertently promote more lengthy, habitual cellphone interactions.

The previous paragraphs discussed the extent to which cellphone interactions can become habitual. However, the elicitation of cellphone habits behind the wheel is entirely dependent upon the presence of associated cues. If no cues are present when an individual drives, then habitual cellphone interactions are unlikely to occur. Given that cellphone use while driving is illegal, it is unlikely that cellphone habits form or are associated with any specific cues within the driving environment. While it is possible that individuals who are frequent passengers may develop cellphone habits in response to cues within the vehicle, it is more likely that individuals bring “portable” cues into their vehicles when they drive. In this thesis, the term “portable cues” refers to any cue or context which triggers cellphone usage, which is not specifically bound to an environmental context or particular time of day (two cues/contexts frequently referred to in the habit literature; Ouellette & Wood, 1998). Cellphones are portable devices, and as such, they are used across environments and throughout different times of day. Therefore, it is likely that cellphone habits are more related to portable cues, which can then be brought into the vehicle when individuals drive. Examples of “portable cues” for cellphones may include notifications (e.g. push notifications to the home screen, which result in the home screen lighting up), incoming calls and messages (i.e. ringing, vibrating, flashing), the cellphone itself (i.e. glancing at the phone may elicit a reaching response) or the driver’s mood (i.e. states of boredom or under stimulation; Ji & Wood, 2007; Adriaanse et al., 2009). Within our definition, any contextual element that has consistently covaried with the cellphone behavior in the past that is not dependent upon the environment or time of day can qualify as a portable habit cue.

In conclusion, research has found that certain cellphone interactions are habitual in nature (Oulasvirta et al., 2012). Further, it is likely that a sequence of cellphone interactions can become habitual, based on the principal of behavior chunking (Graybiel, 1998). As such, it may be the case that simple cellphone habits, such as checking for notifications (Oulasvirta et al., 2012), may lead to other, more complex habitual cellphone interactions, which may be normally associated with intentions (i.e. sending a text message). These extended habitual action sequences may pose a particular danger when it comes to cellphone use while driving. However, it is unknown whether cellphone habits carry into the vehicle environment. In this thesis, we identified several portable cues which could potentially account for cellphone habits in the vehicle environment. Given that habit cues carry over, it is possible that cellphone habits influence the extent to which drivers use their handheld cellphones while driving.

2.5.3 Past Research Examining the Role of Habit in Predicting Handheld Cellphone Use While Driving

To date, only a few studies have examined the influence of cellphone habits on drivers' cellphone use while driving. The first study to examine the role of habit was Nemme and White (2010), who used a measure of past texting frequency to predict drivers' self-reported texting while driving. They found that past texting frequency significantly predicted self-reported texting behavior (both reading and sending) after controlling for intentions. These findings are limited, however, due to the fact Nemme and White (2010) employed a measure of past-behavioral frequency to measure texting habits. A number of researchers have pointed out that measures of past behavioral frequency do not necessarily imply habit (Oullette & Wood, 1998; Sutton, 1994) - past behavioral frequency has been identified as a necessary, but not a sufficient condition for habit development. One also has to consider the frequency in which a behavior is paired with an associated contextual cue, as well as the automaticity in which the behavior is elicited and enacted (Oullette & Wood, 1998; Verplanken & Orbell, 2003).

More recent studies examining the role of habits in predicting drivers' handheld cellphone use have used Verplanken and Orbell's (2003) Self-Report Habit Index (SHRI), which is a validated questionnaire that has been employed in over 300 studies (Verplanken & Orbell, 2010). The SRHI primarily measures the automaticity of a habit (i.e. the uncontrollability, lack of awareness, and mental efficiency of the behavior; Bargh, 1994), but also has items dedicated towards measuring past behavioral frequency and the belongingness of the habit to one's daily routine. Specifically, texting habits were examined by Bayer and Campbell (2012), who found that texting habits as measured by a ten-item SRHI (2 items measuring past behavioral frequency were removed) predicted self-reported frequency of texting while driving, after controlling for measures of TPB, as well as for general past texting frequency. Texting habits (both reading and sending) were the second strongest predictor of self-reported frequency of texting while driving, behind a composite measure of social norms (i.e. subjective, moral and group norms). The results showed that the SRHI could be used as a measure of texting habits to predict texting behavior while driving. Results also showed that the SRHI measure was independent of general past texting frequency, which adds support to the idea that habit is more than simply past behavioral frequency.

More recently, conflicting results have been published by Murphy et al. (2020). Murphy et al. (2020) found that reading/monitoring social interactive technology habits (i.e. any app used for social communication on a smartphone), as measured by the SRHI (Verplanken & Orbell, 2003), did not predict future behavior regarding reading/monitoring social interactive technology while driving. However, their sample size (n = 167 for time one measures and n = 95 for time two) may not have been large enough to detect a significant effect of habit. Murphy et al. (2020) entered habits in the third step of a regression as part of an exploratory analysis. In this final model, seven predictors were present (e.g. intentions, the original TPB constructs, habit and mindfulness), with neither the overall model nor any individual predictors being significant. Given that a model with five predictors (just the TPB constructs) was significant, it is possible that a lack of statistical power can explain the non-significance of habits.

In conclusion, there is a need to study the role cellphone habits play in facilitating cellphone use while driving. To date, only a limited number of studies have been conducted, with only a single study utilizing an approach that had sufficient statistical power to find an effect of habit (Bayer & Campbell, 2012). Despite this, Bayer and Campbell's (2012) study was limited in that only texting while driving was examined; in addition, their sample was limited to undergraduate students (M = 18.43, SD = 2.49) from psychology and communication studies classes. Therefore, there is a need to replicate their findings with a broader sample, as well as to examine different types of cellphone interactions. It may be that certain cellphone behaviors are more habitual than others, and it is unknown whether cellphones habits in general (i.e. across behaviors) predict cellphone use while driving. Both Chapters 3 and 4 examine the role of habits in predicting handheld cellphone use while driving.

Further, there is also a need to examine the relationship between intentions to use a cellphone while driving, and cellphone habits. A number of studies in the health psychology domain have found an interaction between habits and intentions, such that when habits strongly predict a behavior, intentions do not (or do so weakly). It may be the case that habits are driving cellphone related distractions behind the wheel, which may explain why drivers are persisting in using cellphones, despite the fact that cellphone distractions are illegal in many regions. This interaction will be examined in the proposed study, which is outlined in Chapter 5.

Lastly, no study to date has examined whether inhibition can moderate the influence of cellphone habits on drivers' self-reported handheld cellphone engagement. In this thesis, we capture inhibition through the construct of counter-habitual intentions. Counter-habitual intentions involve the formation of a specific intention not to engage in cellphone distractions, which then must be enacted through monitoring (e.g. vigilant monitoring) and actively employing self-control. It may be the case that individuals form counter-habitual intentions to control their habitual cellphone use, with the result being a weaker effect of habits on behavior. This interaction will be examined in the proposed survey study in Chapter 5. Further, the possible role the environment plays in influencing the relationship between counter-habitual intentions and cellphone habits in predicting frequency of cellphone use while driving will also be examined in the proposed study. It may be the case that driving environments with higher complexity deplete the cognitive capacity necessary to enact counter-habitual intentions. In this scenario, more complex driving environment may be associated with a stronger habit – cellphone use relationship, as individuals with strong cellphone habits will be unable to employ their counter-habitual intentions. The above modeling would help bridge the gap between simpler social-cognitive models which assume cellphone behavior is under voluntary control and a more realistic portrayal of the complex interaction between drivers' intentions, habits and counter-habitual intentions, in predicting handheld cellphone use while driving.

Chapter 3

3 North American Survey Study

Expanding upon the work of Bayer and Campbell (2012), the following chapter reports an online survey study conducted in North America that examined the role of cellphone habits, in addition to TPB constructs, in predicting driver engagement with a broad selection of cellphone related distractions (e.g. social media). The study utilized data that was collected as part of a larger survey study aimed at improving the Susceptibility to Driver Distraction Questionnaire, which has been validated in earlier studies (SDDQ; Feng et al., 2014; Marulanda et al., 2015). The sample reported in this analysis represents a much more diverse group of drivers compared to the psychology and communication studies undergraduate students sampled in Bayer and Campbell (2012). The following chapter is awaiting publication in the journal *Transportation Research Record.*

> Hansma, B.J**.**, Marulanda, S., Chen, H-Y. & Donmez, B. (in press). The role of habits in cellphone related driver distractions. *Transportation Research Record*.

It is important to note that this study was initiated by a prior master's student (Marulanda, 2015). As such, certain measures were utilized which ignore various aspects of the literature reviewed in Sections 2.4 and 2.5 One example of this is the use of the Self-Report Habit Index to measure individuals' cellphone habits. The original SRHI does not measure habits in response to a specific associated cue (e.g. rather than "Texting is something I do automatically when bored", the study used "Texting is something I do automatically"), which is a cited weakness of the questionnaire (Sniehotta & Presseau, 2012). Although a weakness of the current study, Orbell & Verplanken (2015) stated that the SRHI was a general measure of habit for a given behavior. Thus, given that there could be many cues for a given cellphone behavior, we deemed that the use of a general measure was appropriate. Section 1.1 of Chapter 1 provides the relevant background information for this study.

3.1 Participants

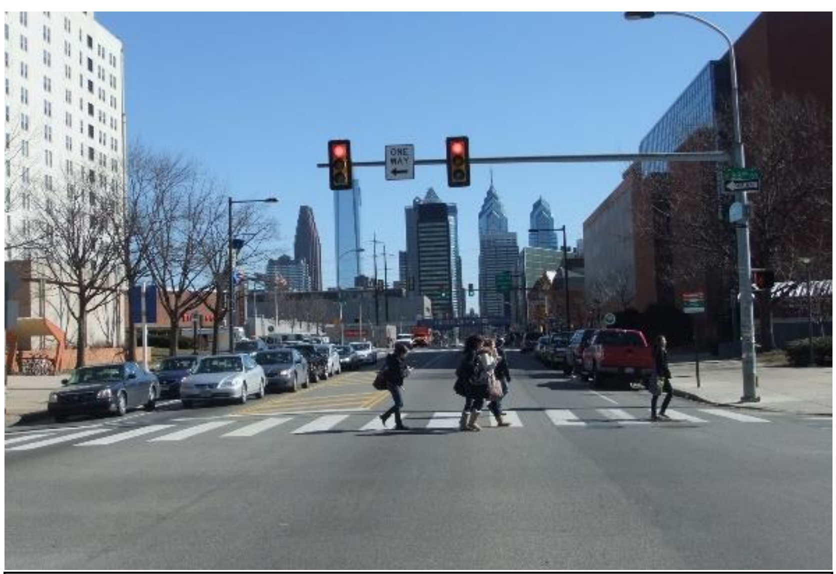
Survey respondents were recruited using online advertisements, and posts to local communities in downtown Toronto, ON, Canada. A total of 227 survey responses were collected over a five-month period in 2015. One participant who reported their age as the current year was removed from the analyses as they may not have read the survey questions closely, along with eight respondents who chose the option ‘I don’t use this technology’ for all surveyed cellphone distractions. In the remaining sample (n=218), 61.5% of respondents were female, and the respondents’ age ranged between 17 and 79 years old, with a mean of 38.6 and standard deviation (SD) of 13.1 (**Table 4**). Respondents were not permitted to skip survey questions and were encouraged to complete the entire questionnaire to become eligible for a draw to win one of three Apple iPads and several $10 Starbucks gift cards.

Table 4. Number of respondents (analyzed) across different demographic categories

	Females	17-25 years	26-35 years	36-55 years	55+ years	**Total**
N	134	37	64	87	30	218
% of total	61.5%	17%	29%	40%	14%	100%

3.2 Measures Analyzed

Participants were presented with an image of an urban driving environment (*Figure 5*) at the beginning of the survey and were asked to respond to questions by thinking back about their experiences over the last year while driving in similar scenarios. Participants were asked to answer questions according to their actual experience rather than what they thought their experience should be.



Imagine yourself driving along on a 3-lane urban road with heavy traffic, high pedestrian flow, and traffic lights. (The photo illustrates what this scenario may look like.)

Figure 5. The context image and accompanying text provided to the survey respondents.

We collected data on seven common cellphone distractions, which have been widely banned across multiple regions in North America (see **Table 5**; GHSA, 2019; Canadian Automobile Association, 2019). Participants were asked to report their frequency of engagement in, attitudes towards, perceived behavioral control over (i.e. self-efficacy and perceived control) and perceived social norms (i.e. injunctive and descriptive) related to these distractions within the driving scenario mentioned above. As a reminder, the image and the text shown in *Figure 5* were re-presented to the participants before each of these constructs, with the exception of perceived control. Since we wanted general assessments for perceived control, participants were told that they did not have to base their answers on the scenario presented to them earlier. Items (see **Table 5** for a complete list) used in the survey were those from a revised version of the SDDQ (Marulanda et al., 2015), which is a validated North American survey designed to study driver distraction. The revised version of the SDDQ is an enhanced version of the original that improves the wording of some of the original items, in addition to including extra items meant to better capture some of the multi-faceted constructs within the questionnaire. One example of this is for attitude, where five items replaced the single item used in the original SDDQ (i.e. three bi-polar semantic differential scales and two belief-based measures that assess a value of convenience and an evaluation of others performing the behavior). A detailed description of revisions to the SDDQ can be found in Marulanda et al. (2015).

The current study assessed perceived behavioral control through its two sub-constructs: self-efficacy and perceived control (Trafimow, Sheeran, Conner, & Finlay, 2002). This was done because several studies have found self-efficacy (i.e. the perceived difficulty of engaging in a specific behavior) and perceived control (i.e. a person's self-assessment of how much personal control they feel over the behavior) to be separate, but inter-related constructs (Trafimow et al.,2002; Armitage & Conner, 2001). The lack of distinction made between self-efficacy and perceived control may explain why perceived behavioral control has been somewhat of an inconsistent predictor of driver intention/willingness to engage in cellphone distractions across studies (Walsh et al., 2008; Rozario et al., 2010; Waddel & Wiener, 2014; Nemme & White, 2010; Przepiorka et al., 2018). In fact, certain studies outside of the distracted driving domain have found self-efficacy to a better predictor of behavioral intention than perceived control (Trafimow, Sheeran, Conner, & Finlay, 2002). By examining these sub-constructs separately, we aimed to obtain a clearer picture of whether and how perceived behavioral control predicts drivers' self-reported engagement in cellphone distractions. In addition, two types of social norms were examined, injunctive norms (i.e. perceived approval of important others) and descriptive norms (i.e. perceptions of others' behaviors). Injunctive norms, otherwise known as subjective norms, are an original construct of the TPB, while descriptive norms are a somewhat recent addition to the TPB. To date, research has found that descriptive norms predict both general driver distraction engagement and drivers' willingness to use a cellphone above and beyond the traditional constructs of the TPB (Waddel & Wiener, 2014; Chen & Donmez, 2016; Chen, Donmez, Hoekstra-Atwood, & Marulanda, 2016).

To measure cellphone habits, we utilized a variation of the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003) also used by Bayer and Campbell (2012) to collect data on three cellphone habits: (1) checking for new notifications, (2) answering a phone call, and (3) responding to new notifications. Only three cellphone habits were examined in order to prevent lengthening the survey. Notification-related habits were selected, rather than other types of cellphone habits, based on findings from Oulasvirta et al. (2012) that checking for notifications appears to be a habitual cellphone interaction. For each habit type, participants rated ten statements: e.g. "checking for new notifications is something…" (1) I do automatically, (2) I do without having to consciously remember, (3) I do without thinking, (4) I start before I realize I am doing it, (5) I have no need to think about doing, (6) I do without meaning to do it, (7) That would require effort not to do it, (8) That I would find hard not to do, (9) That is typically me, (10) That belongs to my daily routine. The responses were collected on a 5-point Likert scale ranging from 1=Strongly Disagree to 5=Strongly Agree.

Average scores were calculated for each participant before our regression analysis. Self-reported frequency of engagement was averaged across all distractions, excluding ones where a participant chose "I don't use this technology". Average scores for self-efficacy and descriptive norms where calculated in a manner similar to frequency of engagement, where self-efficacy/descriptive norms were averaged across all distractions pertaining to each construct. Average scores for attitude, perceived control and injunctive norms were calculated by averaging across each item for a given distraction (e.g. averaging A1-A5 across D1, averaging IN1 and IN2 across D1), and then averaging across distractions. Finally, an average habit score was calculated by averaging the

SRHI items for a given cellphone habit, and then averaging those cellphone habits for a given participant.

Table 5. Cellphone distractions surveyed and SDDQ items used to assess TPB constructs related to cellphone use while driving.

Surveyed Cellphone Distractions	
D1	Talk(ing) on the phone using a hand-held device
D2	Dial(ing) a phone number (not available through speed dial) using the keypad of a hand-held device (e.g. cellphone)
D3	Manually enter(ing) text messages on a hand-held device (e.g. cellphone)
D4	Read(ing) text messages on a hand-held device (e.g. cellphone)
D5	Read(ing) emails on a hand-held device (e.g. cellphone)
D6	Update(ing) social media (i.e. Facebook, Instagram, Twitter) on a hand-held device (e.g. cellphone)
D7	Manually enter(ing) an address into a navigational app on a smartphone that is NOT mounted inside the vehicle
SDDQ ITEMS (Utilizing the Above Distractions)	
Engagement Frequency 1 = Never, 2 = Rarely, 3 = Occasionally/Sometimes, 4 = Often, 5 = Very Often, NA = I don't use this technology	
FREQ	On average, how often did you engage in each of these tasks over the last year, while driving in an environment similar to the image above?
Attitudes A1: 1 = Pleasant to 5 = Unpleasant; A2: 1 = Safe to 5 = Dangerous; A3: 1 = Wise to 5 = Unwise A4 & A5: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
A1 to A3	For me, driving and [D1-D7] is…
A4	While driving, it is a good use of my time to [D1-D7]
A5	I lose respect for people who drive and [D1-D7]
Self-Efficacy 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
SE	While driving, I have no difficulty [D1-D7]
Perceived Control 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral 4 = Agree, 5 = Strongly Agree	
PC1	I decide whether I drive and [D1-D7]
PC2	Circumstances determine if I [D1-D7]
Injunctive Norms 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
IN1	People who are important to me would approve of me driving and [D1-D7]
IN2	People who are important to me would think it is okay for me to drive and [D1-D7]
Descriptive Norms 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
DN	Most drivers drive and [D1-D7]

The wording of the seven cellphone distractions can be changed to accommodate different question prompts (e.g. A1-A3). For D2 and D7, the measure A4 was not collected as it was deemed to be uninformative for these two distractions. Participants were given the opportunity to select the option "I don't use this technology" for the cellphone distractions in the "Frequency of Engagement" section; if they chose this, then that distraction would be removed from all subsequent sections of the survey, except those relating to injunctive and descriptive norms. The presentation of distraction items remained consistent throughout the survey, and respondents answered all questions pertaining to the TPB constructs in the same order.

3.3 Results

Descriptive statistics are reported for self-reported engagement in each of the distractions, as well as for constructs of the TPB, and habitual cellphone use. These statistics are followed by Pearson correlation analysis between different constructs. Finally, a hierarchical multiple linear regression model is reported which examined the effect of habitual cellphone use on frequency of engagement in cellphone related driver distractions, while controlling for constructs of TPB. A logarithmic transformation was used on the dependent variable to ensure normality of the residuals. No issues of multicollinearity were found through the examination of Variance Inflation Factors.

3.3.1 Descriptive Statistics and Correlation Analysis

Self-reported frequency of engagement in cellphone distractions was considerably low, roughly corresponding to an average rating of "rarely" on the five-point Likert Scale (**Table 6**). Age appeared to be a for the frequency of engagement in cellphone distractions, with engagement being most frequent for drivers 26-35 years old and least for drivers older than 55. Overall, attitudes were found to be highly negative towards engaging in the cellphone distractions surveyed, with a mean of 4.39 on a scale ranging from 1 to 5 (see **Table 7** for descriptive statistics on all constructs). On average, respondents felt that engaging in these cellphone distractions while driving was difficult, while at the same time feeling neutral towards their control over engaging in them. In regard to descriptive norms, on average, respondents felt neutral towards whether most drivers engaged in these cellphone related distractions; however, they did believe that people important to them would not approve of them engaging in these distractions while driving. Finally, respondents rated the automaticity of their notification-related cellphone behaviors on the lower side (average score of 2.24 on a scale from 1 to 5).

Table 6. Mean values (and standard deviation in parentheses) for self-reported engagement in the different cellphone distractions surveyed.

Cellphone related Distraction	Overall M(SD)	17-25 M(SD)	26-35 M(SD)	36-55 M(SD)	55+ M(SD)
D1. Talk on the phone	1.79(1.02)	1.81(1.04)	1.98(1.07)	1.80(1.04)	1.31(0.66)
D2. Dial a phone number using the keypad	1.65(0.97)	1.89(1.13)	1.62(0.92)	1.71(1.02)	1.24(0.58)
D3. Manually enter text messages	1.74(0.96)	1.73(1.10)	1.97(0.98)	1.73(0.94)	1.22(0.51)
D4. Read text messages	1.95(1.06)	2.16(1.19)	2.22(1.07)	1.88(1.02)	1.13(0.34)
D5. Read emails	1.51(0.89)	1.54(1.01)	1.58(0.94)	1.58(0.90)	1.08(0.28)
D6. Update social media (i.e., Facebook, Instagram or Twitter)	1.26(0.73)	1.33(0.79)	1.36(0.87)	1.22(0.67)	1.04(0.20)
D7. Manually enter an address into a navigational app	1.86(1.06)	1.97(1.21)	2.05(1.11)	1.91(1.00)	1.08(0.28)

Table 7. Descriptive statistics for average scores of self-reported engagement frequency, TPB constructs, and habitual cellphone use (n=218).

Construct	Mean	Standard Deviation
Engagement frequency	1.68	0.78
Attitudes	4.39	0.59
Self-efficacy	1.98	0.98
Perceived control	3.19	1.06
Descriptive norms	3.26	0.89
Injunctive norms	1.65	0.78
Habitual cellphone use	2.24	0.83

As can be seen in **Table 8**, attitudes (r = -.61) and self-efficacy (r = .55) had the largest correlations with engagement frequency, while descriptive norms have the weakest correlation (r = .20). Among TPB constructs, attitudes and self-efficacy (r = -.68) and attitudes and injunctive norms (r = -.69) were highly correlated. This indicates that those with increasingly negative attitudes towards engaging in hand-held cellphone distractions often felt they had higher difficulty executing these tasks while driving and perceived less approval from people who are important to them. It is worth noting that descriptive norms were only weakly correlated with the other variables of TPB, with correlations ranging from r = .13 to r =.23. In regard to habitual cellphone use, notification-related habits were moderately correlated with attitudes (r = -.36), perceived control (r = .29), and self-efficacy (r = .29). This indicated that stronger notification-related habits, in general (i.e. not confined to the vehicle environment) were associated with more positive attitudes, higher perception of control, and less perceived difficulty of engaging in cellphone related distractions while driving.

Table 8. Bivariate correlations among self-reported engagement frequency, TPB constructs, and habitual cellphone use.

	1	2	3	4	5	6
1. Engagement frequency						
2. Attitudes	-0.61***					
3. Self-efficacy	0.55***	-0.68***				
4. Perceived control	0.43***	-0.32**	0.32***			
5. Descriptive norms	0.20***	0.19**	0.22**	0.22***		
6. Injunctive norms	0.46***	-0.69***	0.55***	0.28***	0.19**	
7. Cellphone habits	0.45***	-0.36***	0.29***	0.29***	0.13	0.28***

p values: p < .05*, p < .01**, p < .001***

3.3.2 Multiple Linear Regression

A hierarchical multiple linear regression was conducted with two blocks (**Table 9**). In the first block, TPB constructs were entered into the model and were found to account for a significant amount of the variance in self-reported engagement frequency, $F(5, 212) = 42.69$, $p < .001$, $R^2 = .50$. Notification-related cellphone habits were added to this model in the second block, and this resulted in a statistically significant increase in the variance explained, $F(1, 211) = 13.64$, $p < .001$, $\Delta R^2 = .03$. The final model again accounted for a significant amount of the variance in self-reported engagement, $F(6, 211) = 39.97$, $p < .001$, $R^2 = .53$. All TPB constructs were significant except for descriptive and injunctive norms. As indicated by standardized coefficient estimates, attitudes were found to be the strongest predictor of self-reported engagement, followed by perceived control, self-efficacy, and then habits. Age was not included as a predictor due to sample size limitations.

Table 9. Linear models predicting cellphone distraction engagement (log-transformed).

	Estimate	Standard Error	Standardized Estimate	t-value	p-value	R^2 (Adjusted R^2)
Block 1						
Intercept	0.96	0.32		3.04	**< .01**	.50 (.49)
Attitudes	-0.26	0.05	-0.36	-4.68	**< .001**	
Self-efficacy	0.12	0.02	0.22	5.68	**< .001**	
Perceived control	0.09	0.03	0.30	3.28	**< .01**	
Descriptive norms	0.02	0.02	0.03	0.55	> .05	
Injunctive norms	-0.001	0.04	-0.003	-0.04	> .05	
Block 2						
Intercept	0.67	0.32		2.14	**< .05**	.53 (.52)
Attitudes	-0.22	0.05	-0.32	-4.17	**< .001**	**ΔR^2 = .03***
Self-efficacy	0.10	0.02	0.21	5.07	**< .001**	
Perceived control	0.09	0.03	0.26	3.24	**< .01**	
Descriptive norms	0.01	0.02	0.02	0.46	0.12	
Injunctive norms	-0.01	0.04	-0.01	-0.16	0.4	
Cellphone habits	0.09	0.03	0.19	3.69	**< .001**	

Age was not entered in as a predictor as there was not enough statistical power to analyze it as an effect.

3.4 Discussion

We reported on the analysis of an online survey study examining the role of notification-related cellphone habits in predicting self-reported cellphone use while driving. Although previous research has found texting habits to be a significant contributor to self-reported frequency of texting while driving (Bayer & Campbell, 2012), the current analysis extended this finding by examining the impact of notification-related habits in eliciting a broader selection of visual-manual cellphone distractions, such as reading emails, updating social media, and entering an address in a navigation app. In addition, this analysis used a more heterogeneous and representative sample than Bayer and Campbell (2012) who recruited undergraduate students from psychology and communication studies classes.

Based on descriptive statistics, the cellphone distractions that were self-reported to be most frequently engaged in were reading a text message, manually entering an address into a navigational app not mounted to the dashboard and talking on a hand-held device. It is interesting to note that manually entering an address on a smartphone had a higher average frequency of engagement than talking on a hand-held phone. Thus, the current results may indicate that patterns of cellphone engagement behind the wheel may be changing with the evolution of cellphones. Recent studies modeling drivers' cellphone use (e.g. TPB) have primarily focused on text messaging (Przepiorka et al., 2018; Bazargan-Hejazi et al., 2016; Waddel & Weiner, 2014); however, the capabilities of smartphones are expanding, with drivers being able to use these devices for a variety of tasks other than texting. Thus, it is important to investigate new use cases of these devices within the vehicle.

Similar to Bayer and Campbell (2012), we found that habitual cellphone behaviors were significant in predicting self-reported engagement in a selection of cellphone distractions, after controlling for the volitional factors (i.e. the TPB constructs). Specifically, we examined notification-related cellphone habits (e.g. checking for/respond to notifications) in general (i.e. daily life), and found that increased habitualness was associated with higher self-reported engagement in other cellphone distractions while driving (controlling for volitional factors). While our findings are strictly correlational, there may be a causal explanation for this association. First, notification-related habits may be carried into the vehicle when people drive - cellphone use is ubiquitous, and thus, portable cues, such as internal mental states (Ji & Wood, 2007) and cues specific to the phone itself (e.g. receiving a notification) follow people into their vehicles. Second, once notification-related habits have been carried into the vehicle environment (e.g. checking for notifications), they may automatically prompt engagement in other cellphone distractions (e.g. reading text messages, sending text messages); this assumption is based on the principle of behavioral chunking (Graybiel, 1998). In this way, notification-related habits that have been developed outside of the vehicle may directly elicit habitual engagement in a variety of other cellphone distractions (i.e. those examined in the current study). This may explain why we found an association between general notification-related habits and self-reported frequency of engagement in other cellphone distractions while driving, after controlling for volitional facilitators relating to those distractions. While this hypothesis seems reasonable, it is important to note that it is only speculation, and other factors may explain the relationship between notification-related habits and self-reported frequency of engagement in cellphone distractions while driving.

The finding that cellphone habits significantly predict frequency of engagement in cellphone related driver distractions, after controlling for volitional factors, is important, as it indicates that volitional facilitators of cellphone distraction may not fully account for drivers' engagement in these distracted driving behaviors. This has implications for the development of public safety awareness campaigns and educational messages that solely focus on challenging driver attitudes, perceived behavioral control, and perceived social norms. Such endeavors should also consider the role habits may play in eliciting cellphone use behind the wheel. Research shows that people are at least aware of the existence of their current habits (Wood et al., 2002), and as such, drivers could take appropriate measures to combat their cellphone habits if the issue is brought to their attention. Examples of potential countermeasures include features such as the "Do Not Disturb Mode", which blocks all incoming notifications to the phone. This may be an effective countermeasure, as it removes cues that likely trigger habitual cellphone use (e.g. checking your phone in response to receiving a notification).

In general, we found that TPB constructs explained 50% of the variance in self-reported engagement frequency in cellphone related distractions. In addition, attitudes, self-efficacy, and perceived control were significant predictors, with attitudes being the strongest, followed by perceived control. This result is in line with the findings from Chen et al. (2016), who reported that TPB accounted for 45% of the variance in self-reported engagement in distractions (including distractions other than cell-phone related ones), with attitudes and perceived behavioral control as measured through self-efficacy being the strongest predictors. Although descriptive norms were found to be significant by Chen et al (2016), they were not significant in our analysis. This discrepancy may be due to the different distraction items used in our analysis. For example, in their analysis, Chen et al (2016) combined legal (e.g., talking to passengers) and illegal distractions, whereas we only focused on illegal ones. Drivers may perceive legal distractions to be more common and socially acceptable; thus, perceptions of others' engagement in these distractions may be more likely to influence drivers' own engagement. Similar to our study, injunctive norms were not found to be a significant predictor in Chen et al (2016), indicating that, although North American drivers appear to think that important others would not approve of them engaging in cellphone related distracted driving, this may have no influence on their self-reported behavior. This result differs from Bayer and Campbell (2012), who found norms to be significant in predicting self-reported texting while driving; however, they used a composite measure of norms, including moral, group, and injunctive norms. Thus, it is difficult to interpret which aspect of norms may have influenced behavior in Bayer and Campbell (2012). Future studies should make an effort to investigate these different aspects of social norms separately.

3.5 Limitations and Future Research

We acknowledge that the reported dataset is vulnerable to self-report bias and the non-random sampling methods used in online surveys. Given that cellphone related distractions are largely banned, it is possible that the respondents were influenced by social desirability bias to respond in a manner that reflected them in a more positive light. This influence of social desirability may in part account for the low frequencies we found for self-reported engagement in cellphone distractions. Online surveys have been found to reduce the effects of social desirability bias due to their remote nature (Tourangeau, Rips, & Rasinski, 2000). However, Bayer and Campbell (2012) found similarly low engagement frequencies for reading and sending text messages in their study (equating to "rarely"), where participants completed a survey in a laboratory environment. Thus, it is unclear how much the online format helped with counteracting the social desirability bias for our survey. It is also possible that both our and Bayer and Campbell's (2012) participants underestimated their cellphone use while driving, which may in part be attributable to our finding that cellphone use can be habitually driven. Regardless of the underlying reason, it is possible and maybe likely that there was underreporting, given that at any given daylight moment in 2017, 5.3% of U.S. drivers were estimated to be manipulating handheld electronic devices while driving (NHTSA, 2019b). Naturalistic studies provide the best avenue for estimating drivers' actual cellphone use, and thus, one potential avenue for future research is to see whether the TPB constructs, as well as cellphone habits, predict actual frequencies of cellphone use in real-world driving.

We also recognize that our results and discussion about the psychological variables used in this analysis are limited to the extent that the scales we employed measured them accurately and completely. While it is hard to ensure a measure ever achieves this entirely, we started with an already validated tool (i.e., SDDQ) and further revised it from lessons learned developing this tool. Further, we used a popular and validated questionnaire to measure respondents' cellphone habits (i.e. SRHI). While the SRHI ignores certain important elements of habit (e.g. associated cues), it has been used as a general measure of habit in a large number of studies (Gardner et al., 2011). Future studies conducting cellphone habit research should consider exploring what cues are associated with cellphone habits, or if known, incorporating cues into the SRHI item prompts (e.g. "Doing behavior X in context Y is something I do automatically"; Sniehotta & Presseau, 2012).

Finally, we only report data collected for an urban driving scenario. Drivers often report engaging in cellphone related distractions when they perceive driving conditions to be less demanding and safer (e.g. when stopped at a red light; Lerner & Boyd, 2005; Schroeder et al., 2018); thus, future studies should also consider different driving environments. In a rural environment where driving demands are lower, habitual cellphone use may play a larger role in triggering drivers to engage in further distractions.

3.6 Conclusion

The role of habitual cellphone use in influencing drivers' self-reported engagement in a variety of cellphone distractions was examined. It was found that habitual cellphone use accounted for unique additional variance in self-reported engagement above and beyond voluntary engagement as measured by TPB. This study adds to the literature by replicating the findings of Bayer and Campbell (2012) with a broader selection of cellphone distractions and a more diverse sample of participants.

Chapter 4

4 Online Survey Study in China

The following paper has been submitted to a transportation research journal and is under review.

> **Hansma, B.J.**, Du, J., Chen, H-Y., Gu, X. & Donmez, B. (under review). Volitional and habitual facilitators of cellphone related driver distraction: An online survey study from China.

4.1 Motivation

To provide insight into the contribution of volitional and habitual facilitators of driver engagement in cellphone related distracted driving, an online survey study was conducted in China over a 5-month period in 2016. In China, the percentage of traffic fatalities associated with driver distraction is considerably high for certain regions, with a recent report indicating distraction being a factor in 44.3% of traffic fatalities for the Zhejiang province (Xiaofeng, 2017). This is notably higher than estimates for other countries, such as the U.S. (7.8% of fatal crashes in 2018 were distraction-affected; NHTSA, 2019a) and Canada (10% of all fatal crashes in 2014; Canadian Automotive Association, 2018). Further, a recent survey of Beijing drivers found that 91.8% of respondents reported talking on a cellphone while driving at least some of the time, while 78% and 60% of respondents indicated that they read and wrote text messages while driving, respectively (Shi et al., 2016). These estimates appear to be higher than those found in both the U.S. (Schroeder et al., 2018) and Canada (Berebaum et al., 2015). High frequency of handheld cellphone distractions persists in China despite the fact they have been illegal since 2003 (State Council, 2004). As such, it is important to understand why drivers in China engage in handheld cellphone distractions – once understood, countermeasures (e.g. educational messages) can be developed which specifically target predictors of handheld cellphone related distracted driving.

While the TPB has been applied to understand handheld cellphone use in a number of other countries (e.g. Australia), few studies have applied the TPB to understand Chinese drivers' intentions to use a handheld cellphone while driving. Zhou et al. (2009) found that global measures of perceived control, subjective norms, and attitude accounted for 48% of the variance in drivers' intentions to answer phone calls on a handheld device, while Zhou, Rau, Zhang and Zhuang (2012) found that a combined measure of perceived control and risk, along with belief-based measures of attitude and subjective norms, accounted for 59% of the variance. These variance estimates from China appear to be consistent with findings from other countries, including Australia (e.g. White et al. 2008), Poland (e.g. Przepiorka et al., 2018) and the United States (e.g. Bazargan-Hejazi et al., 2016).

To the best of this author's knowledge, no study has examined the role of cellphone habits in predicting Chinese drivers' handheld cellphone use behind the wheel. It may be that findings from more "Western" societies (e.g. North American and Australian) do not apply to drivers from China. For example, Chinese citizens have been found to spend over an hour more on their smartphone per day (3 hours/day), on average, than North Americans (2 hours a day; People's Daily, 2017). While frequency does not imply habit strength, it is a necessary condition for habit development. Therefore, it may be that Chinese citizens have stronger cellphone habits than North Americans, which may influence the extent to which they use their cellphone while driving. For this reason, it is important to examine the role cellphone habits play in predicting Chinese drivers' self-reported frequency of engagement in handheld cellphone distractions. The current study aimed to examine this relationship. Specifically, it attempted to assess whether notification-related cellphone habits developed outside of the vehicle context could predict drivers' self-reported frequency of engagement in a variety of cellphone distractions inside the vehicle, while controlling for a number of volitional facilitators (i.e. TPB constructs).

This study aimed to verify and expand the results of the study presented in Chapter 3. A more advanced modelling technique could be used (structural equation modelling) given the larger sample size. Further, the role of the driving environment was taken into consideration (rural highway vs downtown urban), which was not possible in Chapter 3 due there being sample imbalances within the rural and urban conditions (i.e. different demographic characteristics). Section 1.1 of Chapter 1 provides further background for this study.

4.2 Study Outline

An online survey was completed by 1,016 drivers from mainland China and structural equation modelling (SEM) was used to build predictive models. Respondents completed the survey under one of two conditions, either a rural highway condition (n = 510) or a downtown urban condition (n = 506). Environments with differing complexities were examined because increasingly complex driving environments (e.g. downtown urban core) present higher levels of perceptual and cognitive workload for drivers (Schweitzer & Green, 2007; Miura, 1992). Thus, environmental complexity may moderate the relationship between TPB variables and self-reported engagement in cellphone distractions while driving; previous research has found this to be the case (e.g. White et al., 2008; Przepiorka et al., 2018). We hypothesized that:

1) Notification-related habitual cellphone use would significantly predict self-reported engagement in the surveyed cellphone distractions after controlling for TPB constructs.

2) Ratings for self-reported frequency of engagement in cellphone distractions and TPB constructs would vary based on the driving context, and that the driving context would moderate the relationship between the TPB variables and self-reported frequency of engagement in cellphone use while driving.

4.3 Methods

4.3.1 Participants

Respondents were recruited using posts to community websites (e.g. 58 Tongcheng) and printed advertisements on the Beihang University campus. In addition, a survey institute, Changsha Ranxing Information Technology Co., Ltd., was hired to help distribute the survey link to eligible clients. Respondents were required to be current residents of mainland China and hold a valid Chinese driver license (e.g. C1 License, valid for small cars, SUVs and light trucks). To ensure participant eligibility, IP addresses were matched to the respondent’s current address; if they did not match, respondents were disqualified from the study. Additionally, IP addresses were used to ensure only a single survey was submitted from each IP address. Respondents were compensated 6 to 20 Chinese Yuan (equivalent of 0.85 to 2.83 USD) based on the extent of the completion of the questionnaire. In addition, each respondent was entered into a raffle for a chance to win one of two iPad Minis.

A total of 1,016 respondents completed the survey from November 2015 to April 2016. From the total sample, 510 respondents completed the questionnaire within the context of a rural highway environment and 506 within the context of a downtown urban environment. Fifty-four respondents from the rural environment and 38 respondents from the urban were removed from the analysis because they indicated they drove “a few days a year or less”. In addition, respondents were removed from the analysis if they chose the response “I don’t use this technology” for three or more of the seven distraction-related items (N = 30). A breakdown of the demographics for respondents whose data was analyzed can be found in **Table 10**. On average, respondents took 20 minutes to complete the survey and they were not allowed to skip any questions.

Table 10. Participant demographics for the rural and urban driving contexts

	n	% Male	Age in Years	Driving Experience in Months	Frequency of Driving in Past Year	Kilometers Driven in Past Year
			Mean (Standard Deviation)			
Rural	441	66.44	28.26 (5.34)	46.34 (33.96)	1.84 (.70)	2.58 (1.23)
Urban	453	68.43	27.69 (5.26)	45.37 (33.75)	1.85 (.73)	2.73 (1.25)

Frequency of driving in the past year was measured on a 3-point Likert scale from 1 (almost every day) to 3 (a few days a month). Kilometers driven in the past year was measured on a 6-point Likert from 1 (under 5,000 km) to 6 (over 45,000 km) with 10,000 km intervals.

4.3.2 Measures

4.3.2.1 Susceptibility to Driver Distraction Questionnaire

Seven common cellphone distractions that were illegal in China at the time of the online survey were surveyed (see **Table 11**; State Council, 2004). Participants were asked to report their frequency of engagement in, attitudes towards, perceived behavioral control over and perceived social norms related to these distractions within a specific driving context (either a rural highway or downtown urban scenario; see *Figure 6*). The items were a Mandarin translation of those from a revised version of the Susceptibility to Driver Distraction Questionnaire (SDDQ; Feng et al., 2014; Marulanda et al., 2015), which is a validated North American survey designed to study distraction engagement. The revised version of the SDDQ, is an enhanced version of the original (Feng et al. 2014) that includes more precise wording and includes some additional items meant to better capture some of the multi-faceted constructs within the SDDQ (e.g., attitudes; see Marulanda et al. 2015 for a detailed account of revisions), and it has been shown to have concurrent validity (i.e. most TPB constructs were correlated with prior behavioral frequency) and be internally reliable (as assessed through Cronbach’s alpha; Marulanda, 2015).

The driving context (see *Figure 6*) was presented at the beginning of the survey, and participants were asked to answer certain sections of the survey by "thinking back about their experiences over the previous year while driving in similar scenarios". As a reminder, driving scenarios were re-presented to participants before each TPB construct was measured. Participants were encouraged to answer according to their actual experience rather than what they thought their experience should be. For both the sections on perceived control and habitual cellphone use, participants were told not to consider the driving environment as we wanted general measurements of these constructs.

Imagine yourself driving on a 4-lane highway where local lanes are divided by a barrier, traffic conditions are low and there is good weather. The photo below illustrates the environment that you should consider when answering the following questions.

Imagine yourself driving along on a 3-lane urban road with heavy traffic, high pedestrian flow, and traffic lights. The photo below illustrates the environment that you should consider when answering the following questions.

Figure 6. The driving context images, and text provided to the survey respondents.

Table 11. Cellphone distractions surveyed and the back translated SDDQ items used in the study (translated from the Mandarin version)

Surveyed Cellphone Distractions	
D1	Talk on a hand-held device (e.g. cellphone)
D2	Dial a phone number (not using speed dial) using the keypad of a hand-held device (e.g. cellphone)
D3	Manually enter text messages on a hand-held device (e.g. cellphone)
D4	Read text messages on a hand-held device (e.g. cellphone)
D5	Read emails on a hand-held device (e.g. cellphone)
D6	Update social media (e.g. WeChat, QQ) on a hand-held device (e.g. cellphone)
D7	Manually enter an address into a navigational app on a smartphone that is NOT mounted inside the vehicle

SDDQ ITEMS	
Frequency of Engagement 1 = Never, 2 = Rarely, 3 = Occasionally/Sometimes, 4 = Often, 5 = Very Often	
FREQ	On average, in the last year while driving in a scenario similar to the image above, what is the frequency you engaged in each of these tasks?
Attitude A1: 1 = Safe, 2 = Relatively Safe, 3 = Neither Safe nor Dangerous, 4 = Relatively Dangerous, 5 = Dangerous A2: 1 = Pleasant, 2 = Relatively Pleasant, 3 = Neutral, 4 = Relatively Unpleasant, 5 = Unpleasant A3: 1 = Wise, 2 = Relatively Wise, 3 = Neutral, 4 = Relatively Unwise, 5 = Unwise A4: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree A5: 1 = Definitely will not, 2 = Will not, 3 = Neutral, 4 = Will, 5 = Definitely will	
When answering the following questions, please consider a driving event similar to the image above	
A1	To you personally, how safe is it to engage in the following activities when driving?
A2	To you personally, how pleasant is it to engage in the following activities when driving?
A3	To you personally, how wise is it to engage in the following activities when driving?
A4	When driving, it is a good use of my time to …
A5	Will those who drive and [D1 – D7] make you lose respect for them?
Self-Efficacy 1 = Not difficult at all, 2 = Not difficult, 3 = Neutral, 4 = Difficult, 5 = Very difficult	
Please consider a similar driving event when answering the following questions	
SE	How difficult is it for you to drive and…
Perceived Control 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree	
When answering the following questions, there is no need to consider the scenario depicted by the earlier image.	
PC1	I decide whether I drive and…
PC2	I decide, depending on the circumstances, whether or not to engage in the following.
Injunctive Norms 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree	
Please consider a similar driving event when answering the following questions	
IN1	People who are important to me (such as parents, spouses and friends) would *approve* of me driving and…
IN2	People who are important to me (such as parents, spouses and friends) would think I am able to handle driving and…
Descriptive Norms 1 = No, 2 = To A Certain Extent No, 3 = Neutral, 4 = To A Certain Extent Yes, 5 = Yes	
Please consider a similar driving event when answering the following questions	
DN	Do you see many drivers drive and…

This table presents an English translation of the Mandarin version of the SDDQ. Note, some of the items and scales in this translation are slightly different from the North American version of the revised SDDQ as presented in Chapter 3. Participants indicated how strongly they agreed or disagreed with each statement for the seven cellphone distractions (D1-D7). For D2 and D7, the measure A4 was not collected as it was deemed to be not informative for these two distractions. Participants were given the opportunity to select the option "I don't use this technology" for the cellphone distractions listed in the frequency of engagement section. *If a respondent chose this option, then that distraction was removed from all subsequent sections of the survey*.

4.3.2.2 Habitual Cellphone Use

To measure cellphone habits, we utilized the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003; Orbell & Verplanken, 2010) adopted by other driver distraction studies (Bayer and Campbell, 2012; Panek, Bayer, Dal Cin, & Campbell, 2015) to collect data on three notification-related cellphone habits thought to carry across spatial contexts: (1) checking for new notifications, (2) answering a phone call, and (3) responding to new notifications; prior research has found that notification-related interactions appear to be habitual (Oulasvirta et al., 2012). Participants were asked to consider the three notification-related cellphone habits outside of the vehicle/driving contexts, as we wanted a general measure of these cellphone habits. Only three cellphone habits were examined in order to reduce the length of the overall questionnaire.

A Mandarin translation of the SRHI was used for the current study. Each item of the SRHI was translated back to English for reporting purposes (**Table 12**). For each habit type, participants rated ten statements that assessed the automaticity (i.e. unintentionality, uncontrollability, lack of awareness, and efficiency) of the behavior from strongly disagree to strongly agree: e.g. "checking for new notifications is something…" followed by the ten statements.

4.3.2.3 Inter-Item Reliability and Unidimensionality

Because we translated the original items of the SRHI and SDDQ to Mandarin for this survey study, we tested the inter-item reliability and construct validity (i.e. unidimensionality) of the constructs measured through both questionnaires. Cronbach α was used to determine the inter-item reliability for constructs with three or more items, whereas Kendall's τ was used for constructs measured with two items. Confirmatory factor analyses were used to check for unidimensionality (**Table 13**) for constructs measured with three or more items (models for constructs measured with two items were unidentifiable). It was found that most of the TPB constructs had acceptable reliability ($\alpha > 0.70$; DeVellis, 2012; τ significant at $p > 0.05$) and validity ($\lambda > 0.30$; Field, Miles, & Field, 2012) across each of the seven cellphone distractions surveyed. The exception to this was perceived control, which had low standardized alphas. Despite this, the measures for perceived control were found to have acceptable construct validity ($\lambda > 0.30$)). For this reason, both measures of perceived control were kept in the analysis, since the two measures addressed different aspects of perceived control (as specified in Trafimow et al., 2002). For the SRHI, we found that the ten items had excellent inter-item reliability for the three notification-related habits examined (α > 0.90; **Table 12**). Further, all items had high standardized factor loadings for each cellphone interaction (**Table 12**), which indicates the items measured a single unidimensional factor (i.e. habit).

Table 12. Back translated SRHI items; Confirmatory Factor Analysis (CFA) assessing the unidimensionality of SRHI for notification-related cellphone habits

SRHI ITEMS 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree	CH1: Checking my phone for new notifications is something…	CH2: Answering a phone call is something…	CH3: Responding to notifications on my cellphone is something…
	λ: standardized factor loading		
H1: I do automatically	0.85	0.85	0.85
H2: I do without having to consciously remember	0.82	0.82	0.80
H3: I do without thinking	0.83	0.83	0.84
H4: I start doing before I realize I am doing it	0.84	0.82	0.82
H5: I have no need to think about doing	0.83	0.84	0.85
H6: I do without meaning to do it	0.73	0.70	0.71
H7: That I would need to try hard not to do it	0.62	0.64	0.67
H8: That I would find hard not to do	0.77	0.73	0.76
H9: That is typically 'me'	0.77	0.78	0.78
H10: That belongs to my daily routine	0.78	0.75	0.80
Model Fit and Reliability	Cronbach's α = 0.94 CFI = 0.982 RMSEA = 0.06	α = 0.94 CFI = 0.981 RMSEA = 0.06	α = 0.94 CFI = 0.990 RMSEA = 0.05

Only the wording for H7 was affected by translation from English to Mandarin. The original item in English is: That would require effort not to do it. All factor loadings were significant (p<.001). CFI: Comparative Fit Index. RMSEA: Root Mean Square Error Approximation.

Table 13. Inter-item reliability and unidimensionality for attitude, perceived control and injunctive norms

	SDDQ Items	λ	Fit		SDDQ Items	λ	Fit		SDDQ Items	λ	Fit
D1	**Attitude**			**D4**	**Attitude**			**D7**	**Attitude**		
	A1	0.72			A1	0.71			A1	0.70	
	A2	0.65	CFI: 0.997		A2	0.70	CFI: 0.999		A2	0.72	CFI: 1
	A3	0.70	RMSEA: 0.02		A3	0.73	RMSEA: 0.01		A3	0.78	RMSEA: 0.01
	A4	0.53	α: 0.71		A4	0.45	α: 0.72		A4	NA	α: 0.73
	A5	0.32			A5	0.39			A5	0.39	
	Perceived Control				**Perceived Control**				**Perceived Control**		
	PC1	0.89	τ: 0.22		PC1	0.85	τ: 0.26		PC1	0.88	τ: 0.27
	PC2	0.30	p < 0.001		PC2	0.38	p < 0.001		PC2	0.37	p < 0.001
	Injunctive Norms				**Injunctive Norms**				**Injunctive Norms**		
	IN1	0.92	τ: 0.50		IN1	0.94	τ: 0.55		IN1	0.98	τ: 0.54
	IN2	0.60	p < 0.001		IN2	0.63	p < 0.001		IN2	0.61	p < 0.001
D2	**Attitude**			**D5**	**Attitude**						
	A1	0.69			A1	0.74					
	A2	0.67	CFI: 1		A2	0.74	CFI: 0.992				
	A3	0.74	RMSEA< 0.01		A3	0.75	RMSEA: 0.04				
	A4	NA	α: 0.71		A4	0.46	α: 0.75				
	A5	0.40			A5	0.40					
	Perceived Control				**Perceived Control**						
	PC1	0.87	τ: 0.24		PC1	0.82	τ: 0.26				
	PC2	0.33	p < 0.001		PC2	0.38	p < 0.001				
	Injunctive Norms				**Injunctive Norms**						
	IN1	0.98	τ: 0.53		IN1	0.94	τ: 0.57				
	IN2	0.60	p < 0.001		IN2	0.65	p < 0.001				
D3	**Attitude**			**D6**	**Attitude**						
	A1	0.73			A1	0.76					
	A2	0.74	CFI: 0.994		A2	0.67	CFI: 0.990				
	A3	0.73	RMSEA: 0.04		A3	0.76	RMSEA: 0.05				
	A4	0.49	α: 0.75		A4	0.53	α: 0.75				
	A5	0.42			A5	0.40					
	Perceived Control				**Perceived Control**						
	PC1	0.81	τ: 0.25		PC1	0.80	τ: 0.26				
	PC2	0.37	p < 0.001		PC2	0.40	p < 0.001				
	Injunctive Norms				**Injunctive Norms**						
	IN1	0.94	τ: 0.57		IN1	0.96	τ: 0.58				
	IN2	0.66	p < 0.001		IN2	0.63	p < 0.001				

λ: standardized factor loading. All factor loadings were significant (p<.001). CFI: Comparative Fit Index. RMSEA: Root Mean Square Error Approximation. α = *Cronbach's alpha.* τ = *Kendall's Tau. As stated earlier in Table 2, for D2 and D7, the measure A4 was not collected.*

4.4 Analysis and Results

All statistical analysis of the data was performed using R 3.5.1. First, a number of descriptive statistics were calculated for self-reported frequency of cellphone distractions, TPB constructs, and habitual cellphone use for both driving contexts. Following this, structural equation models were built to examine the relationship between self-reported frequency of engagement, TPB components, and habitual cellphone use. Finally, a multigroup SEM was built to examine whether the driving context (rural vs. urban) moderated the relationship between the TPB constructs and self-reported frequency of engagement. For SEMs, Satorra-Bentler robust estimation (Satorra & Bentler, 1988; 1994) was used because the data showed multivariate non-normality. In addition, multivariate outliers were not removed from the analyses (n = 53) because no discernable reason for removal could be identified. Finally, missing data was handled using pairwise deletion.

For all SEM models, the following model fit criteria were used: Chi-square divided by its degrees of freedom ($\chi^2/DF < 5$), the Comparison Fit Index (CFI > 0.90), the Tucker-Lewis Fit Index (TLI > 0.90), the Root Mean-Square Error of Approximation (RMSEA < 0.08) and the Standardized Root Mean Square Residual (SRMR < 0.08; Bentler, 1990). In addition, it should be noted that while chi-square tests were reported for models, they were often disregarded when interpreting model fit, as previous research has indicated that chi-square is overly sensitive to sample size (Bollen, 1989; Jo¨reskog, 1993). Instead, more weight was given to the fit criteria mentioned above.

4.4.1 Descriptive Statistics

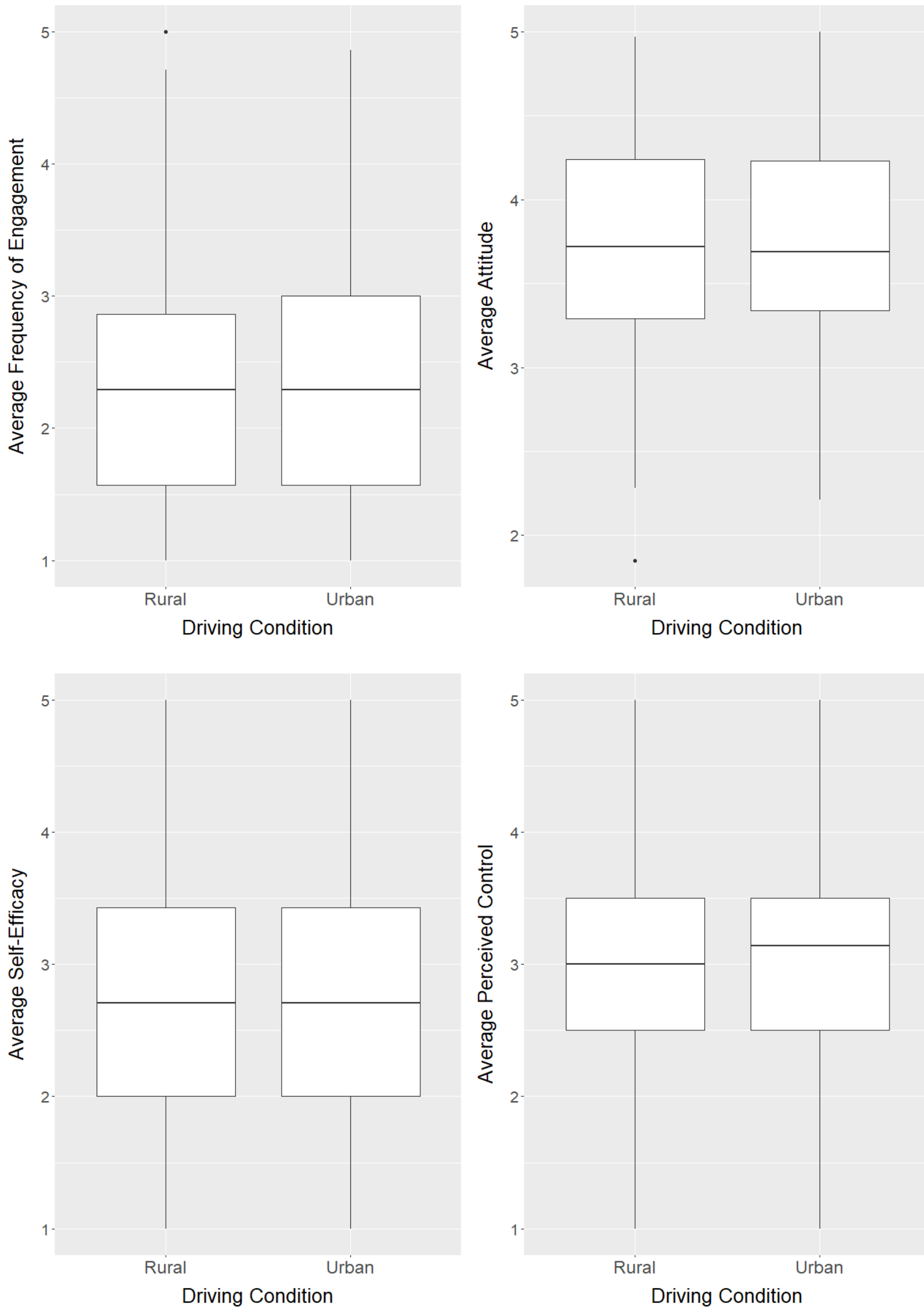
Self-reported frequency of engagement in the surveyed cellphone distractions ranged from “rarely” to “occasionally” (**Table 14**). The most common type of cellphone distraction reported in both driving contexts was “Talk on the phone using a hand-held device” and “Dial a phone number on the keypad of a hand-held device”. The least common distractions reported for both driving contexts included “Read e-mails on a hand-held device” and “Manually enter a text message while driving”. Independent t-tests showed no significant differences between the rural and urban condition for each of the surveyed cellphone distractions.

Table 14. Descriptive statistics for self-reported frequency of engagement in cellphone distractions, TPB constructs, and habitual cellphone use

	Rural	**Urban**
Frequency of engagement in surveyed distractions	Mean (Standard Deviation)	
D1. Talk on the phone	2.76 (1.05)	2.65 (1.12)
D2. Dial a phone number (not available through speed dial) using the keypad	2.56 (1.06)	2.46 (1.09)
D3. Manually enter text messages	2.06 (1.14)	2.12 (1.13)
D4. Read text messages	2.31 (1.12)	2.27 (1.14)
D5. Read emails	1.91 (1.09)	1.98 (1.09)
D6. Update social media (i.e., Facebook, Instagram or Twitter)	2.12 (1.18)	2.22 (1.20)
D7. Manually enter an address into a navigational app on a smartphone that is NOT mounted inside the vehicle	2.37 (1.13)	2.41 (1.09)
SDDQ constructs*		
avgFREQ. Average frequency of engagement	2.30 (0.85)	2.30 (0.90)
avgA. Average attitude	3.76 (0.61)	3.78 (0.59)
avgSE. Average self-efficacy	2.73 (0.89)	2.76 (0.89)
avgPC. Average perceived control	2.97 (0.81)	3.04 (0.79)
avgDN. Average descriptive norms	3.14 (0.81)	3.17 (0.88)
avgIN. Average injunctive norms	2.36 (0.81)	2.36 (0.81)
SRHI*		
avgH. Average notification-related cellphone habits	2.84 (0.80)	2.88 (0.81)

All constructs and distractions were measured on five-point Likert scales (see Tables 2 and 3 for the scales). *Average SDDQ and SRHI constructs were obtained by averaging responses first across items (e.g. A1 to A5 for Attitude construct) for both SDDQ and SRHI, and then across distractions (i.e. D1 to D7) for SDDQ and across the three cell-phone habits (i.e. CH1 to CH3) for SRHI.

Means were also calculated for overall self-reported frequency of engagement, TPB constructs, and notification-related habits (**Table 14**). On average, attitudes were found to be negative towards engaging in the surveyed cellphone distractions, while participants felt roughly "neutral" towards their perception of self-efficacy, perceived control, descriptive norms, and notification-related cellphone habits. On average, respondents felt that they disagreed that other drivers would approve of them/think they would be able to handle driving and engaging in the surveyed cellphone distractions. Independent t-tests showed that there was no significant difference between the rural and urban condition for these means. Boxplots showing the distributions of the averaged SDDQ constructs can be found in *Figure 7*.


Average Frequency of Engagement
Average Attitude
Average Self-Efficacy
Average Perceived Control
Rural
Urban
Driving Condition

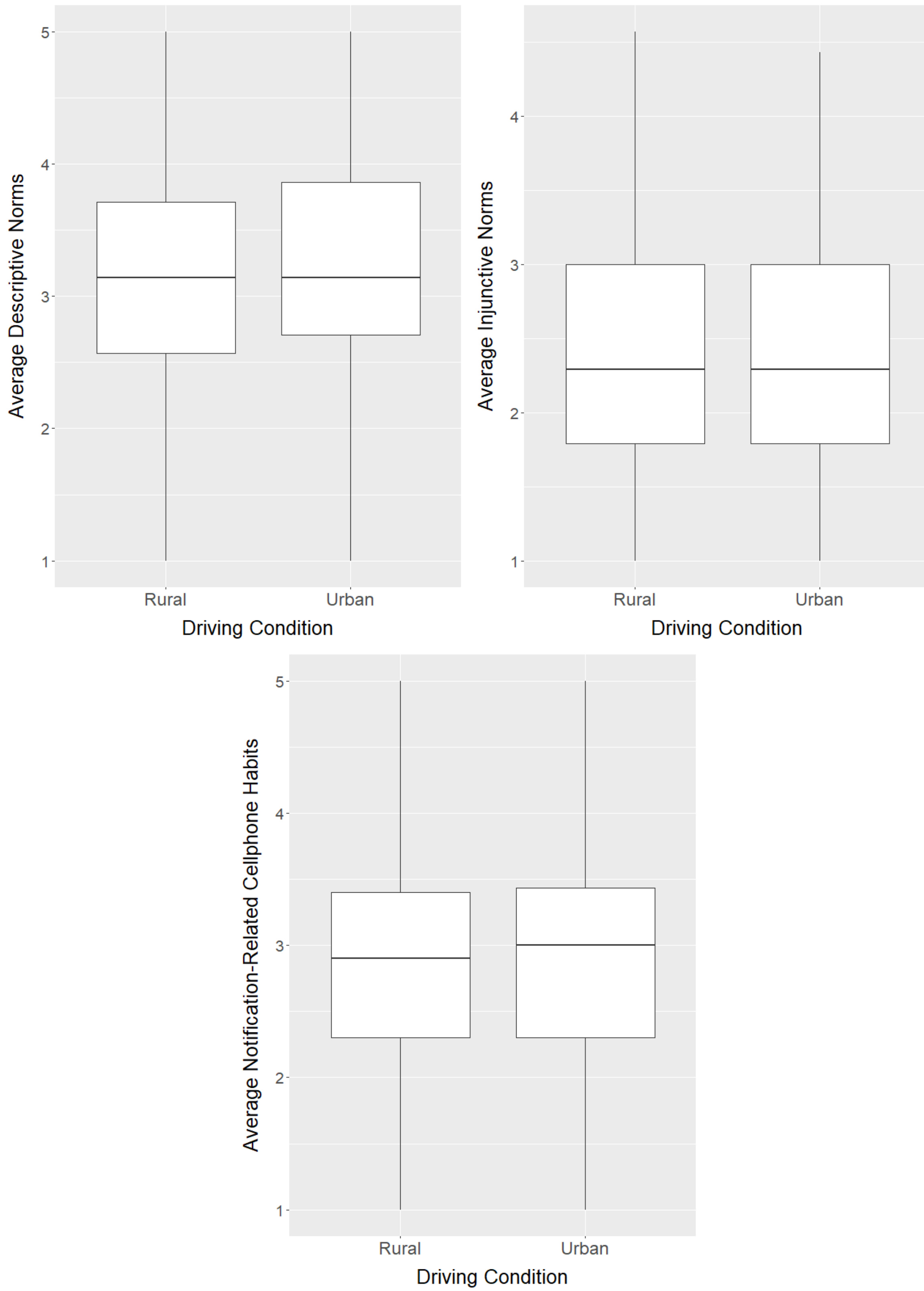


Figure 7. Boxplots showing the distribution for each of the average SDDQ Constructs found in Table 14.

4.4.2 Structural Equation Models (SEMs)

4.4.2.1 Measurement Model

Since measures within the Mandarin version of the SDDQ were found to be acceptably reliable/valid for given constructs, an average score was created for constructs with multiple measures. This resulted in average scores for attitudes, perceived control, and injunctive norms regarding each of the cellphone distractions (e.g. an average attitude score for "talking on a handheld mobile device while driving"). No averaging was needed for frequency of engagement, self-efficacy, and descriptive norms, as these constructs had single measures for each cellphone distraction. Given that the measures within the Mandarin translation of the SRHI were also found to have acceptable reliability/validity, the ten items assessing habit strength were averaged for each of the three notification-related cellphone habits

A measurement model was constructed for the overall data (n = 894), in which self-reported frequency of engagement in cellphone distractions, constructs of TPB, and notification-related habits were modeled as first order latent variables. Indicator variables for self-reported engagement and the TPB constructs were the items relating to the seven cellphone distractions examined within each construct, whereas indicator variables for cellphone habits were average habit scores for the three notification-related cellphone habits examined. Fit indices for the measurement model showed acceptable fits, $\chi^2(924) = 3975.66$, $p < .001$, $\chi^2/DF = 4.30$, RMSEA = 0.068 [90% Confidence Interval (CI): 0.066 – 0.071], SRMR = 0.051; however, CFI (.877) and TLI (.868) values were below the minimum acceptable value of 0.90 (Bentler, 1990).

To improve model fit, residual correlations between select indicator variables were added to the model (i.e. these correlations were not assumed to be zero). The selection was based on theoretical considerations (e.g. distractions that are highly related, such as D1 and D2), and no cross-factor residual correlations were estimated (e.g. across attitude and injunctive norms). Residual correlations were added to the model until the CFI changed less than 0.001 (Beaujean, 2014). In the end, a total of nine residual correlations were estimated. These correlations primarily existed between the distractions "Talk on the phone using a hand-held device" and "Dial a phone number, not available through speed dial, using the key pad of a hand-held device" within multiple constructs (attitude, injunctive norms, descriptive norms, self-efficacy, perceived control, and self-reported engagement). The final measurement model had improved model fit, $\chi^2(915) = 3302.81$, $p < .001$, $\chi^2/DF = 3.61$, CFI = .904, TLI = .896, RMSEA = 0.061 [90% CI: 0.058-0.063], SRMR = 0.049. In addition, it was found that all indicator variables significantly loaded onto their latent variables (See **Table 15**).

Table 15. Standardized factor loadings (λ) for the measurement model

	D1	D2	D3	D4	D5	D6	D7
Frequency of engagement	0.64	0.71	0.84	0.83	0.75	0.82	0.62
Attitude	0.63	0.71	0.93	0.91	0.91	0.89	0.70
Self-efficacy	0.56	0.71	0.80	0.81	0.78	0.81	0.70
Perceived control	0.62	0.78	0.88	0.86	0.86	0.87	0.75
Descriptive norms	0.53	0.62	0.79	0.81	0.71	0.76	0.62
Injunctive norms	0.65	0.77	0.89	0.88	0.88	0.88	0.78

This table is read from left to right (D1-D7) for a given construct (e.g. Attitude). D1 to D7 refer to the cellphone distractions listed in Table 2. All standardized factor loadings were significant (p<.001).

4.4.2.2 Structural Model

A structural model was built for the overall data (i.e. regardless of driving context) to examine whether the TPB constructs, as well as notification-related cellphone habits, predicted participants' self-reported frequency of engagement in cellphone distractions while driving. It was found that the model had appropriate fit, $\chi^2(915) = 3302.82$, $p < .001$, χ2/DF = 3.61, CFI = .904. TLI = .896, RMSEA = 0.061 [90% CI: 0.058- 0.063], SRMR = 0.049. Results of the regression showed that attitudes (B, i.e. standardized path coefficient = -0.16), self-efficacy (B = 0.24), descriptive norms (B = 0.14), injunctive norms (B = 0.15), and notification-related cellphone habits (B = 0.25) were significant predictors of self-reported engagement in cellphone distractions while driving (see *Figure 7* for the structural diagram, **Table 16** for path coefficients, and **Table 17** for estimated correlations). Notification-related cellphone habits were found to be significant after controlling for all other TPB constructs, and standardized path coefficients showed that notification-related habits were the strongest predictor of self-reported frequency of engagement in cellphone distractions while driving. The only TPB construct that wasn't significant in predicting self-reported engagement was perceived control (B = 0.04). Overall, the TPB constructs and the cellphone habits explained 56% of the variance in self-reported frequency of engagement in cellphone distractions while driving.

4.4.2.3 Multi-Group SEM

A multi-group model was constructed for driving context, in which a separate measurement/structural model was built for both the rural and urban driving context. The multigroup model had appropriate fit overall, $\chi^2(1830) = 4293.25$, $p < 0.001$, $\chi^2/DF = 2.34$, CFI = 0.902, TLI = 0.894, RMSEA = 0.062 [90% CI: 0.059, 0.064], SRMR = 0.053. A comparison of the multigroup model with the overall model reported earlier showed that the overall model had slightly better fit (AIC = 79,143, sample-size adjusted BIC = 79,329 and CFI = 0.904 for the overall model vs AIC = 79,335, BIC = 79,848 and CFI = 0.902 for the multigroup model).

The structural models for each driving context can be seen in *Figure 7*; **Table 16** reports the standardized path coefficients for the predictor variables (see **Table 17** for correlations between predictors). In both driving contexts, attitudes, self-efficacy, descriptive norms, and notification-related habits were significant predictors of self-reported frequency of engagement in cellphone distractions. Perceived control was not a significant predictor in either driving context, while injunctive norms was found to be a marginally significant predictor in the urban driving context (p = .056), but not the rural driving context (p = .08). Notification-related habits were found to be the strongest predictor in the urban driving context (B = 0.26), followed by self-efficacy (B = 0.20) and attitudes (B = -0.20), and then descriptive norms (B = 0.13). For the rural context, self-efficacy was the strongest predictor (B = 0.28), followed by notification-related habits (B = 0.24), descriptive norms (B = 0.14), and attitudes (B = -0.13). Both models accounted for a large amount of the variance in self-reported frequency of engagement in cellphone distractions, with the predictors for the urban context accounting for 55% of the variance and the predictors for the rural context accounting for 57% of the variance.

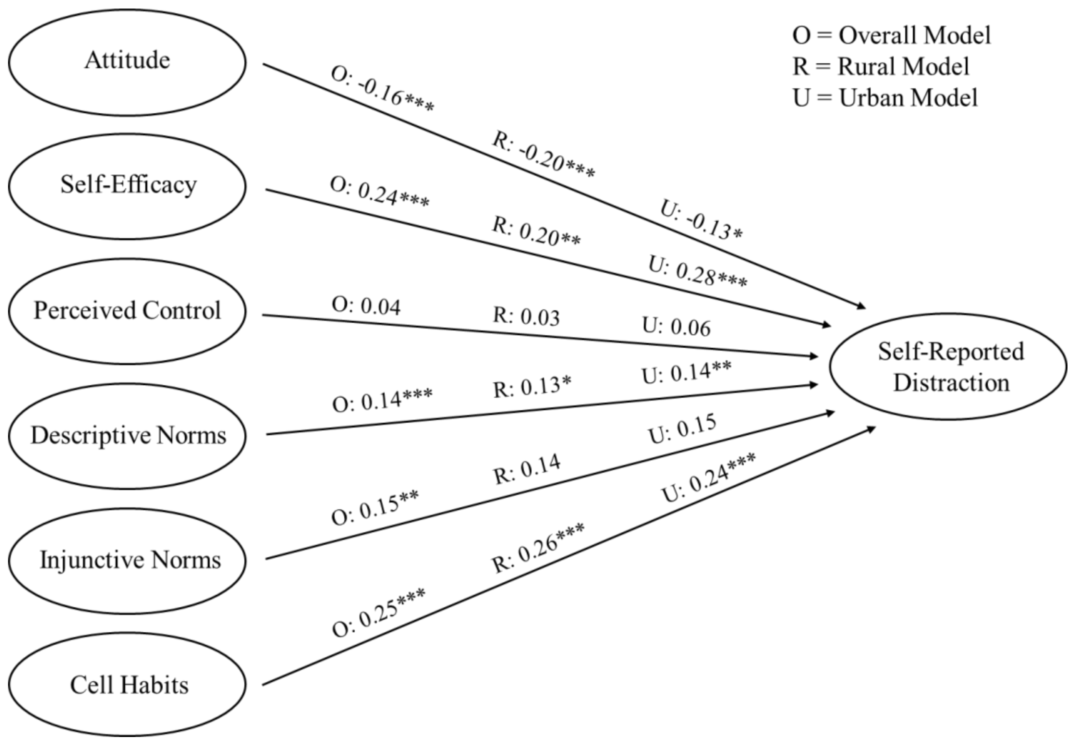


Figure 8. Structural equation models showing the standardized path coefficients for models built on the overall, rural and urban models. Correlations were freely estimated between the predictors in each model and are reported in Table 11. * = p < .05, ** = p < .01, *** = p < .001.

Table 16. Standardized and unstandardized path coefficient estimates, standard errors, and significance tests for the overall, rural, and urban structural models

Variables	Standardized Estimate	Estimate	Standard Error	z-value	p-value
Overall Model					
A. Attitude	-0.16	-0.25	0.07	-3.63	**p < .001**
SE. Self-efficacy	0.24	0.26	0.06	4.35	**p < .001**
PC. Perceived control	0.04	0.05	0.04	1.13	p > .05
DN. Descriptive norms	0.14	0.16	0.04	4.23	**p < .001**
IN. Injunctive norms	0.15	0.17	0.06	2.70	**P < .01**
CH. Notification-related habits	0.25	0.21	0.04	5.73	**p < .001**
Rural Model					
A. Attitude	-0.13	-0.20	0.10	-2.06	**< .05**
SE. Self-efficacy	0.28	0.28	0.09	3.26	**< .001**
PC. Perceived control	0.06	0.07	0.07	0.98	> .05
DN. Descriptive norms	0.14	0.19	0.07	2.84	**< .01**
IN. Injunctive norms	0.15	0.15	0.09	1.77	.08

CH. Notification-related habits	0.24	0.19	0.05	3.53	**< .001**
Urban Model					
A. Attitude	-0.20	-0.34	0.10	-3.28	**<.001**
SE. Self-efficacy	0.20	0.23	0.09	2.70	**< .01**
PC. Perceived control	0.03	0.04	0.06	0.65	> .05
DN. Descriptive norms	0.13	0.15	0.05	3.08	**< .01**
IN. Injunctive norms	0.14	0.17	0.09	1.91	.06
CH. Notification-related habits	0.26	0.23	0.05	4.70	**< .001**

Table 17. Freely estimated correlations between latent predictors in the overall, rural, and urban structural models

Correlations	A	SE	PC	DN	IN	CH
Overall Model						
A. Attitude	1					
SE. Self-efficacy	-0.60	1				
PC. Perceived control	-0.35	0.50	1			
DN. Descriptive norms	-0.24	0.42	0.42	1		
IN. Injunctive norms	-0.68	0.70	0.49	0.35	1	
CH. Notification-related habits	-0.43	0.49	0.39	0.37	0.54	1
Urban Model						
A. Attitude	1					
SE. Self-efficacy	-0.66	1				
PC. Perceived control	-0.37	0.50	1			
DN. Descriptive norms	-0.29	0.46	0.45	1		
IN. Injunctive norms	-0.71	0.69	0.47	0.36	1	
CH. Notification-related habits	-0.43	0.49	0.36	0.40	0.53	1
Rural Model						
A. Attitude	1					
SE. Self-efficacy	-0.55	1				
PC. Perceived control	-0.34	0.50	1			
DN. Descriptive norms	-0.19	0.39	0.39	1		
IN. Injunctive norms	-0.65	0.70	0.51	0.34	1	
CH. Notification-related habits	-0.43	0.49	0.41	0.34	0.55	1

All correlations were significant ($p < .001$).

4.5 Discussion

This paper reports the results of an online survey that was conducted in China examining the volitional (as measured by the TPB) and habitual facilitators of engagement in cellphone related distracted driving. It was found that attitude, self-efficacy, injunctive norms, and descriptive norms significantly predicted self-reported frequency of engagement in cellphone related distractions for Chinese drivers. In addition, it was found that notification-related cellphone habits, measured in general (i.e. not specific to the vehicle environment), predicted self-reported frequency of engagement in cellphone related driver distractions while controlling for TPB constructs. The results are in line with other studies that have examined the role of TPB (Walsh et al., 2008; Zhou et al., 2009; Rozario et al., 2010; Nemme & White, 2010; Waddel & Wiener, 2014; Przepiorka et al., 2018) and habitual cellphone use (Bayer & Campbell, 2012; Hansma et al., in press, see Chapter 3) in predicting cellphone use while driving. This work extends findings from Chapter 3 by examining the role of driving context (rural or urban) within a large, diverse dataset from China. In addition, the current study extends a previous study by Bayer and Campbell (2012) by examining the role of cellphone habits in predicting self-reported frequency of engagement in cellphone distractions for a broader selection of visual-manual cellphone interactions, such as reading emails and updating social media.

4.5.1 The Role of Habits

It was found through structural equation modelling that notification-related cellphone habits were the strongest predictor of self-reported engagement in cellphone distractions while controlling for TPB constructs. This means that regardless of how individuals felt about engaging in the surveyed cellphone distractions (as measured through the TPB), the strength of their notification-related cellphone habits, in general (i.e. daily life), predicted the frequency of their use in the surveyed cellphone distraction while driving. While we cannot determine whether the cellphone distractions examined in the frequency of engagement measure themselves were carried out habitually, by controlling for volitional facilitators, it becomes increasingly likely that a portion of the remaining variance in self-reported frequency of engagement represented a more automatic type of interaction. Thus, it may be that notification-related habits are carried into the vehicle when people drive (i.e. cellphone use is ubiquitous), and once brought in, they may automatically prompt engagement in other types of cellphone distractions (e.g. reading text messages, sending text messages); this chaining of behavior is known as behavioral chunking (Graybiel, 1998). This may explain the association we found between notification-related habits, measured in general, and self-reported frequency of engagement in other cellphone distractions, after controlling for volitional facilitators relating to those distractions. Results concerning the significance of habits are similar to those found in Chapter 3.

While our results regarding habits were similar to those in Chapter 3, notification-related habits were found to be a stronger predictor of self-reported engagement in the Chinese sample vs the North American one. A comparison of mean habit strength between the two studies showed that Chinese drivers had stronger notification-related cellphone habits (M = 2.87, roughly corresponding to neutral) than North American drivers (M = 2.24, roughly corresponding to disagree) in general (i.e. not specific to the driving environment). Previous research has reported that Chinese residents spend more time on their phones per day than North Americans do (People's Daily, 2017), and since past behavioral frequency is necessary for habit development (Ouellette & Wood, 1998), it may be that this explains why our Chinese participants had stronger notification-related cellphone habits. This may in turn explain the stronger relationship between notification-related habits and self-reported frequency of use for Chinese drivers compared to North American ones. Specifically, stronger notification-related cellphone habits for Chinese drivers may carry over to the vehicle to a greater extent, where they may automatically elicit greater engagement in the surveyed cellphone distractions (i.e. they have greater habitual chunking). Results from both the current study and Chapter 3 also support Bayer and Campbell's (2012) findings, however, it is important to note that Bayer and Campbell (2012) examined texting habits, while we examined notification-related habits.

The finding that notification-related cellphone habits are a significant factor in explaining why drivers engage in cellphone distractions is important because one of the more commonly used approaches that government/non-government organizations take to reduce cellphone related distracted driving is targeting drivers with educational material meant to influence their volitional decision-making processes (e.g. "Friends would prefer a late text, rather than an early death"; Nemme & White, 2010). However, based on the current findings, these organizations should also endorse specific countermeasures that directly target notification-related cellphone habits. An example of this includes driver mode, a feature that can be found on most modern smartphones and infotainment systems. Driver mode works by blocking all incoming messages/calls and notifications to the phone, and it may work as a habit specific countermeasure because it reduces the number of contextual cues presented to the driver (i.e. notifications), which can automatically trigger habitual behavior (e.g. checking/responding to notifications). Therefore, blocking these cues may result in less automatic checking/responding while driving. Further, driver mode may eliminate other types of cellphone interactions (e.g. reading a message), which may be habitually (via behavioral chunking) or volitionally (via being a gateway) performed themselves. Thus, eliminating contextual cues through driver mode may have the benefit of reducing both habitual and volitional cellphone use for a variety of different cellphone distractions. Lastly, a final benefit of driver mode is that it can notify people attempting to reach the driver that they are driving and are currently unavailable. This is important, as the automated replies may mitigate the social pressure people feel to respond to texts/calls while driving (Atchley et al., 2011).

While technological tools, such as driving mode, may eliminate contextual cues directly from the phone, internal cues, such as mood (e.g. boredom) may still have an impact on eliciting habitual responses. Therefore, it is important to raise awareness of the role of cellphone habits in contributing to distracted driving. Research has found that people are at least aware of their habits (Wood et al., 2002), therefore, shining a light on the role that internal cues play in eliciting behavior may guide individuals in understanding their own internal cues. Once this awareness is created, it may be possible for individuals to limit their habitual responses, by potentially putting their phone out of sight/reach, or by engaging in a safer alternative behavior when they realize they are experiencing an internal cue. This counter-habitual behavior can be developed through performing mental contrasting with implantation intentions (MCII; Stadler et al., 2009; Adriaanse et al., 2010), which involves drivers thinking about a behavior change goal (e.g. stop distracted driving), imagining a positive future where behavior change has been successful (e.g. not being involved in distracted driving related accidents), and then mentally contrast this with the negative realities that stand in the way (e.g. I use my phone while driving and being bored). Contrasting in this way has been found to be effective for eliciting peoples' habit cues (Stadler et al., 2009; Adriaanse et al., 2010), which can then be targeted with implementation intentions (e.g. ''If I am driving and I am bored, then I will change the radio station instead of checking my phone”). Implementation intentions attempt to override the paired cue-behavior association in memory, creating safer, alternative habitual behaviors.

4.5.2 The Role of Volitional Facilitators

Looking strictly at the TPB variables for the overall SEM model, it was found that self-efficacy, attitudes, injunctive norms and descriptive norms were significant predictors of self-reported engagement in cellphone distractions while driving, while perceived control was not. The significance of attitude as a predictor of intentions/self-reported engagement has been widely observed in previous research (Walsh et al., 2008; Zhou et al., 2009; Rozario et al., 2010; Nemme & White, 2010; Waddel & Weiner, 2014; Przepiorka et al., 2018), while to our knowledge, only two other studies (Murphy et al., 2020; and our study reported in Chapter 3) have examined self-efficacy independent of perceived control within the distracted driving domain. Similar to Murphy et al. (2020) and our Chapter 3 findings, we found that self-efficacy was a significant predictor of self-reported engagement in cellphone distractions while driving; however, different from our Chapter 3 findings, we did not find perceived control to be significant. It may be that there are cultural differences between the samples that led to the differential predictive ability of perceived control. Despite this discrepancy, the current study findings are consistent with previous literature (e.g. Trafimow et al., 2002), which has found that self-efficacy is a better predictor of behavioral intentions/behavior than perceived control. This finding supports the idea that researchers engaging in TPB research should consider separating self-efficacy and perceived control when constructing predictive models of intentions/behavior, as combining them may mask the unique relationship each construct has on intentions/behavior. This was a potential issue with the two previous distracted driving related TPB studies conducted in China (Zhou et al., 2009; Zhou et al., 2012).

In regard to the effect of perceived social norms, our findings for descriptive norms align with the results from several other studies (Waddel & Wiener, 2014; Chen & Donmez, 2016; Chen et al., 2016). For injunctive norms, our results are in line with some studies (Nemme & White, 2010; Bayer & Campbell, 2012), but not others (Chen et al., 2016; Chen & Donmez, 2016; and our study reported in Chapter 3). As a rule, the impact/significance of subjective/injunctive norms has varied in the literature. This has led others to create composite measures of norms, similar to the approach taken by Bayer and Campbell (2012). The fact that we found injunctive norms to be significant in the current study may be due to cultural differences in the samples. It may be that injunctive norms are mostly a non-significant predictor of behavior in western cultures (i.e. North America and Australia), whereas they are a stronger predictor in eastern cultures (Zhou et al., 2009). This may be due to the role collectivism plays in eastern cultures (i.e. higher levels of collectivism may enhance the effectiveness of perceived social norms in influencing behavior).

4.5.3 The Role of the Driving Environment

Finally, a multi-group model was fit to the data to see whether the relationship between the TPB constructs, habitual cellphone use, and self-reported frequency of engagement in cellphone related distractions was moderated by driving context. It was found that a multigroup model had acceptable fit; however, the multigroup model's fit was statistically worse than the model for the overall data. An examination of the multigroup model showed that attitudes, self-efficacy, descriptive norms, and notification-related cellphone habits were significant predictors of self-reported frequency of engagement in cellphone distractions in both driving contexts. Surprisingly, injunctive norms became an insignificant predictor in both driving contexts for the multigroup model, which was probably due to the loss of power associated with splitting the sample size between groups.

An examination of the standardized estimates for both driving contexts showed that attitudes and self-efficacy had the greatest difference in the magnitude of their estimates. The standardized estimate for self-efficacy was higher in the rural context (B = 0.28) than the urban (B = 0.20), which indicates that higher self-efficacy over cellphone distractions was associated with a larger increase in self-reported frequency of engagement in the rural highway condition compared to the urban context. This may be because participants in the rural driving context associated this context with lower perceptual/cognitive demands, which may have resulted in them believing cellphone distractions would be easier to perform. For attitudes, the standardized estimate was higher (in absolute value) for the urban (B = -0.20) than the rural (B = -0.13) context, indicating that a more negative attitude in the urban condition resulted in a larger decrease in self-reported engagement in cellphone distractions than when compared to the rural condition. This may be attributable to the fact that urban environments have higher perceptual/cognitive demands and thus, participants with more negative attitudes may be less likely to engage in distractions due to the complexity of the environment. These differences in predictor strength may indicate that it is important to consider different driving environments/contexts when examining the impact of the TPB in predicting driver engagement in cellphone distractions (at least for certain constructs of the TPB).

Independent t-tests showed that self-reported frequency of engagement in cellphone distractions and ratings of the TPB constructs were not significantly different between the rural and urban driving context. We had originally hypothesized that cellphone distractions would be reported as less frequent, attitudes and injunctive norms reported as more negative, and self-efficacy rated as lower, for the urban context compared to the rural. This would have been due to respondents considering the increased cognitive/perceptual load associated with urban intersections (Schweitzer & Green, 2007; Miura, 1992) while reflecting on their experiences within this context. This hypothesis was based on research suggesting that drivers assess driving demand when deciding to engage in distractions (Lerner & Boyd, 2005). However, there are several reasons why we may not have found support for this hypothesis. First, it may be that the increased travel speed associated with the rural highway context increased the perceived risk of engaging in cellphone distractions; as a result, respondents may have perceived engaging in cellphone distractions to be equally hazardous in both contexts. Alternately, it may be that respondents did not fully consider the provided driving context when answering the survey questions. This may be an issue with the between-subject design of the experiment. This could potentially be improved by adopting a within-subject design in future research. However, the survey was relatively long (mean completion time = 20 minutes), so taking this approach would have led to significant increases in survey length.

4.6 Limitations and Future Research

The researchers acknowledge that the online survey conducted for this study may be susceptible to biases. Given that cellphone related distractions have been illegal in China since 2003 (State Council, 2004), participants may have been influenced by social desirability bias. However, online surveys have been found to mitigate social desirability bias due their remote nature (Tourangeau et al., 2000); therefore, the use of an online survey was thought to have more practical, as well as theoretical benefits, compared to an in-person survey. Despite this, our study may have been impacted by a self-selection bias, as online surveys require participants be familiar with digital technology (e.g. computers), which may exclude certain demographic groups (e.g. older users).

Our sample had a relatively limited age range (aged 16-51 years old), which may be a side effect of using an online survey. However, other studies conducted in China (Zhou et al., 2009; Zhou et al., 2012), which have used different approach styles (online surveys and cold approaches at local areas) have ended up with samples with a similar age range to our study (17-43 years old for Zhou et al. 2009 and 25-59 for Zhou et al. 2012). Thus, our limited age range may just reflect the fact that a smaller proportion of older people drive in China (Lingfeng, 2019).

We also recognize that our results and discussion about the psychological variables used in this analysis are limited to the extent that the scales we employed measured them fully and accurately. While it is hard to ensure a measure ever achieves this, we used previously validated questionnaires and examined the construct validity and inter-item reliability of our variables – it was found that the SDDQ constructs and our measure of cellphone habits were valid and reliable. It is also worthwhile to acknowledge that we measured cellphone habits, rather than cellphone addiction. Cellphone addiction can be categorized as a type of technological addiction (i.e. addictions that involve human-machine interfaces), which is a type of behavioral addiction (Griffiths, 1996). In addition to including compulsions (one aspect of the SRHI e.g. items 6-8), cellphone addiction include several additional elements such as withdrawal symptoms (irritation or anxiety about not being able to use a cellphone), tolerance (using a cellphone for longer than intended) and interference with daily routines (Cho & Lee, 2015). Previous research has found that cellphone use is addictive, especially for younger people (e.g. Bianchi & Phillips, 2005), and cellphone addiction has been found to predict self-reported distraction engagement in healthcare settings (Cho & Lee, 2015). Although it would have been interesting to examine the role of cellphone addiction within the current study, it can be argued that a smaller portion of the general driving population possess smartphone addictions; instead, it is more likely that individuals have a range of habits relating to their smartphone use. Since the purpose of this study was to examine whether habits predicted self-reported use while controlling for volitional factors within a broader population of drivers than those previously studied (Nemme & White, 2010; Bayer & Campbell, 2012), we determined the examination of cellphone addiction was outside the scope of the current study. Given the current study's finding that habits are one of the strongest predictors of self-reported cellphone use, future research could examine whether measures of cellphone addiction predict self-reported cellphone use while driving, while controlling for measures of volitional and habitual facilitators. This approach could be examined within a younger driving demographic, as previous research has found that young age predicts mobile phone use and addiction (e.g. Bianchi & Phillips, 2005). Finally, we also acknowledge that a potential weakness of the current study, as well as the first survey study reported in Chapter 3, is that we only measured notification-related cellphone habits. Thus, we could only state that stronger notification-related habits, in general, predicted more specific types of cellphone use behind the wheel, while controlling for volitional factors. An alternative approach would have been to measure the habitualness of the same set of cellphone distraction themselves, then, any significant effect of habit could have been attributed to the cellphone distractions themselves. We plan to do this in the survey study proposed in Chapter 5. In addition, we plan to examine the interaction between cellphone habits and intentions in predicting the frequency of cellphone use while driving. A meta-analysis by Gardner et al. (2011) found that habits had a moderating influence on intentions for health-related behavior (exercise and diet), such that when habits were strong, intentions to perform a given behavior did not predict actual behavior. Examining the interaction between habits and intentions in predicting frequency of cellphone use will allow further exploration of the role of volitional and habitual facilitators in predicting driver cellphone use behind the wheel.

Chapter 5

5 Proposed Survey Study

The previous two studies (Chapter Three and Four, respectively) explored whether the Theory of Planned Behavior (TPB), in addition to notification-related cellphone habits, predicted drivers' self-reported past frequency of engagement in a selection of cellphone distractions while driving. The studies covered both North American and Chinese drivers.

In the North American online survey study (Chapter 3) it was found that attitude, perceived control, self-efficacy, and notification-related habits were significant predictors of drivers' self-reported frequency of engagement in handheld cellphone distractions, while descriptive and injunctive norms were not (see **Table 18**). Using hierarchical regression analysis, we found that after controlling for the TPB variables, notification-related cellphone habits accounted for unique variance in drivers' self-reported engagement frequency. This indicates that individuals who have stronger cellphone habits related to checking/responding to notifications and answering phone calls use their cellphones for other types of distractions (e.g. reading emails or messages) more frequently while driving. It may be that checking/responding habits act as a gateway for a variety of other cellphone distractions to occur; by controlling for volitional factors (i.e. participants attitudes, perceptions of behavioral control and perceived social norms regarding the seven cellphone distractions), we showed that these cellphone distractions may themselves be habitual performed. This relationship may exist because behavior can be habitually chunked (Graybiel, 1998), such that notification-related habits may automatically elicit habitual performance of other cellphone distractions while driving.

Results from our Chinese study (Chapter 4) corroborated our earlier results for notification-related habits (see **Table 18**); however, there were several discrepancies when it came to the role of the TPB. In our Chinese study, we found that perceived control was not significant in predicting drivers' self-reported engagement frequency, while both types of social norms (descriptive and injunctive) were significant. This differs from our North American study, where perceived control was significant, with neither measure of social norms (descriptive and injunctive) being so. These differences in predictor significance between samples (North American and Chinese) may be due to cultural differences, which may have implications for countermeasure development (i.e.

educational messages targeting social norms may be effective in reducing handheld cellphone use in China). Further, in our Chinese study, we found that the type of driving environment (urban downtown vs rural highway) moderated the TPB's influence on drivers' self-reported engagement in cellphone distractions while driving. Thus, it is important to consider the role of the driving environment in influencing the psycho-social facilitators of drivers' handheld cellphone use.

Table 18. Summary of standardized estimates for SEM and Linear Regression for both the Chinese and North American study.

	China		**NA**
Predictor	Rural	Urban	Urban
Attitude	-0.13*	-0.20*	-0.32*
Self-efficacy	0.28*	0.20*	0.21*
Perceived Control	0.06	0.03	0.26*
Descriptive Norms	0.14*	0.13*	0.02
Injunctive Norms	0.15*	0.14*	-0.01
Notification-Related Habits	0.24*	0.26*	0.19*
%Variance Explained	55%	56%	53%

**Indicates a variable was significant at a p value of at least 0.05.*

5.1 Limitations of Prior Studies and Motivations for the Current Study

While we deemed our initial studies a success, there were a number of limitations in our prior methodologies which limit our results (specifically regarding habits). For this reason, a new study was developed, which addresses the methodological limitations of the previous studies, while also exploring a number of new constructs and their interactions with habits. In the following pages, the limitations of the previous studies will be addressed, and potential remedies will be put forth. In addition, new constructs and their hypothesized relationship with habits will be discussed. The new survey can be found in **Appendix E** and **F**. Finally, it is important to note that the term "smartphone" will now be used instead of "cellphone" to refer to respondents' cellular/wireless handheld devices. Although people may still refer to their smartphone devices as cellphones, this change in terminology was made to bring our usage of the word in line with the terminology used in more recent studies (e.g. Gauld et al., 2017; Murphy et al., 2020). Although we have received

REB approval for this survey, given the effects of COVID-19, we decided to delay data collection as people's smartphone use and driving behaviors likely changed significantly during lockdown.

In the following pages, mention will be made to both a pilot study and a preliminary study. The pilot study had participants fill out the survey in **Appendix E** and note any questions that they found confusing. Changes to the survey were then briefly discussed with participants to ensure they addressed the participants' concerns. Ten participants participated in the pilot study and they were compensated $10 CA. Detailed results from the pilot study are not reported in this thesis. In addition, a preliminary study was also conducted to determine which handheld smartphone distractions were most relevant to study – relevant handheld distractions were those that had high frequency of manual engagement while driving, and low preference for the use of voice recognition technology. Detailed results from the preliminary study are reported in Section 5.3.

5.1.1 Smartphone Habits

One of the limitations of the previous two studies was that the examination of smartphone habits was somewhat partial. For instance, only three types of smartphone habits related to notifications were examined - these were checking for notifications, responding to notifications and answering a phone call. These smartphone interactions did not correspond to the seven, other types of smartphone interactions that were examined in the self-reported frequency of engagement section (see **Table 12**). Thus, our findings of a significant positive association between smartphone habits and self-reported frequency of use only indicated that increased habitual checking of / responding to notifications/calls in general (i.e. not limited to the vehicle) were associated with higher self-reported frequency of engagement in other types of smartphone use while driving (e.g. reading text messages). The interpretation of this is that notification-related habits may act as a gateway to the use of other cellphone distractions while driving. However, the issue with this approach is that it does not indicate whether the smartphone distractions examined within the self-reported frequency section themselves were carried out habitually. Instead, this association can only be inferred by the fact that we controlled for volitional facilitators of drivers' smartphone use. To directly examine whether the smartphone distractions themselves are primarily carried out habitually or volitionally, the same set of smartphone distractions must be examined within the habit, TPB, and frequency of engagement measures. In this manner, the habitualness of the actual smartphone interactions themselves (e.g. reading a text while driving) and their relationship to self-reported frequency of engagement behind the wheel, can be more clearly established. This line of reasoning also has implications for the interpretation of aggregate behavior models, which combine multiple behaviors. Instead of examining cellphone habits' influence on smartphone use overall (i.e. for all distractions), individual smartphone distractions should be examined. It may be that certain types of smartphone use behind the wheel (e.g. reading/monitoring behavior) are more habitually driven than other kinds of smartphone use (e.g. dialing a phone number or sending a message). This corresponds with the idea that more complex behaviors are less likely to become habitual than simpler ones (Lally, Van Jaarsveld, Potts & Wardle, 2010).

A further issue with our previous studies was that our habit measures lacked contextualization within the vehicle environment. In the previous studies, we obtained measures of smartphone notification habits, in general (i.e. daily life, meaning these habits measures were not confined to the vehicle/environment). It would have been arguably more interesting to measure notification-related smartphone habits within the vehicle context; then, any association between notification-related habits and frequency of smartphone use could have been more directly established. Instead, we decided to measure notification habits in general, since smartphone use is ubiquitous (i.e. used throughout the day and carried across environments). As such, cues associated with cellphone habits are likely to be portable (i.e. not contingent upon the environment) and thus can be brought into the vehicle and trigger individuals smartphone habits as they drive. Under this assumption, there is no need to capture the influence of the surrounding environment itself. However, this assumption ignores the fact that the driving context itself may be enough of a change in scenery to impede individuals' smartphone habits. For example, if drivers put their phone on silent, and put their phone out of sight, then there may be less cues available to elicit habitual smartphone interactions in the driving context. Further, individuals may actively resist their habitual impulses through engaging in self-control and vigilant monitoring - individuals will be highly motivated to control such habits, since handheld smartphone use while driving is illegal. Thus, the previous approach of measuring smartphone habits in general may be inappropriate. Instead, smartphone habits can be measured within the context of the driving environment itself (e.g. "While driving in X scenario, checking for a notification is something I do automatically"). It may be that people self-report weaker handheld smartphone habits behind the wheel, as opposed to smartphone habits outside of the driving context. This difference in habits may represent the intervening role of self-control mechanisms or indicate that the change in context is enough to weaken the paired portable cue-behavior associations, which are responsible for eliciting habit interactions.

Based on the reasoning above, the new proposed survey (see **Appendix E** and **F**) contextualizes habit measures within the driving context. In the survey, two different driving environments are specified (rural highway and downtown urban), with participants being semi—randomly assigned to a condition based upon their past driving frequency in both environments (see Section 5.2 for more details). While not a central hypothesis to the current study, it may be that the type of driving environment moderates the relationship between a specific smartphone habit and participants' self-reported frequency of engagement in that specific smartphone distraction. For example, it could be that a smartphone habit is more pervasive in simpler driving environments (i.e. individuals employ less self-control due to a decrease in the perceived risk of driving conditions), which may result in habit being a larger facilitator of use in those environments (e.g. rural highway scenario). Alternatively, it could be that the influence of a smartphone habit on frequency of use is greater for urban driving scenarios, as urban scenarios are associated with higher cognitive workload (Schweitzer & Green, 2007; Miura, 1992), which may deplete the cognitive capacity necessary for drivers to employ self-control mechanisms to limit habitual engagement. In our previous study, we were unable to interpret the moderating effect of the driving environment on the habit and self-reported engagement relationship, as habit was measured outside of the driving environment.

Lastly, a number of studies have cited that a weakness of the SRHI is that it does not consider the role of contextual cues, which are responsible for automatically eliciting habitual behavior. Instead, the SRHI focuses on measuring the automaticity of behavior, which is the active ingredient of habit (Verplanken & Orbell, 2003). One potential avenue for including contextual cues was put forth by Sniehotta and Presseau (2012), who recommended question prompts for the SRHI include the context (i.e. "Behavior X in Context Y is something I do automatically"). In this way, the automaticity, unconsciousness and mental efficiency (all elements of the SRHI) of the behavior can be assessed in regard to a specific context or covarying cue. Our previous studies did not explicitly state any contextual cues, although for two of the examined smartphone habits, a preceding temporal cue was most likely considered by respondents; for answering a phone call, the preceding cue of receiving the phone call (vibration of the phone, ring tone, etc) was probably inferred, while for responding to a notification, the preceding cue of receiving the notification was probably inferred.

To ensure that the relationship between covarying cues and behavior is clearer, our proposed study fully incorporates the role of contextual cues. However, because little is actually known about which cues may elicit habitual smartphone use while driving, the current study takes a slightly different approach to including contextual cues than that recommended by Sniehotta and Presseau (2012). Instead, similar to the frequency in context measure developed by Oullette & Wood (1998), the current study utilizes an "automaticity in context" measure, which will measure the automaticity of drivers' smartphone use via the Self Report Behavioral Automaticity Index (a validated short-item version of the SRHI; Gardner et al., 2012) and the cue-behavior association between smartphone habits and different cues with a cue-behavior frequency measure (e.g. "While driving in similar scenarios, how often do you read text messages in response to the following cues?"). Four portable cues that the author identified as being common through a pilot study (n = 10) are used in the proposed survey study, including: (1) receiving notifications from a smartphone, (2) feeling bored, (3) feeling lonely, (4) experiencing feelings of social pressure. Portable cues are used instead of cues related to the driving environment or vehicle itself, since there is a higher likelihood that smartphone habits have developed around them (i.e. most people only drive a limited number of hours a day, and smartphone use behind the wheel is an illegal activity). Participants will rate each handheld smartphone interaction and cue in terms of frequency of co-occurrence (1 = Never, 5 = Very Often). The multiplicative product between the different cue-behavior associations and automaticity can then be calculated and entered into a predictive analysis to determine which kinds of smartphone cues are most significant in predicting smartphone use behind the wheel.

5.1.2 The Habit and Intention Interaction

Another limitation of both our prior studies is that we did not obtain a measure of behavioral intention, and instead, assessed respondents' prior self-reported behavior over the past year. Further, we also did not obtain a measure of drivers' prospective behavior (i.e. self-reported behavior measured at some point in the future). The TPB, as it was set out by Ajzen (1991), specifically states that attitude, subjective norms, and perceptions of behavioral control directly predict intentions to behave, with intentions being the most direct and proximate antecedent of behavior (Ajzen, 1991; see *Figure 3* on pg. 42). Traditionally, in the TPB's application to the distracted driving domain, researchers have conducted cross-sectional studies, with survey data being collected at a single point in time. This type of research design is not conducive to testing the full model of the TPB as set out by Ajzen (1991) and as such, researchers have mostly focused on predicting drivers' intentions to engage in handheld smartphone distractions, or their willingness to do so (e.g. Walsh et al., 2008; Waddel & Wiener, 2014). Other studies have focused on using the TPB constructs to predict self-reported behavior directly (e.g. Bayer & Campbell, 2012; Chen & Donmez, 2016), with behavior being assessed via self-reports of past behavior (which took place over a specified time period). Generally, findings from these studies are similar to studies examining intentions/willingness, with the TPB constructs accounting for a similar amount of variance in self-reported behavior as compared to intentions, e.g. 45% of the variance in self-reported engagement in a variety of distractions in Chen et al. (2016) vs 49-51% of the variance in intentions to engage in smartphone distractions in Waddel et al. (2014).

While both approaches utilizing a cross-sectional design appear to have similar results, they both have limitations when it comes to fully exploring the role of habits in predicting behavior. For instance, a number of studies examining the role of habits in predicting health behavior (e.g. flossing, exercising and dieting) have found that an interaction exists between habits and intentions, such that when habits are a strong predictor of behavior (as measured by the Self-Reported Habit Index), intentions are a weak, insignificant predictor; vice versa, when habits are weak, intentions are a strong, significant predictor (Gardner et al., 2011). The cross-sectional design utilized by our two prior studies does not allow for this interaction to be examined. Even if measures of intentions were collected in those studies, current intentions to engage in a behavior should not be used to predict self-reported behavior over the past year, as current intentions may differ from past behavioral frequency. A similar logic can be applied to having current habits predict past self-reported behavior, which may be another limitation of our previous studies (Chapter 3 and 4).

Based on this, our proposed survey study adopted a prospective design, whereby intentions to engage in handheld smartphone distractions, current smartphone habits, and TPB constructs are measured at time point one, and prospective behavior (i.e. self-reported smartphone distraction engagement over the previous month) is assessed one month later. A prospective design will also allow us to examine self-control/inhibition over engaging in handheld smartphone distractions; these constructs will be captured through counter-habitual intentions measured at time point one (i.e. "I intend to avoid doing" and "I intend to not do"). Examining the interaction between counter-habitual intentions and habits has been advocated by habit researchers (e.g. Gardner, 2015), and as such, the proposed study will examine the interaction between counter-habitual intentions and smartphone habits in predicting self-reported frequency of use. It may be that counter-habitual intentions can dampen the effect of smartphone habits on self-reported smartphone use behind the wheel.

5.1.3 Limitations of the SDDQ

This section outlines some of the limitations of the SDDQ employed in Chapter 3 and 4, and it records the changes made to it for the purposes of the proposed study (see **Table 19** for a summary of changes made). Some of the changes made to the SDDQ were based upon comments from participants (n = 10) who piloted the proposed survey in April 2020.

Table 19. Summary of the changes made to Marulanda's (2015) version of the SDDQ.

Change made to the SDDQ for the proposed survey
1. The "Good use of time" and "Lose respect" items for measuring attitude were removed.
2. The sematic differential scale 1 = Not Worthwhile to 5 = Worthwhile was added to replace the "Good use of time" item.
3. The semantic differential scales that assessed "Pleasantness" was replaced with a similar scale "Enjoyability".
4. The items for perceived control were contextualized within the driving contexts (as opposed to being general measures).
5. Constructs that only had a single item in the revised SDDQ were given another item to enhance construct validity and measurement reliability (e.g. descriptive norms).
6. A number of constructs were added, including intentions, counter-habitual intentions and moral norms.
7. The number of distractions examined was altered so that only handheld cellphone distractions were examined.

Marulanda's (2015) version of the SDDQ was the version used in both studies (Chapter 3 and 4) within this thesis.

The first set of alterations made to the SDDQ for the current study were the removal/replacement of several attitude items. First, the "Good use of time" and "Lose respect for others" items were removed, as these items assess belief outcomes and are not global measures of attitude; there may be theoretical issues with averaging or extracting common factors from a combination of these measures. Furthermore, the item “lose respect” was noted as having low standardized factor scores and poor inter-item reliability (as accessed through Cronbach’s Alpha) for each of the seven smartphone distractions examined in the previous two studies. The “good use of time” scale was replaced with a global attitude measure, “worthwhileness”, which resembles the worthless-valuable scale used by Nemme and White (2010) and Waddel and Wiener (2014). “Good use of time” was replaced because we believed the “good use of time” item was an important aspect of drivers’ attitude to capture, and because it displayed higher standardized factor loadings than the “lose respect” scale for the latent variable attitude in the previous studies (Chapter 3 and 4; results from the latent variable analysis for the North American sample are not reported in this thesis). Other changes made to the measurement of the attitude construct included the removal of the semantic differential scale “wisdom”, as it had large correlations with “safety” (i.e. r values from 0.60 to 0.85, depending on the smartphone distraction) and thus appeared to be a redundant measure, as well as the replacement of the semantic differential scale “pleasantness” with “enjoyability”, as some of our pilot participants (n = 10) for the proposed survey noted that the term “pleasantness” was outdated.

The second major change to the SDDQ was the contextualization of the perceived control measures. In the previous two surveys (Chapter 3 and 4), perceived control was measured outside of the driving scenarios (i.e. general measures of perceived control). This decision was made by one of the previous authors; however, the author of this thesis could see no reason why measures of perceived control should be excluded from contextualization within the driving environment. Perceived control is thought to include individuals’ feelings of personal control over a behavior (similar to internal locus of control), as well as the influence of environmental variables which could restrict/enhance one’s ability to engage in a behavior (similar to external locus of control; Rotter, 1966). Perceived control was included in the TPB because two people could have equal intentions to engage in a given behavior (e.g. text while driving), however, a person may have a better opportunity or more control over doing so (e.g. low traffic density, low traffic fines, being at a red light) and thus, that person will engage in said behavior more frequently when environmental variables facilitate their behavior. For this reason, the perceived control measures were contextualized within the driving environments, as these scenarios likely determine how much control an individual feels over engaging in handheld smartphone distractions.

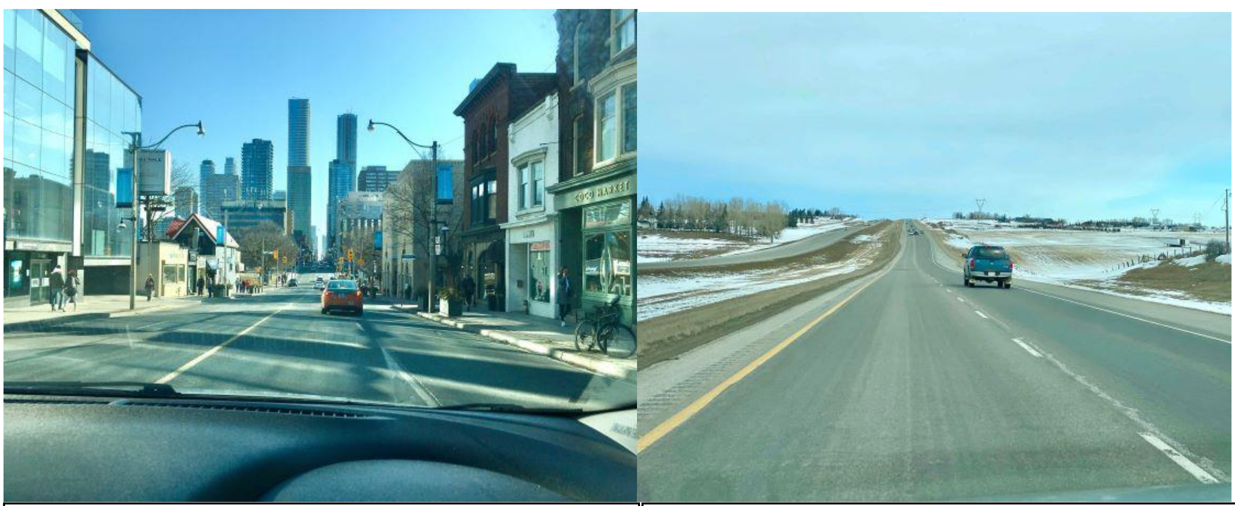
The third change made to the SDDQ for the current study involved the addition of a second item for constructs previously measured with a single item. Measuring constructs with a single item does not allow for item reliability within a construct to be examined, or for the elimination of measurement error through latent variable modeling (Beaujean, 2014). The addition of a second item for constructs will improve the overall reliability and construct validity for constructs measured within the SDDQ, while also keeping the survey at a manageable length. A fourth change to the SDDQ was the addition of a number of constructs to the TPB (some native to the original model and some additional). Both intentions and counter-habitual intentions were added based on reasoning stated in Section 5.1.2. In addition, the construct of moral norms was added based on several studies finding it to be a significant predictor of both drivers' intentions (Nemme & White, 2010; Gauld et al., 2017) and self-reported engagement in smartphone distractions while driving (Nemme & White, 2010).

Finally, the proposed survey will only focus on handheld smartphone distractions, as opposed to the variety of distractions (e.g. hands-free, non-technology based) which were specified in the revised SDDQ (Marulanda, 2015). This narrowing of distractions was done because smartphone habits are of specific interest in this research. Further, by limiting the number of distractions examined, a number of newer cellphone functionalities/interactions (e.g. watching online videos) can be examined. A list of included smartphone distractions can be seen in **Table 20.**

5.2 Proposed Survey Study Methodology

The survey study will be a between-subject, prospective design, with two points of data collection. Participants will be semi-randomly assigned to one of two driving contexts near the beginning of the survey (either a rural highway or a downtown urban scenario; see *Figure 8*). Semi-random assignment indicates that participants will be assigned to a driving scenario according to their past driving frequency in similar scenarios. For example, if a participant indicates they spend less than 20% of their driving time in one type of scenario, they will automatically be assigned to the other scenario. If they spend more than 20% of their driving time in both scenarios, then they will be randomly assigned to one driving scenario. If they spend less than 20% of their driving time in both scenarios, they will be disqualified from the study.

After scenario assignment, participants will fill out an online survey gauging their self-reported frequency of engagement in manual (i.e. hand-held) smartphone distractions while driving over the past three months, their intentions/counter-intentions to engage in manual smartphone distractions while driving in the next month, other TPB variables and their smartphone habits (see **Table 20** for Time-1 measures). At the end of the first survey, participants will be instructed to maintain an awareness of how frequently they use their handheld smartphone for different types of smartphone distractions (e.g. reading messages) while driving over the following month; they will not be required to keep specific track of their actual frequency. One month later, participants will be asked to fill out a short survey asking them to estimate the frequency of their smartphone use within the past month while driving in scenarios similar to the one assigned to them at time point one (i.e., Time-2 measures).



<u>Scenario</u> Imagine yourself driving along on a two or three- lane urban road with moderate traffic, medium pedestrian flow, and traffic lights. The photo above illustrates the type of environment that you should consider when answering the following questions.	**<u>Scenario</u>** Imagine yourself driving on a 4-lane highway where local lanes are divided by a ditch or barrier, traffic conditions are low and there is good weather. The photo above illustrates the type of environment that you should consider when answering the following questions.

Figure 9. The two driving scenarios

5.2.1 Sample Characteristics

Respondents will be workers on the crowdsourcing platform Amazon Mechanical Turk (MTurk for short). MTurk workers are thousands of anonymous workers who are diverse across age, gender, and income demographics (Ross et al. 2010); they participate in academic studies/market research in order to obtain modest financial compensation. The population of MTurk workers has been found to be at a minimum as representative as traditional participant pools, and in many cases, more representative of the general population in terms of geographical location and age (Berinsky, Huber, & Lenz, 2012; Casler, Bickel, & Hackett, 2013; Paolacci & Chandler, 2014; Paolacci, Chandler, & Ipeirotis, 2010). Data quality from crowd-sourcing platforms, in general, have been found to be equivalent to traditional sampling methods (Gosling, Vazire, Srivastava, & John, 2004; Krantz & Dalal, 2000), with data from MTurk being found to meet common psychometric standards (Buhrmester, Kwang & Gosling, 2011).

Only respondents who consent to participate in both parts of the study, possess a valid government issue driver license, own a smartphone, drive their motor vehicle at least a couple times a week, and spent at least 20% of their driving time in either a rural highway or city driving environment will be allowed to participate in the study. These restrictions will ensure that the sample only contains respondents who have the opportunity to engage in handheld smartphone distractions in environments similar to their assigned one. The mean competition time for the first survey is approximately 35 minutes and for the follow-up 5 minutes (based on 10 pilot participants). Participants will be compensated $7.50 CAD for their completion of survey one, and $2.50 CAD for their completion of the follow-up one month later. A higher compensation scheme is planned for the follow-up survey to entice participants to complete the follow-up survey.

5.2.2 Time-1 Survey Measures

Based upon the results of a preliminary survey (see Section 5.3 and **Appendix D** for the preliminary survey), nine handheld smartphone distractions were chosen to be examined in the proposed survey study. These nine smartphone distractions were found to be frequently manually performed over the past year, despite the fact that some smartphone distractions received a high preference to be engaged in via voice recognition (e.g. answering an incoming phone call, initiating a phone call). These nine handheld smartphone distractions are examined within each of the TPB constructs, the SRBAI (Gardner et al., 2012) and the cue-behavior frequency measure.

For the TPB constructs, four semantic differential scales are used to measure the global construct of attitude. One semantic differential scale assesses overall attitude towards a distraction (Good - Bad; Zhou et al., 2009; Nemme & White, 2010; Bayer & Campbell, 2012; Waddel & Wiener, 2014), one differential scale assesses an affective aspect of attitude (Enjoyable - Not Enjoyable; Zhou et al., 2009), and two semantic differential scales assess instrumental aspects of attitude (Safe - Unsafe and Worthwhile - Not Worthwhile; Zhou et al., 2009). Intentions are assessed using two items that were previously used in distracted driving related TPB research (Nemme & White, 2010; Waddel & Wiener, 2014; Zhou et al., 2009), while measures for counter-habitual intentions were developed for the current study.

Similar to our previous studies (Chapter 3 and 4), the two sub-components of PBC, self-efficacy and perceived control, are assessed and will be analyzed separately. Self-efficacy is measured with two items. SE1 (Table 20) is the same item used in previous studies, while SE2 has been adopted from Armitage and Conner (2001). The perceived control items were heavily based upon the items used in our previous studies (Chapter 3 and 4), with examples being added to PC1 to improve clarity (i.e. "that circumstances [e.g. the driving environment, personal/work reasons, etc] would determine") and PC2 being changed from "I decide" to "I would have control over" to enhance clarity (item taken from Armitage & Conner, 2001).

For injunctive norms, IN1 was kept from our previous studies, while IN2 changed the key words from "would think it is okay" to "wouldn't mind". This change was made based on the advice of pilot participants who indicated they perceived little difference between "approve of" and "would think it's okay". The adoption of an item that stated "wouldn't mind" was used instead to represent a non-explicit form of approval. Further, the referent group was altered for injunctive norms items - instead of having each item refer to "people who are important to me", two referent groups that were used in Bayer and Campbell (2012) were adopted. This change was made to accommodate pilot participants (n = 10) who indicated that the items appeared too similar. A similar approach was taken for descriptive norms, with DN1 and DN2 adopting the same referent groups as injunctive norms. DN1 and DN2 were based on the descriptive norm items from our previous studies (Chapter 3 and 4). Moral norm items were based on those from Nemme and White (2010) and Bayer and Campbell (2012).

Habits are measured with the Self-Report Behavioral Automaticity Index (SRBAI), which is a validated short item version of the SRHI (Gardner et al., 2012). The SRBAI has been found to be reliable and valid and has been shown to detect the two hypothesized effects of habit (i.e. both a habit-behavior correlation and a moderating effect of habit on the intention-behavior relationship; Gardner et al., 2012). Habits are measured in both the vehicle context and in general (i.e. daily life). This was done so that participant habits in the different settings can be compared; it may be that habits within the vehicle setting are reported as weaker than in daily life. This may represent the intervening role of self-control/inhibition mechanisms, or the influence of the change of environment. Difference scores between drivers' smartphone habits can be computed for individual distractions to see whether they correlate with measures of inhibition/self-control (i.e. counter-habitual intentions) to explore whether these mechanisms accounted for any observed difference.

Instead of the four items originally specified in the SRBAI, three items were chosen from the scale because pilot participants (n = 10) indicated they had a hard time answering the item "Behavior X is something I do without having to consciously remember". For this reason, that item was removed from this study's application of the SRBAI. While this may affect the construct validity of the habit measure, the majority of the other constructs within the SDDQ were measured with only two items. Further, the removal of the item was deemed necessary to limit the overall length of the survey. Finally, a selection of four contextual cues is used to examine potential cue-behavior association strength – these cues were identified as being common cues by pilot participants (see **Table 20**).

Table 20. Main questionnaire for the proposed survey study

Surveyed Cellphone Distractions	
D1	answer an incoming phone call (e.g. Phone, Facebook Audio, etc)
D2	initiate a phone call (e.g. Phone, Facebook Audio, etc)
D3	read a message (e.g. SMS, WhatsApp, direct message on social media, etc)
D4	enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)
D5	read an email
D6	scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)
D7	browse a website / use a search engine (e.g. Safari, Google Chrome, etc)
D8	check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)
D9	search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)
SDDQ ITEMS (Utilizing the Above Distractions)	
Attitudes A1: 1 = Bad to 5 = Good; A2: 1 = Unsafe to 5 = Safe; A3: 1 = Not Enjoyable to 5 = Enjoyable; A4: 1 = Not Worthwhile to 5 = Worthwhile	
A1:A4	While driving in a similar scenario in the next month, [D1-D9] is something that is…
General Question Prompt and Scale (Used for the rest of the questions) 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
"While driving in a similar scenario in the next month, [D1-D9] on a smartphone is something... "	
Intentions	
IN1	I intend to do
IN2	I will likely do
Counter-Habitual Intentions	
CN1	I intend to avoid doing
CN2	I intend not to do
Self-Efficacy	
SE1	that would not be difficult for me to do
SE2	I am confident I could do well
Perceived Control	
PC1	that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine
PC2	I would have control over
Injunctive Norms	
IN1	that people who are important to me would approve of
IN2	that people that I respect wouldn't mind
Descriptive Norms	
DN1	that most people who are important to me would do
DN2	most of the people I respect would do
Moral Norms	
MN1	I would feel guilty doing
MN2	that would be wrong to do
HABIT ITEMS (Utilizing the Above Distractions)	
SRBAI Items (Vehicle Context) 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
H1	While driving in similar scenarios, engaging in [D1-D9] is something I do automatically.
H2	While driving in similar scenarios, engaging in [D1-D9] is something I do without thinking.

H3	While driving in similar scenarios, engaging in [D1-D9] is something I start doing before I realize I'm doing it.
Cue-Dependency Items 1 = Never, 2 = Rarely, 3 = Occasionally/Sometimes, 4 = Often, 5 = Very Often	
"While driving in similar scenarios, how often do you [D1-D9] in response to the following cues?"	
CD1	Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)
CD2	Being bored
CD3	Feeling lonely
CD4	Feelings of social pressure
SRBAI Items (Daily Life) 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree	
HD1	In daily life (i.e. not confined to the vehicle), engaging in [D1-D9] is something I do automatically.
HD2	In daily life (i.e. not confined to the vehicle), engaging in [D1-D9] is something I do without thinking.
HD3	In daily life (i.e. not confined to the vehicle), engaging in [D1-D9] is something I start doing before I realize I'm doing it.

*Attention check questions are not included in this table. See **Appendix E** for attention checks found within question matrices.*

5.2.3 Follow-Up Survey Measures

The follow-up survey will take place approximately one month after the first survey. Two different surveys have been created, one for each driving condition. Respondents who completed the Time-1 survey will be contacted through MTurk to notify them that their relevant follow-up survey has been posted on MTurk – contact will be made through MTurk, as direct contact of respondents through other means (e.g. e-mailing) is against Amazon's Terms of Service. Only respondents who were assigned to a given driving scenario (e.g. urban) will see their relevant follow-up survey posted on MTurk. This will ensure that respondents who completed the Time-1 survey within a given scenario (e.g. urban) do not complete the follow-up survey within another (e.g. rural). Further, respondents' percent of driving time in a given scenario will be assessed (5-point Likert scale from 0 = 0% to 5 = 100%) and compared to their 3-months estimate from their Time-1 survey to ensure they drove with a similar frequency in their assigned driving environment. Respondents who did not drive in that environment in the intervening month or did so with less frequency (a 2-point difference on the scale) will be removed from the data analysis.

In the follow-up survey, respondents will be primarily asked about their frequency of engagement in handheld smartphone distractions over the intervening month (see **Appendix F** for the follow-up survey). Two different measures of frequency will be obtained:

B1: In the past month, how often did you manually (i.e. not using voice recognition) engage in the following tasks during a **typical drive** in environments similar to the image above? Scale: 1 = Never, 2 = Rarely, 3 = Sometimes/Occasionally, 4 = Often, 5 = Very Often.

B2: In the past month, approximately how many times did you manually (i.e. not using voice recognition) engage in the following tasks during a **typical drive** in environments similar to the image above? Scale: 1 = 0 times, 2 = 1-2 times, 3 = 3-4 times, 4 = 5-6 times, 5 = 7+ times.

Two different measures of engagement frequency are used to increase the reliability of measuring drivers' engagement in handheld smartphone distractions. For both questions, manual engagement is defined as "actively using your handheld smartphone device, rather than using the infotainment system / steering wheel controls to manually perform these tasks". Further, a typical drive is used as a point of reference, rather than having respondents estimate their overall engagement in distractions over the past month. This was done because it may be difficult for respondents to accurately estimate their monthly usage for both measures (B1 and B2). A typical drive is defined to the participants as "a prototypical drive in an environment similar to the image above".

An additional question is asked which inquiries about participants' travel over the past month ("In the past month, approximately how many times did you drive in an environment similar to the scenario above?"). A monthly estimate can then be derived for B2 by multiplying this number by B2 (number of times a distraction is engaged in during a typical drive in that environment). A monthly estimate from B2 can alternatively be used as the dependent variable in the data analysis, rather than the typical drive estimate for B2.

Finally, respondents are asked whether their participation in the first questionnaire influenced their subsequent engagement in smartphone distractions over the past month. Respondents will rate the smartphone distractions they initially selected in the first survey on a 5-point scale, with 1 = Negative influence (more engagement), 3 = No influence (same engagement), 5 = Positive influence (less engagement). This variable can be used as a control variable in the final predictive analyses to control for any possible effects the Time-1 survey may have on subsequent distraction engagement over the intervening month.

5.2.4 Potential Analysis

Structural equation modelling will be used to build predictive models (see *Figure 9*). Both an aggregate behavioral model, as well as individual behavioral models (i.e. for a single smartphone distraction) will be constructed. Individual models will primarily be built to examine whether the role of habits as a facilitator of driver smartphone use changes for different smartphone distractions. It is hypothesized that smartphone distractions that are less complex in nature (e.g. checking for notifications, reading a message), will be more habitual, and thus, have a greater association with self-reported frequency of use behind the wheel. It may be that for these smartphone distractions, there is a greater interaction between habits and intentions, such that when habits are strong, there is a greater decrease in the predictive strength of intentions on prospective behavioral frequency. A similar logic may apply to the interaction between habits and counter-habitual intentions, with more habitual interactions (e.g. checking for notifications) having a larger moderating effect of habits on counter-habitual intentions (i.e. the stronger ones habits, the less of an effect counter-habitual intentions have on prospective behavioral frequency). There is no hypothesized difference in the relationships between the TPB constructs and intentions and the TPB constructs and counter-intentions for individual distractions.

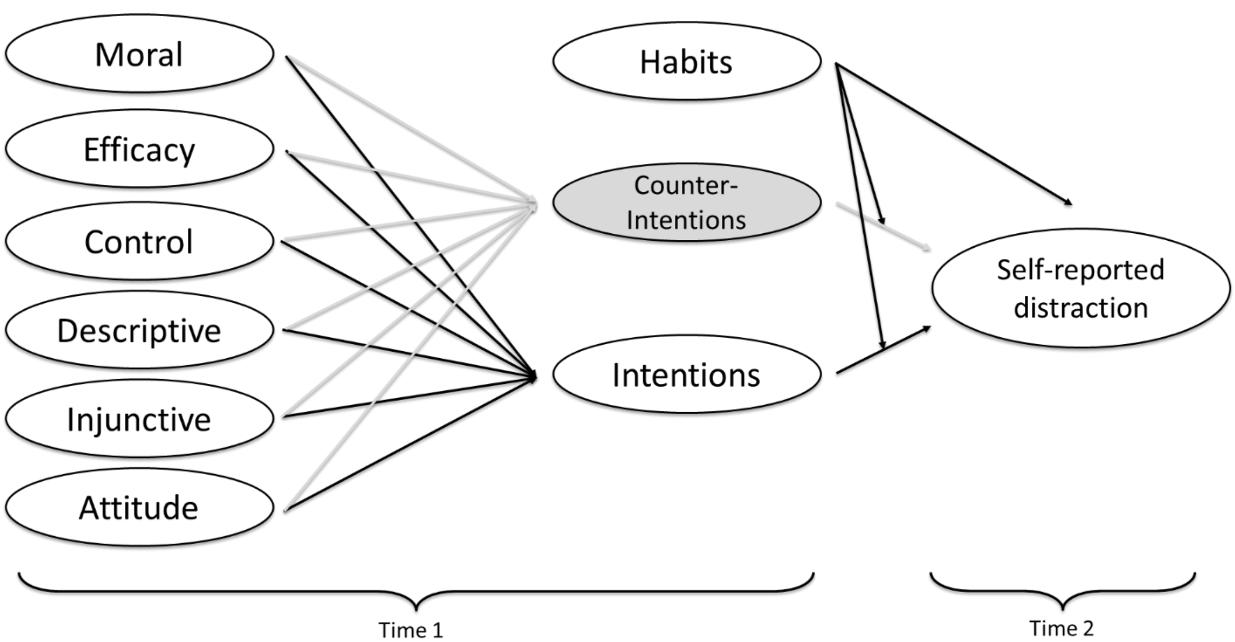


Figure 10. Planned structural model for the current study

For the individual distraction analysis, the constructs in *Figure 9* will either be latent variables or averaged constructs, depending on model convergence. Constructs will only be averaged if model convergence fails and items are found to have acceptable inter-item reliability. Spearman's ranked correlation coefficients will be used to examine inter-item reliability for constructs with two items, while Cronbach's α will be used for constructs with three or more times (attitude and habit).

For the aggregate behavioral analysis, second-order latent variables will be created for each construct; first-order latent variables will be a construct for a given distraction (e.g. attitude towards reading messages), while second-order latent variables will be a construct for all distractions (e.g. attitude towards cellphone distractions). If model convergence fails, either unstandardized factor scores will be calculated for each construct for a given distraction, or given acceptable inter-item reliability, averaged constructs for each distraction will be created (similar to the approach taken for the structural equation model built in Chapter 4). Then, an overall latent variable will be calculated for each construct, which will represent that construct for all nine smartphone distractions (e.g. attitude towards all smartphone distractions). This approach is also similar to that taken in Chapter 4.

The approaches outlined in the above paragraph will result in an overall aggregate model of smartphone distractions (see *Figure 10*). To test the interaction between habits and intentions / counter-intentions for the aggregate model, latent interaction variables will be created by multiplying each distraction for one construct (e.g. habitualness of reading messages) by that same distraction for another construct (e.g. intentions to read text messages). A latent variable based on those interactions (i.e. all nine habit-intention interactions) will then be extracted and entered as a predictor variable in the aggregate model. The calculation of latent variables is in line with the method outlined by Marsh, Wen and Hau (2004).

5.3 Preliminary Survey Study for Selecting Relevant Handheld Smartphone Distractions

As mentioned earlier, in order to determine what handheld smartphone distractions should be examined within the proposed study, a preliminary survey was developed and data on respondents' self-reported engagement in twelve handheld smartphone distractions was examined. In addition, drivers' preferences for using voice recognition technology was collected. The aim of this initial survey study was to select a subset of handheld smartphone distractions that were frequently manually performed, as well as having a low preference for being performed via voice recognition. It was thought that these handheld smartphone distractions would be the most relevant to examine in the proposed survey study. See **Appendix D** for the preliminary survey questions.

5.3.1 Methods

An online survey was conducted on Amazon Mechanical Turk and Survey Gizmo from March 12 to March 17, 2020 to examine Canadian drivers' self-reported frequency of engagement in smartphone distractions over the past year, as well as their preference for using voice recognition technology. Respondents were recruited on Amazon Mechanical Turk (MTurk for short), an online crowdsourcing platform where "Workers" participate in Human Intelligence Tasks (HITS) for modest financial compensation. Respondents were required to be Canadian citizens and have a Canadian IP address to see the HIT. IP addresses were manually examined to ensure only participants with Canadian IP addresses were included in the study. Once respondents accepted the HIT, they were provided with a URL link to SurveyGizmo, which was where the online survey was hosted. After respondents completed the survey, they were provided with a randomly generated code on SurveyGizmo, which they could then enter on MTurk to redeem their compensation. Respondents were compensated $0.40USD for the competition of the survey, and it took respondents, on average, 4 minutes and 12 seconds to complete the survey (SD = 3.05, Min = 1:10, Max = 21:15).

5.3.2 Respondents

One hundred and forty-four respondents participated in the pilot survey. Thirty-one respondents were disqualified, either because they indicated they drove less than a few times a week, or because they were not from Canada (i.e. their IP address listed a country other than Canada, or they indicated they currently resided outside of Canada in the survey). Two respondents provided partial responses, and their responses were removed from the analysis. *Figure 10* shows a breakdown of respondents by province. Based on quarterly Canadian population estimates (Statistics Canada, 2020), there was a disproportionate percentage of Albertans (sample ~ 22%, population ~ 12%) and Quebecers (sample ~ 13%, population ~ 23%) in our sample. Other provinces were reasonably represented; however, we did not have respondents from

Newfoundland and Labrador, or any of the three northern territories. Results from our small sample appear to indicate that the population of MTurk workers in Canada is relatively representative of the distribution of Canadians across provinces.

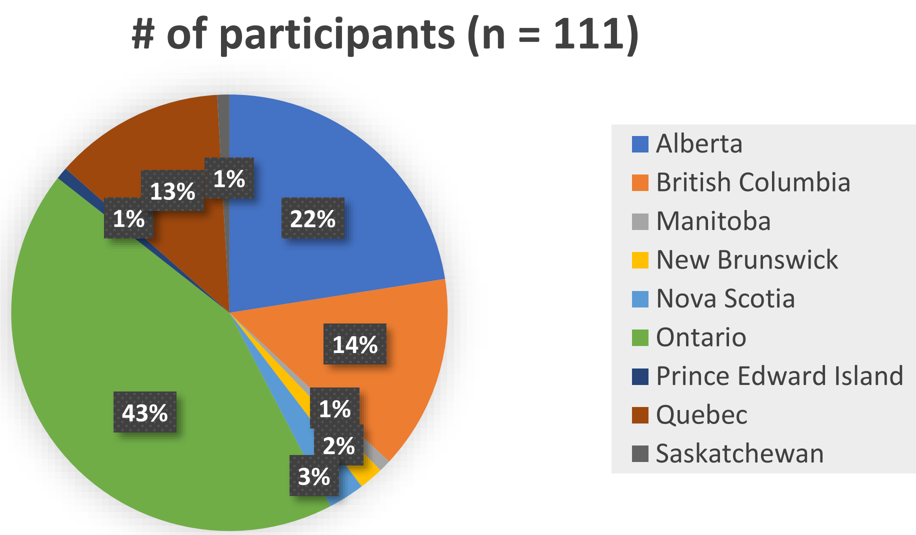


Figure 11. Percentage of participants in the initial survey by province

5.3.3 Measures

Twelve different smartphone distractions were examined (see **Table 21**). First, respondents were asked to: "Please indicate the functions/activities that **you have ever** performed on your smartphone". This acted as a screening question to eliminate smartphone interactions respondents indicated they never used from the rest of the survey. Following this, respondents answered two questions about their past frequency of engagement in manual handheld smartphone distractions over the past year. The first question asked respondents "During a ***typical drive*** over the past year, **how often** did you manually (i.e. not using a voice recognition system) engage in each of the following smartphone activities? It was assessed using a frequency scale from 1 = NEVER to 5 = VERY OFTEN. The second question asked respondents: "During a ***typical drive*** over the past year, **how many times** did you manually (i.e. not using a voice recognition system) engage in each of the following smartphone activities?". It was assessed using a frequency scale from 1 = 0 times to 5 = 4+ times. In the survey, a typical drive was defined as: "your most frequent drive over the past year (e.g. If you commute to work daily, then this is most likely your typical drive.)". A typical drive was chosen over a yearly estimate in order to make numerical estimation easier for respondents. Further, manual smartphone distractions were defined as "actively using your handheld smartphone device, rather than using the infotainment system, to manually perform these tasks."

Finally, respondents were asked: "When driving, how much do you prefer using a voice recognition system (e.g. Apple Carplay), rather than visually/manually performing these tasks on a handheld smartphone? Respondents rated the nine smartphone distractions on a scale from 1 (Never prefer voice rec.) to 5 (Always prefer voice rec). Only nine smartphone distractions were examined for this item, since "scrolling through the newsfeed of a social media app", "updating/making a post on a social media app" and "watching an online video" are functions/activities that cannot be controlled/performed via voice recognition.

5.3.4 Results

5.3.4.1 Descriptive statistics

On average, respondents ranged between never and sometimes/occasionally engaging in the smartphone distractions examined (see **Table 21**). Further, respondents indicated that they interacted with their smartphones somewhere between zero and two times during a typical drive, on average. Specifically, it was found that the most common smartphone distractions were "checking the home screen for any sort of notification", "answering an incoming phone call", "searching for a song/artist/album/playlist on a music app", and "reading a message"; the least common distractions were "updating/making a post on a social media app", "watching an online video" and "sending an email". Medium to high spearman rank correlation coefficients were found between both measures of frequency of engagement (i.e. oftenest and number of times) for each smartphone distraction (ranging from $\rho = 0.52$ *to* $\rho = 0.93$; see **Table 21**), indicating respondents tended to rate both scales similarly. Despite this, respondents generally rated the number of times they engaged in a smartphone distraction as higher than what they indicated on the oftenest scale. It was found that a larger number of respondents used the top end of the scale (i.e. a rating of 5) for the "number of times" scale, which equated to engaging in a distraction 4+ times during a typical drive. The smartphone distractions with the largest percentage of respondents selecting the top end of the scale (excluding missing data) were searching for a specific song (44%), checking the phone home screen (43%), reading a message (29%) and answering a phone call (28%). Based on this finding, a decision was made to adjust the scale for B2 in the proposed study (see Section 5.2.3), which originally had the same scale as the current "number of times" measure. The scale was changed so that the top end of the scale for B2 now equaled 7+ times, with the bin width equaling two interactions (e.g. 1-2 times).

In regard to participants' preference for using voice recognition software over manually engaging in the handheld smartphone distractions, participants indicated that they approximately "sometimes" preferred using voice recognition for "answering an incoming phone call" (M = 3.41), "initiating a phone call" (M = 3.30), and "searching for a song/artist/album/playlist on a music app" (M = 3.00). The smartphone distractions with the lowest preference for voice recognition included "browsing a website / using a search engine" (M = 2.17) and sending/reading emails (M = 2.20 and M = 2.18, respectively).

Table 21. Engagement frequency for 12 handheld cellphone distractions and preferences for voice control

Cellphone Distraction	**Freq. Often**	**Freq. Times**	**Reliability for Freq.**	**Pref. Voice Rec.**	**n**
D1: answer an incoming phone call (e.g. Phone, Facebook Audio, etc)	2.50 (1.10)	2.96 (1.60)	α = 0.62 ρ = 0.52	3.41 (1.61)	107
D2: initiate a phone call (e.g. Phone, Facebook Audio, etc)	2.17 (1.06)	2.49 (1.57)	α = 0.74 ρ = 0.72	3.30 (1.69)	102
D3: read a message (e.g. SMS, WhatsApp, direct message on social media, etc	2.35 (1.14)	3.00 (1.62)	α = 0.76 ρ = 0.69	2.88 (1.64)	105
D4: enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)	2.01 (1.06)	2.47 (1.67)	α = 0.79 ρ = 0.79	2.76 (1.71)	94
D5: read an email	1.58 (0.88)	1.82 (1.40)	α = 0.79 ρ = 0.85	2.18 (1.64)	84
D6: send an email	1.29 (0.63)	1.50 (1.17)	α = 0.80 ρ = 0.80	2.20 (1.66)	76
D7: scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)	1.40 (0.85)	1.67 (1.33)	α = 0.71 ρ = 0.86	N/A	73
D8: update/make a post on a social media app (e.g. Twitter, Facebook, Instagram, etc)	1.22 (0.71)	1.25 (0.82)	α = 0.91 ρ = 0.87	N/A	63
D9: browse a website / use a search engine (e.g. Safari, Google Chrome, etc)	1.54 (0.95)	1.64 (1.21)	α = 0.74 ρ = 0.79	2.17 (1.65)	78

D10: check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)	2.62 (1.26)	3.22 (1.73)	α = 0.73 ρ = 0.62	2.39 (1.57)	94
D11: watch an online video (e.g. Youtube, etc):	1.26 (0.75)	1.42 (1.14)	α = 0.80 ρ = 0.93	N/A	72
D12: search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)	2.43 (1.32)	2.85 (1.82)	α = 0.82 ρ = 0.75	3.00 (1.71)	81

ρ is spearman's rank correlation coefficient between the two frequency of engagement scales, while α *is Cronbach's alpha. n is the number of participants who indicated they've used that particular cellphone function in general (i.e. not just limited to while driving). No data was collected for D7, D8 and D11 in regard to preference for voice recognition because voice recognition cannot be used to control these cellphone functions.*

5.3.4.2 Principal Component Analysis

Three principal component analyses were conducted in total, one for each measure (i.e. both frequency of engagement measures and the preference for voice control measure). For the oftenest measure, three components were extracted (see **Table 22**); two components were extracted for both the number of times measure (see **Table 23**) and preference for voice recognition measure (**Table 24**). All three PCA models were found to have excellent fit (model fit > 0.90 and RMSR < 0.08) and all three models accounted for a large amount of the variance in their measure's distraction items (ranging from 72% to 81% of the total variance).

For the frequency of engagement measures, it was found that "entering/sending a message", "reading a message", "searching for a song/artist/album/playlist on a music app" and "checking the home screen for any sort of notification" loaded together for each PCA. For the oftenest measure, these distractions loaded on the medium frequency component, while for the number of times measure, they loaded on the higher frequency component. "Initiating a phone call" and "answering a phone call" were found to load on the higher frequency component for both PCAs, while "updating/making a post on a social media app", "watching an online video", and "sending an email" loaded together on the lower frequency component for both PCA's. Interestingly, "browsing a website / using a search engine", "reading an email" and "scrolling through the newsfeed of a social media app" were found to have split loadings across two frequency components: the medium and low frequency component for the oftenest measure, and the low and high frequency component for the number of times measure (it should be noted that all loadings below 0.40 are not shown in **Tables 22-24**).

Looking at the PCA for voice recognition preference, “sending an email”, “reading an email”, “browsing a website/using a search engine” and “checking for notifications on the home screen” were found to load on the lower preference component. “Answering a phone call” and “initiating a phone call” were found to load on the higher preference component. “Reading a message”, “sending/entering a message” and “searching for music” were found to have split loadings, with two distractions (reading a message and sending/entering a message) primarily loading on the higher preference component and searching for music having a roughly even loadings on both components.

Table 22. PCA for the frequency of engagement in the twelve cellphone distractions (oftenest scale).

Cellphone distractions	**Lower Freq.**	**Medium Freq.**	**Higher Freq.**
D4: enter/send a message		0.81	
D3: read a message		0.78	
D12: search for a song/artist/album/playlist on a music app		0.77	
D10: check the home screen for any sort of notification		0.75	
D5: read an email	0.52	0.66	
D9: browse a website / use a search engine	0.58	0.64	
D8: update/make a post on a social media app	0.94		
D11: watch an online video	0.88		
D7: scroll through the newsfeed of a social media app	0.77	0.49	
D6: send an email	0.75		
D1: answer a phone call			0.89
D2: initiate a phone call			0.87
Model fit:	Fit: 0.99; RMSR = 0.06 Var = 81%		

Component loading values lower than 0.40 are not shown in the table for visual ease.

Table 23. PCA for the frequency of engagement in the twelve cellphone distractions (number of times scale).

Cellphone distractions	**Lower Freq.**	**Higher Freq.**
D3: read a message		0.87
D4: enter/send a message		0.83
D12: search for a song/artist/album/playlist on a music app		0.81
D2: initiate a phone call		0.78
D2: answer a phone call		0.73
D10: check the home screen for any sort of notification		0.72
D8: update/make a post on a social media app	0.90	
D6: send an email	0.88	
D11: watch an online video	0.82	
D5: read an email	0.79	
D9: browse a website / use a search engine	0.67	0.51
D7: scroll through the newsfeed of a social media app	0.65	0.43
Model fit:	Fit = 0.99; RMSR = 0.08 Var = 72%	

Component loading values lower than 0.40 are not shown in the table for visual ease.

Table 24. PCA for preference for voice control over manual engagement in handheld cellphone distractions.

Cellphone distractions	**Lower Pref.**	**Higher Pref.**
D6: send an email	0.94	
D5: read an email	0.92	
D9: browse a website / use a search engine	0.89	
D10: check the home screen for any sort of notification	0.84	
D2: answer a phone call		0.88
D2: initiate a phone call		0.87
D3: read a message	0.48	0.73
D4: enter/send a message	0.55	0.64
D12: search for a song/artist/album/playlist on a music app	0.52	0.54
Model fit:	Fit = 0.99; RMSR = 0.06 Var = 80%	

Component loading values lower than 0.40 are not shown in the table for visual ease.

5.3.5 Discussion

A number of descriptive statistics and exploratory principle component analyses were conducted to examine what handheld smartphone distractions were most relevant to study in the proposed survey study on handheld smartphone distractions. Respondents self-reported their frequency of engagement in handheld smartphone distractions and their preference for using voice recognition technology. Initially, our goal was to select the handheld smartphone distractions that were the most frequently engaged in and had the lowest preference for voice recognition interaction. However, based on the current results, no clear pattern emerged when taking into consideration both frequency of handheld engagement and preference for voice recognition technology.

Based on the frequency of handheld engagement, the distractions "update/make a post on a social media app", "watch an online video" and "send an email" were decided to be excluded in the proposed study. This decision was made because all three distractions had a low mean frequency of engagement as determined by the two measures in the study (i.e. oftenest and number of times). PCA analyses confirmed this, with all three distractions loading onto the lower frequency component for both measures of engagement. Despite this, it should be noted that two of these excluded distractions (updating social media and watching an online video) do not have a voice recognition equivalent. Further, sending emails while driving had one of the lowest preference ratings. As such, these distractions may still be relevant to study. However, a decision was made to remove these distractions from the proposed study so that the overall length of the survey could be reduced.

It is also worth mentioning that the distractions "scrolling through the newsfeed of a social media app", "reading an email", and "browsing a website / using a search engine" had split loadings across two components for both measures of frequency of engagement. These components were the lower frequency and medium frequency components for the oftenest measure, and the lower frequency and higher frequency components for the number of times measure. Both "scrolling through the newsfeed of a social media app" and "browsing a website/using a search engine" primarily loaded onto the medium frequency component for the oftenest measure, with "scrolling through the newsfeed of a social media app" having no voice recognition equivalent and "browsing a website/using a search engine" having a low mean preference score. For these reasons, these distractions were kept in the proposed study questionnaire. The decision to keep "Reading emails" had less support, as this distraction primarily loaded onto the lower frequency component for both frequency scales. However, a decision was made to keep this distraction, as the author believed it would be interesting to explore differences in the predictive models for reading emails and reading messages – these distractions are relatively similar in nature (i.e. both visual reading tasks), so it may be of value to explore what factors influence respondents' lower frequency of engagement in reading emails while driving.

As a final note, future researchers collecting data using the proposed survey, or using the distraction items from the proposed survey, should consider the role of age in determining usage frequency. Results from one of our previous studies (Chapter 3) found that the frequency of engagement in a selection of seven cellphone distractions was mostly greater for drivers 26-35 years old, followed by drivers 17-25 years old. Specifically, more modern smartphone functionalities, such as "Updating social media", were more common in younger age groups (17-25 and 26-35 years old) than older age groups (36-55 and 56+ years old), which may indicate that these types of distractions are more relevant to study in younger age groups. While we did not collect age information from our respondents in this preliminary distraction-selection survey as we were interest in assessing the general driving public, future researchers should consider the effects of age when selecting relevant handheld distractions to examine in their studies.

Chapter 6

6 Conclusions

This thesis examined the impact of volitional and habitual facilitators on drivers' self-reported handheld cellphone use while driving. Volitional facilitators were captured though the Theory of Planned Behavior, while cellphone habits were captured via the Self-Report Habit Index. Results from two of the survey studies (Chapters 3 and 4) showed that notification-related cellphone habits predicted self-reported frequency of cellphone use while controlling for volitional measures. This indicates that notification-related habits relate to cellphone use while driving, above and beyond how drivers feel about them. Notification-related habits may specifically influence the cellphone distractions examined in this thesis (e.g. updating social media, sending a text message) by acting as a gateway. These cellphone distractions themselves may be conducted habitually or volitionally – however, by controlling for volitional factors related to these distractions, evidence is given towards these cellphone distractions being carried out habitually.

Findings regarding habits from Chapter 3 and 4 have implications for the development and endorsement of countermeasures. Since notification-related habits predict frequency of engagement in other cellphone distractions, countermeasures that directly target notification-related habits, such as driver mode, should be effective in reducing the overall prevalence of cellphone use while driving. Furthermore, countermeasures that target cellphone habits may be the only effective method of eliminating cellphone use for individuals with strong cellphone habits. For these individuals, current countermeasure efforts (e.g. legislation, educational messages) may be ineffective, as they primarily target drivers' rational decision-making processes. Instead, technological countermeasures, like driver mode, should be endorsed by government and non-governmental organizations. While driver mode has its own drawbacks (including a lack of user adoption), it may be possible to sway users with convincing educational messages. Another approach could be to create legislation which makes driver mode mandatory for repeat distracted driving offenders. This approach is similar to the ignition interlock system for repeat drinking and driving offenders, and it may be the only effective means of limiting cellphone use for drivers with strong cellphone habits. A less intrusive countermeasure for repeat offenders may be court-ordered psychologist visits, where habit breaking methods could be used and practiced; examples include mental contrasting and implementation intentions (Stadler et al., 2009; Adriaanse et al., 2010), or vigilant monitoring training (Quinn et al., 2010).

In addition to the role of habits, results from Chapter 3 and 4 highlight the relevance of volitional facilitators in predicting self-reported cellphone use while driving. In our studies, both self-efficacy and attitude were found to be consistently strong predictors of self-reported frequency; findings are consistent with those in the literature (e.g. Rozario et al., 2010; Waddel & Weiner, 2014). Furthermore, it was found that social norms (both injunctive and descriptive) were a significant predictor of cellphone use in China, but not in North America. These findings also have implications for countermeasure development, specifically for educational messages. Based on our findings, educational messages which challenge drivers' attitudes (e.g. that using a cellphone while driving is a good use of time) and perceptions of self-efficacy (i.e. using a cellphone while driving is not difficult) may result in drivers using their cellphones less frequently while driving. However, unlike China, educational messages that target social norms (i.e. through emphasizing social disapproval) may be ineffective.

Finally, an additional prospective survey study was developed to address some of the limitations of the prior two studies (Chapter 3 and 4). The proposed prospective survey study has received REB approval, but was not conducted due to the outbreak of COVID-19. The proposed study will use an updated version of the SDDQ to measures TPB constructs and self-reported engagement in cellphone distraction while driving. The SRBAI, as well as a cue-behavior frequency pairing measure, will be used to measure driver's cellphone habits. The purpose of this study will be to examine whether habits measured at one point in time predict frequency of cellphone use measured one month later, after controlling for drivers' intentions to use their cellphones, as well as their counter-habitual intentions to not use them. The interaction between cellphone habits and intentions / counter-habitual intentions will also be explored. This approach to modeling will more closely capture the complex processes involved in deciding to engage in handheld cellphone use while driving. Also, this study will examine the effect of cue-behavior pairing - it may be that certain cues are more frequently paired with cellphone interactions, which may lead to these type of cellphone interactions having higher habitualness and increased strength in predicting frequency of cellphone use while driving. Results from this analysis may enhance the development of effective habit related countermeasures by providing insight into what cues drive habitual cellphone use while driving.

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Appendices Section

Appendix A. Countermeasures for Handheld Cellphone Related Distracted Driving

Appendix A is a more detailed reporting of the countermeasure summary provided in Section 2.3. It can either be read separately as a standalone appendix or read as a part of the main thesis.

Appendix A.1. Legislation and High Visibility Enforcement Campaigns

In order to combat cellphone related distracted driving, initiatives and countermeasures have been developed that include legislative bans and enforcement (GHSA, 2017), media campaigns (print and television; Philips et al., 2011), and technological constraints (e.g. driver mode; Reagan & Cicchino, 2018). Regarding legislative bans, as of 2015, 131 countries have prohibited handheld cellphone use while driving, whereas another 31 have prohibited both handheld use and hands-free use (WHO, 2015). In Canada, handheld cellphone use is currently prohibited in all 13 provinces/territories (see **Table 3**), while hands-free use is permitted. In the United States, 25 states and the District of Columbia (D.C.) have universal driver bans (i.e. applies to all age-groups/license types for most cellphone distractions) on handheld cellphone use while driving, 48 states and D.C. have full bans on texting while driving (i.e. any sort of message communication), and 38 states and D.C. restrict cellphone use by young drivers (Insurance Institute for Highway Safety, 2020).

Research regarding the effectiveness of legislative bans has been somewhat inconclusive, with some studies finding a positive effect of legislative bans (i.e. decreased use) and others finding no effect. Several studies from the United States have shown that states who enact state-legislation against handheld cellphone use experience a significant decline in the frequency of cellphone related distracted driving (McCartt et al., 2010; Braitman & McCartt, 2010). Braitman and McCartt (2010) found from a survey of 1219 American drivers that the percentage of drivers reporting that they "never" talked on the phone (44%) was higher in states will an all-driver ban (6 states plus D.C. at time of the survey) than for states without it (30% never talked on the phone in 41 states plus D.C.). This trend also applied to texting while driving, but was less pronounced (i.e. 88% for the 17 states with texting bans vs. 86% for the 32 states without). McCartt et al. (2010) conducted an observational survey study of driver cellphone use in states with all-driver bans and comparable control states without it. They collected multiple waves of data (3-5 waves) for each state over the course of five to nine years (2004 to 2009 for D.C. and its comparison states of Virginia and Maryland; 2001 to 2009 for New York and its comparison state, Connecticut). They found that for both D.C. and New York, there was an immediate 41% and 47% drop, respectively, in the frequency of drivers observed talking on their handheld cellphones after legislation was enacted. For D.C., Poisson regression models showed that five years after the ban, the predicted rate of cellphone use was 43% lower than what would have been expected given no law enactment. Similarly, New York models showed that 7 years after the ban, cellphone use was 24% lower than what would have been expected given no ban. However, it should be noted that in both DC and New York, the observed number of drivers talking on their cellphones increased in the follow up periods, however, this rate of growth was less than what was expected given pre-ban growth trajectories (i.e. what would have been expected, given that no law was enacted).

A more recent/broader analysis of the effect of all-driver/universal cellphone bans was conducted by Rudisill and Zhu (2017), who analyzed data from NOPUS during 2008-2013. Rudisill and Zhu (2017) found that states who enacted universal handheld bans had lower observed rates of drivers engaging in handheld cellphone conversations over the 2008-2013 time period. Specifically, states with handheld bans had an observed frequency of engagement of 2.6% (based on 79,678 observations), while states without handheld bans had an observed frequency of 6.2% (based on 183,995 observations). This discrepancy in frequency between states with and without legislation was found to be consistent across different demographic variables (age group, gender, sex, race) and driving contexts (intersection location i.e. rural or urban).

While state-legislation against handheld cellphone use was found to lower levels of cellphone related distracted driving in the previous studies, some studies which have specifically examined young drivers have found no effect of legislation (Goodwin et al., 2012). Goodwin et al. (2012) examined whether North Carolina’s youth cellphone ban (introduced in December 2006) reduced observed use rates for high school students two years after legislation was introduced. They found that North Carolina experienced a significant decrease in teenage cellphone use (i.e. talking on the phone and visibly manipulating it) from 2006 to 2008 (Prevalence in 2006 = 11%, Prevalence in 2008 = 9.7%), however, this decrease was not significantly different from the trend observed in their control state of South Carolina (Prevalence in 2006 = 14.5%, Prevalence in 2008 = 12.1%), where no law was enacted. Thus, at least for young drivers in North Carolina, the establishment of a law specifically banning cellphone use while driving did not have an effect on the frequency of cellphone use that was different from what was observed in a control state.

It may be that young drivers, and even a portion of older drivers (NHTSA, 2019b; Schroeder et al., 2018) simply ignore legislation. This potential disregard for legislation is most likely not attributable to drivers' ignorance of the risks of distracted driving – a number of studies have shown that drivers understand the risks of distracted driving (AAA Foundation for Traffic Safety, 2019; Schroeder et al., 2018; Berenbaum et al., 2015). AAA (2019) found that 51% and 79% of respondents indicated that talking on the phone and reading a text, respectively, were extremely dangerous activities. Instead, there may be other factors that influence drivers' willingness/intentions to engage in distracted driving; such as a perceived lack of enforcement. For example, a survey study by Berenbaum et al. (2015) found that a commonly stated reason for reading/sending text messages while driving was that "No police officers were in sight". Schroeder et al. (2018) found that 43% and 42% of respondents in states with some form of cellphone ban believed it was unlikely that a driver would be ticketed for frequently talking on a cellphone, or sending text messages, respectively. A similar result was found in AAA (2019). This lack of perceived enforcement seems to correspond with citations received, with only 3.6% of respondents indicating they have been pulled over or given a ticket for cellphone related distracted driving (Schroeder et a., 2018). Thus, one approach to potentially curb driver distraction has been to utilize high visibility enforcement (HVE) campaigns to increase the public's perception that they will get caught if they use a cellphone while driving.

To date, several reports from NHTSA have examined the impact of HVE campaigns on reducing the frequency of handheld cellphone related distracted driving. Overall, these reports indicate that HVE campaigns are an effective, but expensive, means of reducing cellphone use while driving. Cosgrove et al. (2011) found that HVE campaigns conducted in Hartford, CT and Syracuse, NY resulted in a 56% decrease in observed handheld cellphone calls for Hartford, CT (from 6.8% to 3.1%) and a 38% reduction in observed use for Syracuse (from 3.7% to 2.3%). A similar decrease was noted for handheld manipulations, with Hartford experiencing a 68% decrease (from 3.9% to 1.4%) and Syracuse experiencing a 42% decrease (from 2.8% to 1.6%). To make enforcement highly visible, both states: (1) adopted the slogan "Phone in one hand, ticket in the other", (2) provided media templates to state offices so that they could develop localized press releases and factsheets, (3) reached out to local news media to increase the number of articles being published about distracted driving and, (4) purchased media air time (television/cable, radio, online impressions on websites) to promote the HVE program and spread awareness. Not only did the HVE campaigns result in decreased handheld use, but it was found that HVE campaigns influenced the public opinion involving the perceived risk of getting caught. Respondents in Hartford, CN reported an increase in their perceptions of the likelihood of receiving a ticket compared to a control state.

Similar HVE campaigns have been conducted in more widespread, multi-jurisdictional areas, such as Sacramento, CA and Delaware (state-wide; Schick et al., 2014). At the time of the study, both states had legislation banning the use of handheld cellphones while driving. Each state conducted three waves of distracted driving HVE from Nov 2012 to June 2013 using a similar approach to Cosgrove et al. (2011), and it was found that the observed frequency of handheld cellphone use amongst drivers significantly declined in both California (from 4.1% at baseline to 2.7% post wave three) and Delaware (from 4.5% at baseline to 3.0% post wave three). Despite this, it should be noted that a decline was similarly observed in the control states for each state. Still, Delaware's decline was significantly greater than that observed in its control state, and further analysis was able to at least partially attribute California's decline to the HVE campaign.

Taken together, it appears that enacting a state-wide ban has some effect on reducing cellphone use while driving; however, this effect may not apply to all demographic groups, such as teenagers (see Goodwin et al. 2014). It may be that a lack of perceived enforcement in states banning distracted driving results in certain drivers disregarding the law; therefore, the use of HVE campaigns may be necessary to alter the public perceptions about the likelihood of getting caught. Still, even after enacting HVE campaigns, observed rates of handheld cellphone use may be as high as 1.4 to 3% (Cosgrove et al., 2011; Burger et al., 2014). Furthermore, HVE campaigns are associated with significant costs. Examples of costs include pay for law enforcement officers, the state highway safety office, media staff, consultants for development/production/distribution of advertising and educational materials, and paid media time. Thus, it is important to also consider other approaches or countermeasures that may help reduce cellphone related driver distraction. Examples of other countermeasures include technological countermeasures (reviewed in

Appendix A.2) and educational messages/social marketing campaigns (reviewed in **Appendix A.3**)

Appendix A.2. Technological Countermeasures

Over recent years, a number of technological countermeasures have made their way to market. Examples of these countermeasures include features such as "Driver / Do Not Disturb Modes" (henceforth referred to as driver mode) and hands-free alternatives to handheld cellphone use (e.g. vehicle voice recognition systems). These technological countermeasures have shown promise in reducing drivers' handheld cellphone use behind the wheel (Reagan & Cicchino, 2018; Schroeder et al., 2018), however, they each have their own set of limitations, which will be discussed in more detail below.

One promising technological countermeasure is driver mode, a smartphone/vehicle feature that works by limiting drivers' smartphone functionality while the vehicle is moving (i.e. driver mode blocks all incoming notifications/calls and locks a driver's phone out). Once driver mode has been set to automatically engage (a setting that can be activated in the device's settings), it will do so once the phone detects vehicle motion of a certain speed (determined via GPS data); alternatively, driver mode can become active after it is paired with a vehicle's wireless Bluetooth system. The benefits of driver mode are somewhat obvious; if drivers do not receive any notifications/calls from others, then they will be less likely to engage in cellphone related distracted driving. Further, most driver modes (e.g. Apple iPhone driver mode) can automatically send replies to people trying to reach the driver, letting them know the person they are trying to reach is driving. This is important, as drivers may feel social pressure to respond to others while driving (Atchley, Atwood & Boulton, 2011).

Two studies have examined the effect of driver mode on cellphone engagement while driving (Reagan & Cicchino, 2018; Creaser et al., 2015). Reagan and Cicchino (2018) conducted a self-report survey on the effectiveness of driver modes, whereas Creaser et al. (2015) conducted a field experiment examining a prototype cellphone blocker. Both studies found that driver mode/cellphone blocker technologies significantly reduced drivers' engagement in handheld cellphone distractions while driving; Creaser et al. (2015) found that cellphones with a prototype blocker reduced rates of phone calls/texts sent per mile driven, compared to a baseline condition with no blocker, while Reagan and Cicchino (2018) found lower self-reported frequency of handheld cellphone use for people who used driver mode as opposed to people who did not.

Despite their success in lowering handheld use, some concerns have been raised about the efficacy of driver mode technologies. One of the more practical limitations is that driver mode is a relatively new technology (e.g. Apple's driver mode was released on iOS11 in Fall 2017), and as such, not all drivers will own smartphones that are compatible with such technology. This concern may be short lived, however, as people will upgrade their phones over time, which will give them access to phones capable of utilizing this technology. A more pressing concern is drivers' actual use of such systems if they have access to it, and their willingness to use such technology (Reagan & Cicchino, 2018).

Reagan and Cicchino (2018) found that only 1 in 5 iPhone owners with a built-in driver mode feature had their driver mode feature set to automatically activate when they drove. A similar statistic was observed for drivers with smartphones that did not have built-in driver mode features; only 19% reported downloading any third-party blocking app, despite apps being available for download on the app market. Of those drivers who downloaded third-party driver modes, 49% indicated that they almost always used it within the past 30 days, but 35% indicated that they never used the feature within the same time frame. Thus, a lack of actual use of such a feature is a hurdle this technology faces; this lack of use persists despite a majority of drivers indicating that using driver mode was a good idea (55% of the respondents who had a smartphone without a built-in driver mode feature). A similar statistic was found in Schroeder et al. (2018), where 48% of drivers indicated they would be willing to use some sort of driver mode app to block incoming notifications/calls. Thus, it may not be that drivers are unwilling to use such a technology, but that there is a gap between drivers' intentions/willingness to use such a technology and their actual behavior. This is a phenomenon that has been noted in psychological research and has been termed the "intention-behavior" gap (Armitage & Conner, 2001). Some of the reasons drivers gave for not wanting to use driver mode in Reagan and Cicchino (2018) included: (1) Drivers felt they needed to access their phone while driving, (2) Drivers had concerns about missing important information, (3) Drivers had big brother concerns (i.e. thought the government was trying to control them). Some of these concerns may be alleviated with driver modes now being compatible with voice recognition technology (i.e. Apple Carplay paired with Siri); however, there still may be a number of cellphone features that are not compatible with voice recognition technology or Apple Carplay, such as tasks that are visual-manual in nature (e.g. scrolling through the Facebook newsfeed). Thus, drivers who engage in these tasks may be less willing to use features like driver mode.

A last concern with driver mode is that even when activated, drivers still have the ability to disengage the feature any time they desire. Thus, drivers may disengage the feature if they feel the need to access their phone while driving, or if they feel they are missing important information. Despite this, some positive findings have been noted by Reagan and Cicchino (2018), who found that very few drivers manually override the feature once it has been activated (Reagan & Cicchino, 2018).

Another widely available countermeasure that addresses handheld cellphone use are hands-free devices (e.g. Bluetooth headsets, vehicle voice recognition) and mirror functions, such as Apple Carplay, which present a stripped-down version of a connected device's interface on the vehicle's infotainment system (with some hands-free capability built in). Hands-free devices have been available for some time, with Bluetooth technology being available in select Chrysler vehicles since 2000 (Choi, 2014). More recently, vehicle manufactures have incorporated more advanced, natural language communication, voice recognition systems into their vehicles, with the aim of reducing both infotainment related distractions (e.g. GPS), as well as connected device distractions (e.g. phone calling). The popularity of hands-free devices has been noted in several studies, with Schroeder et al. (2018) finding that 51% of 3,168 respondents (who at least rarely initiated phone calls) prefer to use voice-dial to initiate phone calls while driving, compared to 29-45% who prefer some sort of manual interaction (e.g. speed dial, keypad entry). Voice recognition systems seem less popular for sending texts or emails, or using a smartphone app, with only 19% and 6.2% of 1,044 and 460 respondents (who at least rarely did these activities on handheld devise) preferring voice recognition systems, respectively. This lack of preference may be due to the limitations of speech-to-text systems, as well as the limitations of voice recognition systems in accessing most app features; however, improvements in voice-recognition technologies have been made recently, which may lead to greater adoptions of these technologies. Despite this, voice recognition technologies are likely to remain unpopular for some app usage, simply because a number of smartphone apps are visual-manual tasks in nature (e.g. viewing pictures or posts on social media apps).

When considering both technological countermeasures discussed above, it becomes apparent that neither offer a completely satisfactory answer to the issue of handheld cellphone use while driving. While driver mode has its benefits, such as completely locking out a driver's phone and sending automated responses, it is hampered by a lack of access to the technology, and more importantly, a lack of actual use once available. This lack of actual use persists, despite the fact that drivers have indicated they are willing to use such a technology (Schroeder et al., 2018). On the other hand, hands-free technologies appear to be a better alternative to handheld use. However, drivers appear to only prefer this type of technology for certain cellphone interactions (e.g. initiating a call; Schroeder et al., 2018). Further, certain kinds of cellphone interactions (e.g. viewing posts) are incompatible with hands-free technologies and even voice control can be distracting and lead to vehicle crashes (Simmons, Caird, & Steel, 2017). Thus, hands-free technologies are unlikely to be an effective countermeasure for all types of cellphone interactions. These insights indicate that while useful, technological countermeasures have significant limitations. As such, it is important to examine the psycho-social factors that lead to drivers' engagement in handheld cellphone use behind the wheel. Only then can effective technological countermeasures be designed that specifically target these psycho-social factors. Psycho-social factors that predict drivers' handheld cellphone use are presented in Section 2.4.

Appendix A.3. Educational messages and safety/social marketing campaigns

A popular approach to changing the public opinion on an issue has been the use of educational messages and safety/social marketing campaigns. Educational messages are publicized messages that encourage people to refrain from performing an unwanted societal behavior (e.g. cellphone related distracted driving), while safety/social marketing campaigns are more elaborate behavior change campaigns that usually involve multiple components (e.g. public speaking events). The logic behind these approaches to behavior change is that organizations (governmental or non-governmental) can decrease the prevalence of an unwanted societal behavior by changing the public opinion on a matter (e.g. through challenging their beliefs about a behavior). Educational messages and safety/social marketing campaigns have been used and have been found to have some success in changing a variety of negative societal behaviors relating to transportation, such as drinking and driving (Tay, 1999; Benson, McLaughlin, & Giles, 2015) and seat belt use (King, Vidourek, Love, Wegley, & Alles-White, 2008). Overall, educational messages and road safety campaigns have been found to be effective in reducing the number of motor vehicle collisions (see Phillips et al. (2011) meta-analysis), with campaigns that emphasized personal communication (e.g. seminars delivered in person, two-way discussions with a teacher or safety expert) and roadside media (e.g. educational messages on billboards) being particularly effective.

In regard to distracted driving, over the past decade, a number of educational messages and road safety/social marketing campaigns have been developed/launched that specifically discourage handheld cellphone use while driving. For example, educational messages, such as "It Can Wait" and "U Drive. U Text. U Pay", have been published on billboards and announced via public service announcements on radio and T.V. (Schroeder et al., 2018). The message "It Can Wait" is part of a broader road safety campaign by AT&T, the "It Can Wait" campaign, which focuses on discouraging American drivers from using handheld cellphones while driving (AT&T, 2020). This campaign includes several components, such as school visits by safety professional and visits from those personally affected by distracted driving related crashes. Further, the "It Can Wait" campaign encourages American drivers to sign the AT&T Distracted Driving Pledge (see the pledge below), which has to date amassed over 40 million pledges (AT&T, 2020).

- *"I pledge to always drive distraction free. No exceptions. I pledge to never allow my phone to endanger myself or others behind the wheel. I pledge to be an advocate for the cause. To lead by example and spread the message. I pledge because I believe driving distraction free can save lives and make the world a better place."*

From the evidence, it is clear that drivers are hearing these messages. Schroeder et al. (2018) found that 71% of 6,001 survey respondents in 2015 had been exposed to some sort of message discouraging handheld device use within the past 30 days. In fact, the "It Can Wait" slogan was one of the most commonly heard educational messages, with more than half of respondents (51%) having heard the message within the past 30 days. In Canada, educational messages are similarly reaching drivers, with a study by Berebaum et al. (2015) finding that 71% of young drivers (Aged 18 to 24) had seen or heard a message discouraging texting while driving.

While it is easy to establish that people are hearing these messages, it is harder to ascertain whether these messages and road safety/social marketing campaigns have an effect on distracted driving related collision statistics - the meta-analysis cited earlier by Phillips et al. (2011) did not specifically examine any road safety campaigns targeting distracted driving. Further, the author of this thesis could not find any studies which specifically examined the effect of educational messages or road safety/social marketing campaigns on the prevalence of handheld cellphone use or cellphone related distracted driving collisions/fatalities. Still, it is unlikely that educational messages and road safety/social marketing campaigns have no effect on driver cellphone use. Given that educational messages and safety campaigns have been effective in reducing other unwanted transportation behaviors (e.g. drunk driving; Tay, 1999; Benson, McLaughlin, & Giles, 2015), it is probable that messages and campaigns related to distracted driving have some effect. For instance, a number of recent studies have indicated that drivers are aware of the risks of handheld related distracted driving (Schroeder et al., 2018, AAA, 2020). Further, studies have found that drivers generally possess unfavorable attitudes towards cellphone use while driving and believe that others would disapprove of them engaging in such behaviors (e.g. Walsh et al., 2008). Negative attitudes and perceived social disapproval have, in turn, been found to predict lower intentions to use cellphones while driving (e.g. Walsh et al., 2008), as well as lower self-reported frequency of use (e.g. Bayer & Campbell, 2012). While negative attitudes/perceived social norms could be due to factors other than educational messages/social marketing campaigns (e.g. legislation against cellphone related distracted driving), it is likely that these factors play some role in shaping how drivers regard the behavior.

In order to make educational messages and road safety / social marketing campaigns more effective, their development should be guided by scientific theory; else, these types of countermeasures may be ineffective. For example, messages such as “U Drive. U Text. U Pay”, may be ineffective, since drivers believe the risks of getting caught are low (e.g. Schroeder et al., 2018); further, measures of apprehension risk have not been found to be a consistent predictor of intentions to use a handheld cellphone across different driving scenarios (Przepiorka et al., 2018; Walsh et al., 2008). Webb, Joseph, Yardley and Michie (2010) examined the effectiveness of three different types of social cognitive theories (Social Cognitive Theory, The Transtheoretical Model, and TPB) in guiding intervention (e.g. educational messages) developments; they found that interventions guided by theory were more effective in changing health behavior than non-theory based interventions. Further, they found that interventions guided by TPB had the greatest effect in inducing health behavior changes. Taken together, it is important that educational messages and road safety / social marketing campaigns are guided by theory. For cellphone related distracted driving, this may involve examining what psycho-social factors predict drivers' cellphone use behind the wheel – message and campaigns can then be developed to target these constructs, with the hopes that relevant psycho-social factors can be influenced enough to result in a change of behavior.

Appendix B. Regression results from 12 studies applying TPB to drivers' handheld cellphone use.

Study	R^2_I	R^2_F	Standardized Regression / Path Coefficients				
			Attitude	SN	PBC	DN	Habits
1. Walsh et al. (2008)							
General Cellphone Use	0.32		0.49*	0.13*	0.08		
Talking on the phone							
Speed 100 Km/Hr & Late	0.39	0.39	0.52*	0.15*	0.06		
Speed 100 Km/Hr & No Hurry	0.39	0.39	0.56*	0.11	0.13*		
Traffic Lights & Late	0.42	0.42	0.47*	0.20*	0.10*		
Traffic Lights & No Hurry	0.38	0.38	0.49*	0.14	0.12*		
Texting on a Cellphone							
Speed 100 Km/Hr & Late	0.14	0.15	0.32*	0.13	-0.04		
Speed 100 Km/Hr & No Hurry	0.14	0.16	0.42*	0.03	-0.02		
Traffic Lights & Late	0.11	0.13	0.32*	0.06	0		
Traffic Lights & No Hurry	0.13	0.14	0.42*	-.05	0.03		
2. Zhou et al. (2009)							
Answer a Phone Call	0.44		0.18*	0.23*	0.41*		
3. Nemme & White (2010)							
Sending Texts	0.28	0.35	0.36*	0.14*	0.15*		
Reading Texts	0.29	0.33	0.31*	0.1	0.08		
4. Rozario et al. (2010)							
General Cellphone Use							
Driving Alone & Late	0.39	0.39	0.29*	0.04	0.49*		
Driving with Friends & No Hurry	0.34	0.34	0.27*	0.37*	0.26*		
Driving Alone & Late	0.35	0.36	0.42*	0.06	0.39*		
Driving with Friends & No Hurry	0.35	0.35	0.31*	0.37*	0.28*		
5. Bayer & Campbell (2012)							
Sending Texts		0.24	0.07	0.41*	0.02		0.25*
Reading Texts		0.18	0.03	0.39*	0.01		0.19*
6. Waddel & Wiener (2014)							
Initiate (Texts and Calls)	0.47	0.51	0.16*	0.26*	0.31*	0.26*	
Respond (Texts and Calls)	0.47	0.49	0.17*	0.18*	0.38*	0.20*	
7. Chen et al. (2016)							
General Distractions		0.41	0.40*	-0.01	0.20*	0.17*	
8. Chen & Donmez (2016)							
Technological Distractions*		0.90	0.98*	-0.18		0.13*	
Under 30 Years Old*		0.81	0.94*	-0.21*		0.13	
Over 30 Years Old*		0.93	0.92*	0.07		0.10	
9. Bazargan-Hejazi et al. (2017)							
Sending Texts	0.36	0.39	0.32*	0.26*	0.21*		

Reading Texts	0.48	0.49	0.22*	0.24*	0.51*		
10. Gauld et al. (2017)							
Initiating SIT	0.67	0.73	0.36*	0.16*	0.19*		
Monitoring/Reading SIT	0.56	0.74	0.12	0.14*	0.27*		
Responding to SIT	0.65	0.73	0.23*	0.25*	0.25*		
11. Przepiorka et al. (2018)							
General Cellphone Use	0.41		0.58*	0.06	0.11		
Talking on the phone							
Speed 100 Km/Hr & Late	0.22	0.24	0.42*	0.12	0.05		
Speed 100 Km/Hr & No Hurry	0.24	0.24	0.49*	-0.02	0.07		
Traffic Lights & Late	0.36	0.36	0.60*	-0.06	0.12*		
Traffic Lights & No Hurry	0.31	0.33	0.42*	0.15*	0.11*		
Texting on a Cellphone							
Speed 100 Km/Hr & Late	0.25	0.27	0.48*	0.1	-0.08		
Speed 100 Km/Hr & No Hurry	0.27	0.29	0.56*	-0.04	0		
Traffic Lights & Late	0.46	0.47	0.65*	0	0.11*		
Traffic Lights & No Hurry	0.34	0.37	0.53*	0.03	0.11*		
12. Gauld et al. (2020)							
Monitoring/Reading SIT	0.77	0.79	0.26*	0.03	0.62* -0.09*		0.09*

*All studies, except for [8] used hierarchical linear regression; [8] used structural equation modelling. R^2_I is the R^2 value for the original TPB model (attitude, subjective norms [SN] and perceived behavioral control [PBC]). R^2_F is for an expanded TPB model (e.g. descriptive norms [DN]). All standardized estimates reported in the table are for the final model reported. Standardized estimates marked by * indicate the estimate was significant at least at $p < 0.05$. See 2nd half of the table below for other predictors included in the models. Not all variables are reported in these tables - variables have been omitted from Gauld et al. (2017) and Gauld et al. (2020) (e.g. cognitive capture, anticipated action regret, etc).*

The dependent variables in the above models were either: intentions to engage in a cellphone distraction [1,2,3,9,10,11,12], behavioral willingness [4,6], or self-reported engagement [5,7,8]. [3,12] had prospective designs, where measures of prospective behavior were taken; regressions of prospective behavior are not reported in the table.

Note: [5] used a composite measure of norms which reported under the subjective norm column. [8] used a measure of attitude that included perceived control– it is reported under the attitude column. R^2_I and R^2_F estimates took different control variables into consideration – control variables differed depending on study.

Study	Standardized Regression / Path Coefficients (continued)				
	Moral Norms	Group Norms	Crash Risk	Apprehension Risk	Personality
1. Walsh et al. (2008)					
General Cellphone Use			NA	NA	
Talking on the phone					
Speed 100 Km/Hr & Late			-0.08	0.06	
Speed 100 Km/Hr & No Hurry			-0.07	0.06	
Traffic Lights & Late			-0.05	0.04	
Traffic Lights & No Hurry			-0.04	0	
Texting on a Cellphone					
Speed 100 Km/Hr & Late			-0.02	0.13	
Speed 100 Km/Hr & No Hurry			-0.02	0.16*	
Traffic Lights & Late			-0.03	0.17*	
Traffic Lights & No Hurry			0.04	0.09	
3. Nemme and White (2010)					
Sending Texts	-0.16*	0.25*			
Reading Texts	-0.23	0.13			
4. Rozario et al. (2010)					
General Cellphone Use					
Driving Alone & Late					-0.01 / 0.004
Driving with Friends & No Hurry					-0.004 / -0.01
Driving Alone & Late					0.02 / 0.01
Driving with Friends & No Hurry					0.01 / 0.002
8. Chen and Donmez (2016)					
Technological Distractions*					0.16*
Under 30 Years Old*					0.13
Over 30 Years Old*					0.18*
9. Bazargan-Hejazi et al. (2017)					
Sending Texts	-0.11	0.15*			
Reading Texts	-0.02	0.1			
10. Gauld et al. (2017)					
Initiating SIT	-0.24*				
Monitoring/Reading SIT	-0.28*				
Responding to SIT	-0.07				
11. Przepiorka et al. (2018)					
General Cellphone Use					
Talking on the phone			NA	NA	
Speed 100 Km/Hr & Late			-0.14*	-0.03	
Speed 100 Km/Hr & No Hurry			0	-0.03	
Traffic Lights & Late			-0.03	-0.01	
Traffic Lights & No Hurry			-0.20*	0.1	
Texting on a Cellphone					
Speed 100 Km/Hr & Late			-0.1	-0.06	
Speed 100 Km/Hr & No Hurry			-0.13	-0.03	
Traffic Lights & Late			-0.05	-0.02	
Traffic Lights & No Hurry			-0.14*	-0.05	

Split values in the personality column for [4] are for neuroticism and extroversion, respectively.

Appendix C. Consent Forms

Appendix C.1. Preliminary Survey Consent Form

<u>Title</u>

Driver Smartphone Use.

<u>Investigators</u>

Braden Joseph Hansma (bhansma@mie.utoronto.ca)
Dr. Birsen Donmez

<u>Purpose</u>

This survey is part of a larger ongoing research project at the University of Toronto that is examining why drivers engage in smartphone related distracted driving.

<u>Benefits & Risks</u>

By participating in this study, you will contribute to research in traffic safety.

There are no inherent risks associated with the current study. You will be asked to provide information on your smartphone use (including while driving), however, there will be no legal repercussions for answering these questions honestly.

<u>Procedure</u>

In the following questionnaire, you will be asked to provide information about your smartphone use (in general and while driving) as well as your opinion on using voice recognition systems. The questionnaire will take approximately 3 minutes to complete.

<u>Confidentiality</u>

No personally identifiable information will be collected from you in this study. All information obtained during the study will be held in strict confidence and stored on secure University of Toronto servers. Only researchers from the Human Factors and Applied Statistics Laboratory will have access to your data, and no data from this survey will be shared with outside parties.

<u>Participation</u>

Your participation in this study is voluntary and you can choose to withdraw at any time. If you would like to withdraw during the questionnaire, simply exit the web browser. Your participation in the study will be considered terminated once the questionnaire is complete. If you have any comments or concerns about the current study, please contact the University of Toronto's Research Oversight and Compliance Office - Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Compensation

You will receive $0.40 CAD for your successful completion of the online questionnaire.

Appendix C.2. Proposed Survey Consent Form

Title

Driver Smartphone Use.

Investigators

Braden Joseph Hansma (bhansma@mie.utoronto.ca)
Dr. Birsen Donmez

Purpose

This study is a part of ongoing research at the University of Toronto, Human Factors and Applied Statistics Laboratory, which is examining why drivers engage in smartphone related distracted driving.

Benefits & Risks

By participating in this study, you will contribute to research in traffic safety. For example, information obtained from this study will be analyzed and published in an academic journal, with the intent being that the results will influence countermeasure development aimed at reducing smartphone related distracted driving.

There are no inherent risks associated with the current study. You will be asked to provide information on your smartphone use while driving, however, there will be no legal repercussions for answering these questions honestly.

Procedure

In the following questionnaire, you will be asked to provide demographic information, details about your driving behavior, information about your smartphone use while driving, and details about your smartphone use in general. The questionnaire will take approximately 30-35 minutes to complete.

One month after the completion of the questionnaire, you will be invited to complete a brief follow-up questionnaire that asks questions about your driving frequency and smartphone use while driving over the previous month. This follow-up questionnaire will be posted as a HIT on

Mechanical Turk; only workers who completed the current questionnaire will be able to view the follow-up HIT and receive an e-mail reminder to complete it. The follow-up questionnaire will take approximately four minutes to complete. We encourage you to complete this follow up questionnaire, as it is an essential component of our research question.

Confidentiality

All information obtained during the study will be held in strict confidence. Your personal information (MTurk worker ID, date of birth, etc) and questionnaire responses will be temporarily stored on Survey Gizmo's secure servers, after which, they will be uploaded to a secured University of Toronto server and removed from Survey Gizmo. Only researchers from the Human Factors and Applied Statistics Laboratory will have access to your data. Once the analysis is complete, the data will be de-identified (i.e. your MTurk worker ID). No personally identifiable information will be used in any publication or presentation and no information identifying you will be transferred to outside parties.

Participation

Your participation in this study is voluntary and you can choose to withdraw at any time. If you would like to withdraw during the first questionnaire, simply exit the web browser. If you would like to withdraw between the initial questionnaire and the follow-up questionnaire, please e-mail the primary investigator to stop receiving reminder e-mails. Your participation in the study will be considered terminated once the follow-up questionnaire is complete. If you have any comments or concerns about the current study, please contact the University of Toronto's Research Oversight and Compliance Office - Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Compensation

You will receive $5.00 USD for your successful completion of the online questionnaire. You will receive an additional $2.00 USD for your completion of the brief follow-up questionnaire given approximately one month later. Warning: Answers to this survey will be screened and compensation may be withheld if it is determined that you are not taking the survey seriously.

Appendix D. Preliminary Survey

1) Do you consent to take the following survey?

( ) Yes

( ) No

2) Do you currently have a valid government issued driver's license?

( ) Yes

( ) No

3) Do you currently own a smartphone?

( ) Yes

( ) No

4) How frequently have you driven over the past year?

( ) A few days a year

( ) A few days a month

( ) A few days a week

( ) Almost every day

5) What country do you currently reside in?

( ) Canada

( ) United States

( ) Other

6) What province do you currently reside in?

( ) Alberta

( ) British Columbia

( ) Manitoba

( ) New Brunswick

( ) Newfoundland and Labrador

( ) North West Territory

( ) Nova Scotia

( ) Nunavut

( ) Ontario

( ) Prince Edward Island

( ) Quebec

( ) Saskatchewan

( ) Yukon

7) Please indicate the functions/activities that you have ever performed on your smartphone:

[ ] answer an incoming phone call (e.g. Phone, Facebook Audio, etc)

[ ] initiate a phone call (e.g. Phone, Facebook Audio, etc)

[ ] read a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] read an email

[ ] send an email

[ ] scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)

[ ] update/make a post on a social media app (e.g. Twitter, Facebook, Instagram, etc)

[ ] browse a website / use a search engine (e.g. Safari, Google Chrome, etc)

[ ] check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)

[ ] watch an online video (e.g. Youtube, etc)

[ ] search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)

By manually engage, we mean actively using your handheld smartphone device, rather than using the infotainment system to manually perform these tasks.

A typical drive is your most frequent drive. E.g. If you commute to work daily, then this is most likely your typical drive.

8) During a *typical drive* over the past year, how often did you manually (i.e. not using a voice recognition system) engage in each of the following smartphone activities?

Cellphone Distractions	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very Often**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
send an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
update/make a post on a social media app (e.g. Twitter, Facebook, Instagram, etc)					

browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
watch an online video (e.g. Youtube, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

9) During a *typical drive* over the past year, how many times did you manually (i.e. not using a voice recognition system) engage in each of the following smartphone activities?

Cellphone Distractions	**0 times**	**1 time**	**2 times**	**3 times**	**4+ times**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
send an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
update/make a post on a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					

watch an online video (e.g. Youtube, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

10) When driving, how much do you prefer using a voice recognition system (e.g. Apple Carplay), rather than visually/manually performing these activites on a handheld smartphone? *

	1 (Never prefer voice rec.)	**2**	**3 (Sometimes prefer voice rec.)**	**4**	**5 (Always prefer voice rec.)**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)	( )	( )	( )	( )	( )
initiate a phone call (e.g. Phone, Facebook Audio, etc)	( )	( )	( )	( )	( )
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)	( )	( )	( )	( )	( )
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)	( )	( )	( )	( )	( )
read an email	( )	( )	( )	( )	( )
send an email	( )	( )	( )	( )	( )
use a search engine (e.g. Safari, Google Chrome, etc)	( )	( )	( )	( )	( )
check for any sort of notification (e.g. missed texts/calls, social media updates, etc)	( )	( )	( )	( )	( )
search for a certain song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)	( )	( )	( )	( )	( )

11) Do you have any comments/concerns regarding the survey (i.e. did you find the question prompts to be clear and the cellphone distractions to be relevant)? ***If you do not have any comments, please respond with NA***. *

____

____

____

____

Thank You!

Thank you for taking our survey. Your response is very important to us.

Appendix E: Proposed Survey Time-1

Note: This survey contains figures and matrix questions and is not optimized for mobile devices (including phones and tablets). It is highly recommended that you complete this survey on a desktop.

Appendix E.1. Disqualification Section

1) Do you consent to participate in this study?

( ) Yes

( ) No

2) Do you currently have a valid government issued driver's license?

( ) Yes

( ) No

3) Do you currently own a smartphone?

( ) Yes

( ) No

4) In general, everyday use (i.e. not just while driving), please indicate the functions/activities that you have ever performed on your smartphone:

[ ] answer an incoming phone call (e.g. Phone, Facebook Audio, etc)

[ ] initiate a phone call (e.g. Phone, Facebook Audio, etc)

[ ] read a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] read an email

[ ] scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)

[ ] browse a website / use a search engine (e.g. Safari, Google Chrome, etc)

[ ] check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)

[ ] search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)

5) Out of the nine possible smartphone functions you could have selected above, how many did you select?

0 ________________________[_to_]_____________________________ 9

6) How often do you drive a motor vehicle (excluding motorcycles)?

( ) Almost every day

( ) A few days a week

( ) A few days a month

( ) A few days a year

Appendix E.2. Demographic Section

Note: The following section will collect demographic information and information relating to your driving behavior.

7) What is your MTurk worker ID? *Please ensure you entered your worker ID correctly*

____

8) What is your sex?

( ) Male

( ) Female

( ) Other

9) What is the date of your birth? (MM/DD/YYYY)

____

10) What country do you currently reside in?

( ) Canada

( ) United States

( ) Other

11) What province/state do you currently reside?

( ) Alberta

( ) British Columbia

( ) Manitoba

( ) New Brunswick

( ) Newfoundland and Labrador

( ) North West Territory

( ) Nova Scotia

( ) Nunavut

( ) Ontario

( ) Prince Edward Island

( ) Quebec

( ) Saskatchewan

( ) Yukon

12) Which driver licenses do you currently hold?

[ ] Full License (e.g. G License for Ontario, CA)

[ ] Learner's License (e.g. G1 and G2 licenses in Ontario, CA)

[ ] Motorcycle License (e.g. M, M1, M2 in Ontario, CA)

[ ] Professional License (e.g. A - F in Ontario, CA. For buses, tractor-trailers, ambulances, etc)

13) When did you first obtain your full driver’s license (e.g. G License for Ontario; MM/DD/YYYY)? *If you are unable to remember this information, please try to provide as close of an estimate as possible.*

____

14) Do you drive for a profession (e.g. Uber, Lyft, Taxi, Limousine)?

( ) Yes

( ) No

15) Approximately how many hours a week do you drive for your profession?

( ) 1 - 10 hours

( ) 11 - 20 hours

( ) 21 - 30 hours

( ) 31 - 40 hours

( ) 40 - 50 hours

( ) 50 - 60 hours

( ) 60+ hours

16) How many kilometers do you drive in a typical week?

( ) Under 100 km (< 5,200 km a year)

( ) Between 101 km and 300 km (5,250 km to 15,600 km a year)

( ) Between 301 km and 500 km (15,650 km to 26,000 km a year)

( ) Between 501 km to 700 km (26,0520 km to 36,400 km a year)

( ) Between 701 km and 900 km (36,450 km to 46,800 km a year)

( ) Over 901 km (46,850 km + a year)

( ) Not sure

Driving Environment

A 4-lane highway where local lanes are divided by a ditch or barrier, traffic conditions are low and there is good weather

17) Within the past month, what percentage of your driving time was spent driving on highways outside of the city, similar to the image above?

( ) Never

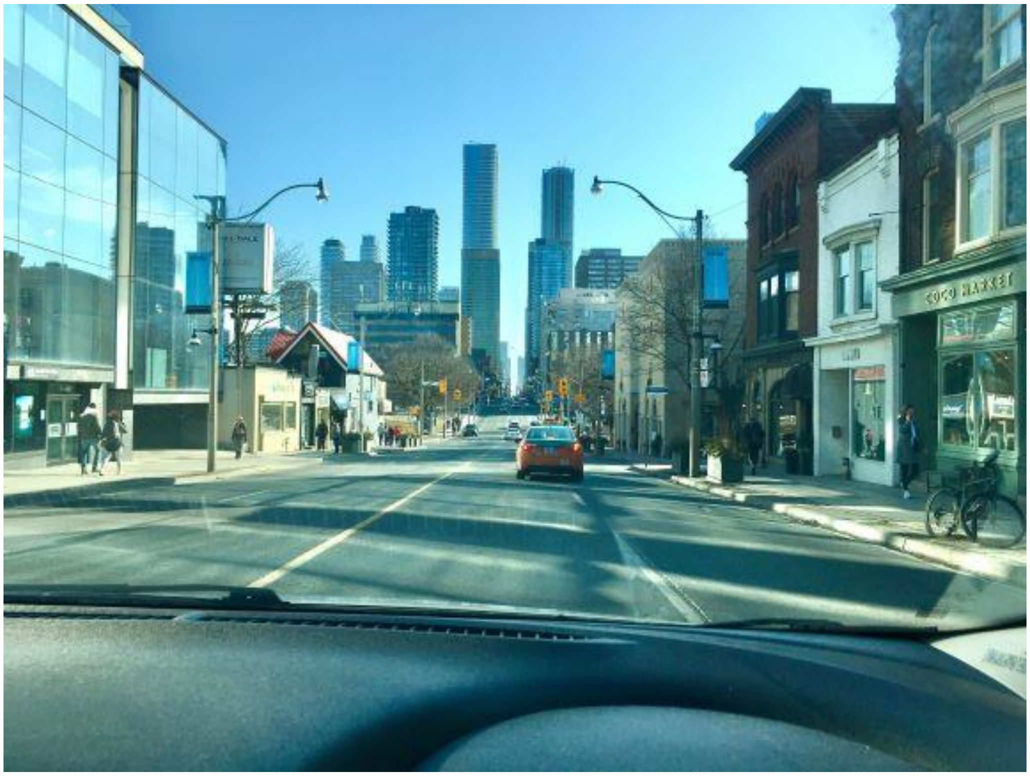
( ) 1-20%

( ) 21-40%

( ) 41-60%

( ) 61-80%

( ) 81-100%



Driving Environment

A two or three-lane urban road with moderate traffic, medium pedestrian flow, and traffic lights.

18) Within the past month, what percentage of your driving time was spent driving within the city, similar to the image above?

( ) Never

( ) 1-20%

( ) 21-40%

( ) 41-60%

( ) 61-80%

( ) 81-100%

19) Which of these driving environments are most stressful to drive in?

Throughout your life, you have probably driven in many different types of driving environments. Driving researchers have observed that some people may answer questions as quick as possible without carefully reading the material. Please select the driving environment, "Rural highway during mid-day", even if this is not true (last item in the list). This will verify that you are carefully reading this item.

( ) Congested, urban downtown core

( ) Congested city freeway

( ) Moderately congested highway (e.g. 401)

( ) City freeway during mid-day

( ) Suburban arterial road in low-light conditions

( ) Rural highway with icy/snowy conditions

( ) City freeway in rainy conditions

( ) Urban downtown core in snowy conditions

( ) Suburban arterial road in foggy conditions

( ) Rural highway with late-afternoon glare

( ) Rural highway during mid-day

20) On a scale of 1 to 10, with 1 being very inexperienced and 10 being very experienced, how would you rate your level of experience with technology (e.g., cellphones, automatic teller machines, digital cameras, computers, etc.)?

1 ________________________[_to_]_____________________________ 10

21) Some people prefer to avoid new technologies as long as possible while others like to try them out as soon as they become available. In general, how would you rate yourself as being an avoider or an early adopter of new technology?

1 ________________________[_to_]_____________________________ 10

22) Does your current vehicle have voice recognition technology (e.g. Apple Carplay, Android Auto, Speech-To-Text, etc)?

( ) Yes

( ) No

23) When driving, how much do you prefer using a voice recognition system (e.g. Apple Carplay), rather than visually/manually performing these activities on a handheld smartphone?

	I never engage in this distraction	**1 (Always prefer handheld use)**	**2**	**3 (Use both equally)**	**4**	**5 (Always prefer voice rec.)**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)	( )	( )	( )	( )	( )	( )
initiate a phone call (e.g. Phone, Facebook Audio, etc)	( )	( )	( )	( )	( )	( )
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)	( )	( )	( )	( )	( )	( )
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)	( )	( )	( )	( )	( )	( )
read an email	( )	( )	( )	( )	( )	( )
use a search engine	( )	( )	( )	( )	( )	( )
check for any sort of notification (e.g. missed texts/calls, social media updates, etc)	( )	( )	( )	( )	( )	( )
search for a certain song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)	( )	( )	( )	( )	( )	( )

Appendix E.3. Theory of Planned Behavior Questionnaire (revision of the SDDQ)

Instructions

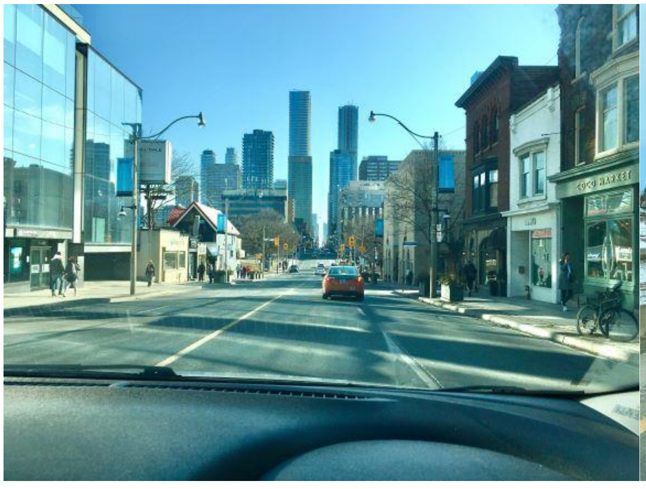
In the following sections, you will be asked to answer questions within the context of the driving scenario depicted below; this scenario will not change for the rest of the questionnaire. When encountering these questions, please visualize the driving scenario before answering each question; you may use your prior experience driving in similar scenarios to inform your answers. It is important that you read each question carefully and answer honestly. Some of the questions may appear to be similar, but they do address somewhat different issues.

Note

Please be aware that some questions at the end of the survey do not require you to use the driving scenario. These questions will be accompanied by instructional text, and they will not have an image of the driving scenario accompanying them.

When answering questions about smart phone distractions, please note that we are inquiring about your manual use of the hand-held device. This does not include performing the distraction using your vehicles infotainment system or using your phone's/vehicle's voice recognition system.

Participant will see one of the driving contexts below, which will reappear at the top of most page for the rest of the survey.



Scenario
Imagine yourself driving along on a two or three- lane urban road with moderate traffic, medium pedestrian flow, and traffic lights. The photo above illustrates the type of environment that you should consider when answering the following questions.

Scenario
Imagine yourself driving on a 4-lane highway where local lanes are divided by a ditch or barrier, traffic conditions are low and there is good weather. The photo above illustrates the type of environment that you should consider when answering the following questions.

24) Over the past year, how often did you manually (i.e. not using voice recognition) engage in each of these tasks during a **typical drive** in an environment similar to the image above?

Cellphone Distractions	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very Often**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

24) While driving in a similar scenario in the next month, **manually answering an incoming phone call** on a smartphone is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
please select agree	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

25) While driving in a similar scenario in the next month, **manually answering an incoming phone call on a smartphone** is something that is…

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

26) While driving in a similar scenario in the next month, **manually initiating a phone call (e.g. Phone, Facebook Audio, etc)** on a smartphone is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

27) While driving in a similar scenario in the next month, **manually initiating a phone call (e.g. Phone, Facebook Audio, etc)** on a smartphone is something that is...

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

28) While driving in a similar scenario in the next month, **reading a message (e.g. SMS, WhatsApp, direct message on social media, etc)** on a smartphone is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

29) While driving in a similar scenario in the next month, **reading a message (e.g. SMS, WhatsApp, direct message on social media, etc)** on a smartphone is something that is...

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

30) While driving in a similar scenario in the next month, **manually entering/sending a message (e.g. SMS, WhatsApp, direct message on social media, etc)** on a smartphone is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
please select strongly disagree	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

31) While driving in a similar scenario in the next month, **manually entering/sending a message (e.g. SMS, WhatsApp, direct message on social media, etc)** on a smartphone is something that is...

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

32) While driving in a similar scenario in the next month, **reading an email** on a smartphone is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

33) While driving in a similar scenario in the next month, **reading an email** on a smartphone is something that is...

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

34) While driving in a similar scenario in the next month, **scrolling through the newsfeed of a social media app using a smartphone (e.g. Twitter, Facebook, Instagram, etc) is** something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
please select strongly agree	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

35) While driving in a similar scenario in the next month, **scrolling through the newsfeed of a social media app using a smartphone (e.g. Twitter, Facebook, Instagram, etc)** is something that is...

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

36) While driving in a similar scenario in the next month**, manually browsing a website / using a search engine (e.g. Safari, Google Chrome, etc)** on a smartphone is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

37) While driving in a similar scenario in the next month, **manually browsing a website / using a search engine (e.g. Safari, Google Chrome, etc)** on a smartphone is something that is...

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

38) While driving in a similar scenario in the next month, **checking the home screen of a smartphone for any sort of notification (e.g. missed texts/calls, social media updates. etc)** is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

39) While driving in a similar scenario in the next month, **checking the home screen of a smartphone for any sort of notification (e.g. missed texts/calls, social media updates, etc)** is something that is...

	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

40) While driving in a similar scenario in the next month, **searching for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)** on a smartphone is something...

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
I intend to do	( )	( )	( )	( )	( )
that would not be difficult for me to do	( )	( )	( )	( )	( )
that circumstances (e.g. the driving environment, personal/work reasons, etc) would determine	( )	( )	( )	( )	( )
that most people who are important to me would do	( )	( )	( )	( )	( )
I intend to avoid doing	( )	( )	( )	( )	( )
that people who are important to me would approve of	( )	( )	( )	( )	( )
I would have control over	( )	( )	( )	( )	( )
most of the people I respect would do	( )	( )	( )	( )	( )
I will likely do	( )	( )	( )	( )	( )
I would feel guilty doing	( )	( )	( )	( )	( )
please select neither agree/disagree	( )	( )	( )	( )	( )
that people that I respect wouldn't mind	( )	( )	( )	( )	( )
I am confident I could do well	( )	( )	( )	( )	( )
I intend not to do	( )	( )	( )	( )	( )
that would be wrong to do	( )	( )	( )	( )	( )

41) While driving in a similar scenario in the next month, **searching for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)** on a smartphone is something that is...

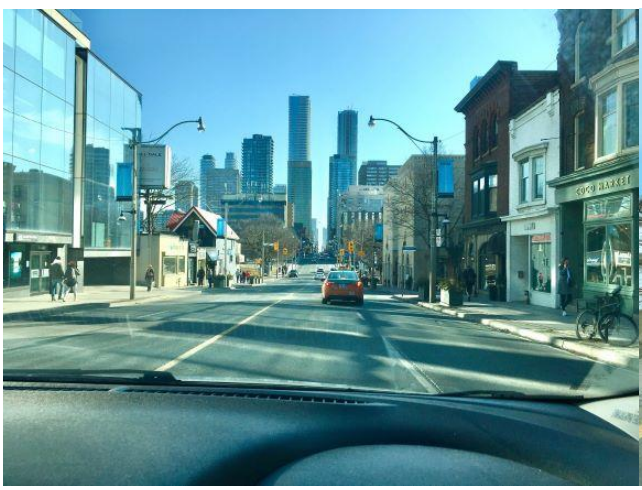
	1	**2**	**3**	**4**	**5**
Bad (1) - Good (5)	( )	( )	( )	( )	( )
Unsafe (1) - Safe (5)	( )	( )	( )	( )	( )
Not Enjoyable (1) - Enjoyable (5)	( )	( )	( )	( )	( )
Not Worthwhile (1) - Worthwhile (5)	( )	( )	( )	( )	( )

Appendix E.4. Habit Questionnaire

Instructions

- The following sections of the survey will ask questions about your smartphone habits inside and outside the vehicle.
- First, you will see questions about your smartphone habits inside the vehicle. These questions will be accompanied by the image/driving scenario presented to you earlier.
- At the end of the questionnaire, you will answer questions about your smartphone habits outside of the vehicle. These questions will not have an accompanying image/driving scenario.

Participant will see the driving context they were assigned to at the beginning of the TPB questionnaire.



Scenario
Imagine yourself driving along on a two or three- lane urban road with moderate traffic, medium pedestrian flow, and traffic lights. The photo above illustrates the type of environment that you should consider when answering the following questions.

Scenario
Imagine yourself driving on a 4-lane highway where local lanes are divided by a ditch or barrier, traffic conditions are low and there is good weather. The photo above illustrates the type of environment that you should consider when answering the following questions.

42) While driving in similar scenarios, engaging in the following tasks is something **I do without thinking.**

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

43) While driving in similar scenarios, engaging in the following tasks is something **I do automatically**.

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

44) While driving in similar scenarios, engaging in the following tasks is **something I start doing before I realize I'm doing it**.

Cellphone Distractions	Strongly Disagree	Disagree	Neither Agree/ Disagree	Agree	Strongly Agree
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					
select neither agree nor disagree					

<u>Instructions</u>

The following two pages will ask you about potential cues that may elicit your engagement in certain smartphone functions while driving. The questions will mention both external (i.e. coming from your surroundings), and internal cues (e.g. mood).

Note:

- There may be several cues that cause a given behavior. This is okay, and you are encouraged to provide an answer for each cue.
- It may be that certain cues precede others in time. For example, when answering your phone, it may be the ringtone that initially attracts your attention. However, we ask you to consider other cues, such as mood, which may cause you to answer your phone.
- By social pressure, we mean the perceived pressure you may feel from others to respond or interact with them.

45) While driving in similar scenarios, how often do you **answer an incoming phone call (e.g. Phone, Facebook Audio, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my smartphone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

46) While driving in similar scenarios, how often do you **initiate a phone call (e.g. Phone, Facebook Audio, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

46) While driving in similar scenarios, how often do you **read a message (e.g. SMS, WhatsApp, direct message on social media, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

47) While driving in similar scenarios, how often do you **enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

48) While driving in similar scenarios, how often do you **read an email** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

49) While driving in similar scenarios, how often do you **scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

50) While driving in similar scenarios, how often do you **browse a website / use a search engine (e.g. Safari, Google Chrome, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

51) While driving in similar scenarios, how often do you **check the home screen of a smartphone for any sort of notification (e.g. missed texts/calls, social media updates, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
Receiving a notification from my phone (e.g. incoming/missed call, vibration, etc)	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )
Feeling lonely	( )	( )	( )	( )	( )
Feelings of social pressure	( )	( )	( )	( )	( )

52) While driving in similar scenarios, how often do you **search for a song/artist/album/playlist on a music app (Apple Music, Spotify, Soundcloud, etc)** in response to the following cues?

Cues	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very often**
A song ending	( )	( )	( )	( )	( )
Being bored	( )	( )	( )	( )	( )

53) Please indicate whether there are any other specific contexts or cues that trigger, or are associated, with your smartphone use while driving (e.g. being sad/depressed, being happy, etc). *If you cannot think of any other cues, please put NA.*

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For the following three questions, please consider your smartphone use in daily life (i.e. not confined to the vehicle).

54) In daily life (i.e. not confined to the vehicle), engaging in the following tasks is something **I do without thinking.**

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

55) In daily life (i.e. not confined to the vehicle), engaging in the following tasks is something **I do automatically**.

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					
please select disagree					

56) In daily life (i.e. not confined to the vehicle), engaging in the following tasks is something **I start doing before I realize I'm doing it**.

Cellphone Distractions	**Strongly Disagree**	**Disagree**	**Neither Agree/ Disagree**	**Agree**	**Strongly Agree**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

57) Did you pay attention during this survey and answer honestly?

( ) Yes

( ) For the most part

( ) No

58) How likely is it that you will participate in the follow-up study?

( ) Very Likely

( ) Somewhat likely

( ) Unsure

( ) Somewhat unlikely

( ) Very unlikely

Appendix E.5. Survey Debrief

Thank you for taking our questionnaire. The follow-up questionnaire will take place in one months' time. You will be sent reminder e-mails closer to the date of the follow-up study.

Important information about the follow-up study:

The follow-up questionnaire will take approximately four minutes to complete and you will be provided $2.00 USD for its competition. The follow-up questionnaire will ask you about the frequency of your smartphone use while driving over the past month and questions about how frequently you drove in environments similar to the one you saw in the current questionnaire.

Over the next month, please try to be aware of how frequently you drive, as well as engage in smartphone distractions, while driving in similar environments. You do not need to keep a specific count, but you will be asked to provide a rough numerical estimate regarding the number of times you engaged in a certain smartphone distraction during a typical drive.

Reminder: We encourage you to participate in the follow-up questionnaire, as it is essential for our analysis.

If you have any questions or concerns, please feel free to contact the primary investigator:
Braden Hansma at bhansma@mie.utoronto.ca.

Appendix F. Follow-Up Survey: Time 2 (Rural and Urban)

This is the follow-up questionnaire to the survey: "Drivers Smartphone Use".

The following questionnaire will ask you questions about the frequency of your smartphone use while driving in an environment similar to the picture below (*this scenario should be the same as the one presented to you in the first questionnaire*). This questionnaire will also ask you questions about how often you drove in environments similar to the picture below within the past month.

Participants will see one of the driving contexts below. This context would have been assigned to them at the start of the first questionnaire.

Scenario
Imagine yourself driving along on a two or three- lane urban road with moderate traffic, medium pedestrian flow, and traffic lights. The photo above illustrates the type of environment that you should consider when answering the following questions.

Scenario
Imagine yourself driving on a 4-lane highway where local lanes are divided by a ditch or barrier, traffic conditions are low and there is good weather. The photo above illustrates the type of environment that you should consider when answering the following questions.

1) What percentage of your driving time, within the past month, was spent driving **on highways outside of the city/within the city**, similar to the image above?

( ) Never

( ) 1-20%

( ) 21-40%

( ) 41-60%

( ) 61-80%

( ) 81-100%

2) In the past month, approximately how many times did you drive in an environment similar to the scenario above?

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3) In general, everyday use (i.e. not just while driving), please indicate the functions/activities that you have ever performed on your smartphone:

[ ] answer an incoming phone call (e.g. Phone, Facebook Audio, etc)

[ ] initiate a phone call (e.g. Phone, Facebook Audio, etc)

[ ] read a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] read an email

[ ] scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)

[ ] browse a website / use a search engine (e.g. Safari, Google Chrome, etc)

[ ] check the home screen for any sort of notification (e.g. missed texts/calls, updating social media, etc)

[ ] search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)

4) In the past month, have you used a new function on your smartphone that you would not have used at the time of the first questionnaire? If so, please select the functions below. If not, please select "NA".

[ ] NA

[ ] answer an incoming phone call (e.g. Phone, Facebook Audio, etc)

[ ] initiate a phone call (e.g. Phone, Facebook Audio, etc)

[ ] read a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)

[ ] read an email

[ ] scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)

[ ] browse a website / use a search engine (e.g. Safari, Google Chrome, etc)

[ ] check the home screen for any sort of notification (e.g. missed texts/calls, updating social media, etc)

[ ] search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)

5) In the past month, how often did you manually (i.e. not using voice recognition) engage in the following tasks during a **typical drive** in an environment similar to the image above?

Cellphone Distractions	**Never**	**Rarely**	**Occasionally/ Sometimes**	**Often**	**Very Often**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

6) In the past month, approximately how many times did you engage in the following tasks during a **typical drive** in an environment similar to the image above?

Cellphone Distractions	**0**	**1-2**	**3-4**	**5-6**	**7+**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)					
initiate a phone call (e.g. Phone, Facebook Audio, etc)					
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)					
read an email					
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)					
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)					
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)					
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)					

7) Would you say that your participation in the first questionnaire influenced your subsequent engagement in smartphone distractions over the previous month? If so, which tasks were influenced and to what extent?

Cellphone Distractions	**Negative influence (more engagement)**	**No influence (same engagement)**	**Positive influence (Less engagement)**
answer an incoming phone call (e.g. Phone, Facebook Audio, etc)			
initiate a phone call (e.g. Phone, Facebook Audio, etc)			
read a message (e.g. SMS, WhatsApp, direct message on social media, etc)			
enter/send a message (e.g. SMS, WhatsApp, direct message on social media, etc)			
read an email			
scroll through the newsfeed of a social media app (e.g. Twitter, Facebook, Instagram, etc)			
browse a website / use a search engine (e.g. Safari, Google Chrome, etc)			
check the home screen for any sort of notification (e.g. missed texts/calls, social media updates, etc)			
search for a song/artist/album/playlist on a music app (e.g. Apple Music, Spotify, etc)			

Thank You!

Thank you for taking our follow-up questionnaire. We appreciate the time you took to participate in our study. By participating in this study, you have provided us with data that will help us understand why drivers engage in smartphone interactions while driving. We hope to use this information to develop countermeasures that reduce the frequency of smartphone related distracted driving.