Validation and Refinement of the Susceptibility to Driver Distraction Questionnaire (SDDQ): A Measure of Voluntary, Involuntary, and Habitual Components of Driver Distraction

by

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Abstract

Driver distraction is a major contributor to vehicle crashes, and as such, it has become a major concern for road safety. The current work presents the findings of various studies examining the validity and reliability of the newly developed Susceptibility to Driver Distraction Questionnaire (SDDQ). In general, SDDQ demonstrated good concurrent validity and internal consistency. In addition, these studies provided valuable insights for improving SDDQ. An exploratory revision incorporated a new component of habitual distraction in addition to the already existing voluntary and involuntary distraction components. Responses to the revised SDDQ were correlated to performance on various measures of executive function to understand the role of individual differences in cognition on drivers' susceptibility to voluntary, involuntary, and habitual distractions. Overall, findings of this research suggest SDDQ to be a promising self-report measure for driver distraction. The implications of these findings for the development of distraction mitigation strategies are discussed.

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Chapter 1

1 Introduction

1.1 Motivation

Traffic crashes are a leading cause of death and injury. While there are many factors that lead to crashes, driver distraction has been identified as a major contributor (Klauer et al., 2014; Olson, Hanowski, Hickman, & Bocanegra, 2009; Kircher, 2007; Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006; Ranney, 2008). Sources of driver distraction can vary significantly, however, in the past decade, cell phone-related distractions have increased dramatically and their impact on driving performance is significant. Studies using phone activity records have been used to investigate the impact of cell phones on crash risk (McEvoy et al., 2005; Redelmeier & Tibshirani, 1997). McEvoy et al. (2005) estimated that texting and talking on a mobile phone increases the odds of being in a crash by fourfold (McEvoy et al., 2005). Similarly, Redelmeier & Tibshirani (1997), demonstrated that, for calls made or received, the risk of a collision when using a mobile phone was four times greater than the risk when it was not used. On the other hand, less complex tasks, such as combing/fixing hair, retrieving tapes/CDs, and eating, increase the odds of being in a crash or near-crash by twofold (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006). Although the crash risk associated with driver distraction is already alarming, as more technologies are introduced in vehicles, it is likely that the issue will worsen (Regan, Hallett, & Gordon, 2011).

Although distraction involvement in crashes relies primarily on information volunteered by drivers to police, and as such, it is likely underreported, distraction-related crashes continue to be a significant portion of motor vehicle crashes. In 2012, U.S. official reports listed 421,000 people injured and 3,360 people killed as a result of distracted driving (National Highway Traffic Safety Administration, 2014). Due to these tragic consequences, much research has focused on developing initiatives to mitigate distractions, especially those caused by the use of cell phones (National Highway Traffic Safety Administration, 2012). Unfortunately, despite efforts to increase awareness of the consequences, drivers continue to engage in activities unrelated to driving (Schroeder, Meyers, & Kostyniuk, 2013). To maximize the effectiveness of distraction mitigation strategies, it is crucial to understand the motivating factors or facilitators of drivers' engagement in distractions.

1.2 Research Questions and Scope

The research presented in this thesis aims at developing a psychometrically-sound questionnaire to understand driver distraction. More specifically, the current work presents the findings of various studies examining the validity and reliability of a newly developed Susceptibility to Driver Distraction Questionnaire (SDDQ). SDDQ is a 39-item self-report measure that examines the psychological and social facilitators of distraction engagement by distinguishing between voluntary distraction, which refers to intentional engagement in a secondary task, and involuntary distraction, which results from an inability to suppress a response to an external stimulus (Feng, Marulanda, & Donmez, 2014a, 2014b). The facilitators of voluntary distraction in particular are assessed through the Theory of Planned Behaviour (TPB; Ajzen, 1991). A detailed description of SDDQ is provided in Chapter 3.

As part of this thesis, an online and a laboratory study (Experiment 1) were conducted to assess the internal consistency, test-retest reliability, and construct validity of SDDQ. These studies are presented in Chapter 4. Construct validity, in particular, was examined by comparing SDDQ responses to well-established measures of unsafe driving behaviours, personality, and cognitive failures. In general, findings from these studies revealed SDDQ to be a promising self-report method for measuring voluntary and involuntary distraction. The internal consistency of SDDQ was satisfactory and the concurrent validity provided support for the distinction between voluntary and involuntary distractions: factors measured by TPB and risk-seeking personality traits were identified as facilitators for engaging in voluntary driver distraction, while susceptibility to involuntary distraction was related to instances of distractibility in everyday life, as well as driving errors and lapses. Although results from the test-retest reliability were positive, some shortcomings were identified, in particular within the involuntary distraction and injunctive social norms scales. These shortcomings are outlined in detail in Chapter 4.

Insights acquired from these studies were later incorporated in a revised version of SDDQ. The revised questionnaire is presented in Chapter 3. Most notably, a new section on habitual distractions around cell phones was added to the already existing sections of voluntary and involuntary distractions. Habits refer to behaviours that were once goal-driven, but are currently performed automatically and with little awareness. Other major changes included the addition of context through road environment descriptions, and the expansion of distraction items to include activities with various amounts of visual/manual and cognitive workload. The revised questionnaire was also subjected to validation. Through a laboratory study, questionnaire responses were correlated with performance on executive function measures, as a means to understand the role of individual cognitive differences on drivers' susceptibility to voluntary, involuntary, and habitual distractions. This validation study is presented in Chapter 5.

The revised questionnaire demonstrated excellent internal consistency for most scales, with the exception of a few, which are further discussed in Chapter 5. In addition, the questionnaire continues to support the Theory of Planned Behaviour as a framework for understanding motivations for voluntary distraction engagement: self-reported distraction engagement is motivated by positive attitudes, high perceived behavioural control, and positive perceptions of social norms about distractions. With respect to executive function, analyses revealed an automatic component to engagement in cell phone-related distractions through relationships observed for measures of inhibition abilities to self-reported engagement, cell phone habits, and compulsiveness to respond to cell phone alerts.

Overall, findings of this research show the revised SDDQ to be a promising self-report measure for driver distraction. The revised SDDQ was exploratory in nature and therefore has several items which make the questionnaire long and hence impractical for use in its current form. Future research will focus on identifying a more efficient set of items through the use of Factor Analysis. These items will be later incorporated into a new and improved version of SDDQ.

1.3 Thesis Overview

- Chapter 2 provides an introduction to the relevant literature on driver distraction and the social and psychological facilitators of driver distraction.
- Chapter 3 presents a description of the original SDDQ and the revised version.
- Chapter 4 presents the findings of an online survey study that examined the internal consistency and concurrent validity of SDDQ, as well as a laboratory study that assessed its test-retest reliability and aimed to validate SDDQ using executive function measures.

- Chapter 5 describes the results of another laboratory study that was conducted to validate the revised SDDQ using various measures of executive function.
- Chapter 6 provides a summary of the contributions of these findings to the field of driver distraction research and recommendations for future work.

Chapter 2

2 Literature Review

This chapter summarizes research in the area of driver distraction and discusses the role that behavioural and psychological theories play in understanding driver distraction. The Theory of Planned Behaviour (Ajzen, 1991) and Miyake et al.'s (2000) framework of the central executive are used as theoretical foundations for understanding the social and cognitive factors underlying engagement in voluntary, involuntary, and habitual distractions while driving.

2.1 Voluntary, Involuntary, and Habitual Distraction

In the past decade, driver distraction has become a growing concern for governments, road safety researchers, and the general public. Over the years, research has established that driver distraction is a major contributor to crash risk. Recently, the National Highway Traffic Safety Administration (NHTSA) reported that 10 percent of fatal crashes and 18 percent of injury crashes in 2012 were distraction-related (National Highway Traffic Safety Administration, 2014).

Despite the heightened awareness of the issue concerning driver distraction, no consensus has been reached on its definition. Over the years, numerous definitions have emerged, many of which are vague or contradictory (Foley, Young, Angell, & Domeyer, 2013). As a result of this inconsistency, driver distraction studies are often difficult to compare and challenging to replicate (Savino, 2009). However, efforts to standardize the definition of inattention and driver distraction have been brought about by the need to reliably operationalize these concepts (Regan et al., 2011; Trick, Enns, Mills, & Vavrik, 2004). For example, Regan et al.'s (2011) taxonomy of driver inattention delineates five subtypes of inattention: restricted, misprioritized, neglected, cursory, and diverted. Driver diverted attention (DDA) is synonymous with driver distraction and occurs when a driver's attention is diverted from activities critical for safe driving to a competing activity. Therefore, distraction is defined as a subtype of inattention, such that drivers can be inattentive without being distracted, but not vice versa. Distractions in this taxonomy are also seen as varying across five aspects: source, location, intentionality, sensory process, and outcomes.

Although the distinctions of intentionality, i.e., voluntary and involuntary, is often considered a strict dichotomy, Trick et al.'s (2004) conceptual framework of attention selection in driving describes it as a continuum of automaticity. Trick et al. (2004) argue that some processes are more automatic than others in that they are initiated faster, require less cognitive effort, and may be in some cases, evoked unintentionally. In addition, this framework incorporates cognitive mechanisms of attentional selection by making the distinction between mechanisms that are innate and those that are acquired through learning and repetition. Overall, this framework describes four modes of attentional selection varying along two dimensions: selection with or without awareness (controlled vs. automatic) and selection by innate and acquired cognitive mechanisms (exogenous vs. endogenous). This thesis uses the Trick et al. (2004) framework to describe the processes involved in voluntary, involuntary, and habitual distraction in driving, which will be explained in detail later in this chapter:

1. Voluntary distraction refers to the intentional engagement in a secondary task while driving and it is governed by a controlled-endogenous process, as it is an intentional, cognitively effortful process driven by a specific goal (e.g., typing a text message).

2. Involuntary distraction is analogous to a reflex or an automatic-exogenous process and occurs as a result of a driver's inability to suppress distracting stimuli due to an innate or 'hard-wired' mechanism (e.g., looking at a flashing bright object).

3. Habitual distraction occurs as a result of an automatic-endogenous process, in which a driver is unable to suppress an automatic response to a stimulus that has been learned by repetition of an originally goal-driven behaviour (e.g., unintentionally glancing at a cell phone in response to a notification).

The distinction between voluntary, involuntary, and habitual driver distraction is evident in the literature. For example, a recent study investigating the prevalence of driver inattention and driver distraction found that of the 54 distraction-based crashes, over 70% were caused by voluntary distractions and the remaining were caused by involuntary distractions (Beanland, Fitzharris, Young, & Lenné, 2013). It should be noted, however, that habitual distraction was not a category in this study; new research suggests that texting while driving, which is commonly identified as a voluntary distraction, may be partially attributable to habits (Bayer and Campbell 2012).

The prevalence and the effects of voluntary distraction have been well documented. In a survey study conducted in the United States in 2010, 41% of drivers reported using cell phones to make or receive calls on at least some of their driving trips, and 17% reported using some type of hands-free device when doing so (Tison, Chaudhary, & Cosgrove, 2011). Although the percentage of drivers who report sending text messages while driving is much smaller than the percentage of those who report having phone conversations, the trend shows a slight increase from 12% in 2010 to 14% in 2012 (Schroeder et al., 2013). Aside from cell phone use, 8% of drivers reported using a navigation system for directions, 11% reported eating or drinking while driving, and 49% reported always or almost always talking to a passenger while driving (Schroeder et al., 2013).

In addition to its high prevalence, the effects of voluntary distraction on driving performance are also significant (Caird, Willness, Steel, & Scialfa, 2008; Donmez, Boyle, & Lee, 2007). For example, a meta-analysis by Caird et al. (2008) on laboratory, driving simulator, and on-road studies found that talking on a cell phone, hand-held or hands-free, delays reaction times to events and stimuli. Talking on a cell phone while driving has also been associated with inattention blindness, a term used to describe when drivers look at an object but fail to see it as a result of their attention being directed elsewhere (Strayer et al., 2003; Strayer & Johnston, 2001). This form of inattention has been associated with lower recognition memory for billboards and traffic signals and slow reactions to signals detected in a simulated environment (Strayer & Drews, 2007; Strayer & Johnston, 2001). Besides talking on a cell phone, the effect of texting behaviours on driving performance has also been examined in a recent meta-analysis (Caird, Johnston, Willness, Asbridge, & Steel, 2014). The meta-analysis indicated that performing these tasks concurrently with driving had deleterious effects on reaction times, eye movements, stimulus detection, collisions, lane keeping, speed, and headway (Caird et al., 2014).

Involuntary distraction is related to drivers' attentional capacity, particularly to their ability to suppress distracting stimuli. Certain stimulus features, such as sudden onset, unpredictability, or high luminance, make stimuli highly salient and thus difficult, or impossible to ignore

(Franconeri & Simons, 2003; Regan et al., 2011; Trick et al., 2004). Most often, these features cause a re-assignment of attentional focus to a secondary stimulus or task. The value of the stimuli to the perceiver may also influence the attention selection process, such that stimuli that are more meaningful to an individual (e.g., their name) are more likely to be captured, as illustrated by the cocktail party effect (Cherry, 1953; Moray, 1959). In addition, significant differences exist in people's ability to inhibit irrelevant information (Murphy, 2002), which may vary as a result of aging or cognitive declines. For example, older drivers have more difficulty in disengaging attention from a previously attended stimulus (Cosman, Lees, Lee, Rizzo, & Vecera, 2011).

There is little research assessing the effects of involuntary distraction on driving performance. A closely related area of research examines the effects of advertising displays on driving. These displays include: stand-alone billboards or signs affixed to or projected onto buildings or other structures that can present either static or dynamic information. Advertising displays may attract attention automatically due to the saliency of their features. They are designed specifically to attract attention through the use of bright colours, high luminance, movement, or other features. In a recent literature review on the road safety impact of billboards, Rempel et al. (2013) concluded that the presence of a digital advertising display, in particular a dynamic one, has detrimental effects on driving performance. For example, in driving simulator studies, dynamic displays have been associated with degraded lateral lane control, hard braking as a result of delayed reaction times, decreased vehicle speed, more crashes, and lower memory of official road signs (Bendak & Al-Saleh, 2010; Chattington, Reed, Basacik, Flint, & Parkes, 2009; Young & Mahfoud, 2008). A recent literature review by Decker et al. (2015) on the impact of billboards on drivers' visual behaviours found that within eight studies reporting long glances to advertising displays, there was considerable evidence that 10-20% of glances made were ≥ 0.75 s in duration, which is the minimum perception-reaction time for a vehicle slowing ahead of the driver (Smiley, Smahel, & Eizenman, 2004). Furthermore, Lee et al. (2007) reported that approximately 3.5% of glances made at static billboards and 6.25% of glances made at dynamic billboards were ≥ 2.0 s, which is a glance duration associated with a high risk of being involved in a crash (Dingus et al., 2006). Although the content of the advertisement can add a voluntary element to this type of distraction, the automatic re-assignment of attentional focus to a billboard from the forward roadway is an involuntary distraction. Overall, these findings suggest that when objects unrelated to driving capture a driver's attention, they can reduce situational awareness and increase the likelihood of a crash.

Habits, although also triggered by external stimuli, are inherently different from involuntary distraction, as these stimuli must be associated with a once goal-driven behaviour. Habits are defined as "…a form of automaticity in responding that develops as people repeat actions in stable circumstances" (Verplanken & Wood, 2006, pp. 91). These actions are goal-oriented behaviours that were originally motivated by an expected reward, but are now performed without deliberate behavioural intention. Although habits have been previously studied in the driving context, for example to examine the role of expertise in motor responses (e.g., gear shifting) (Shinar, McDowell, & Rockwell, 1977), to our knowledge, they have not been studied in the context of driver distraction.

Habits can develop across many behaviours (e.g., smoking or exercising) and can be triggered directly by the perception of the situational cues that were, in the past, contiguous with the behaviour (Verplanken & Wood, 2006). These triggers can include environmental cues, such as time of day and location (Wood & Neal, 2007) or internal mental states, such as a particular mood (Ji & Wood, 2007). However, anecdotal research suggests that habits are primarily associated with environmental cues; people report that breaking habits, such as quitting smoking, is easier when they are removed from their daily routines (Verplanken & Wood, 2006). Furthermore, a study on exercise frequency of university transfer students, who had developed strong exercise-related habits at their old school, showed that their exercise was maintained when the exercise location remained constant; however, when location changed, the exercise habits were disrupted (Wood, Witt, & Tam, 2005). Despite the evidence that contextual cues are one of the main triggers of habitual behaviours, this thesis will explore whether habits around cell phones can translate across environments, meaning that the habits will not be disrupted when the cell phones are carried to the vehicle. This expectation is based on findings by Bayer and Campbell (2012) who identified texting habits occurring outside the context of driving as contributing factors for texting and driving behaviours. In addition, in their discussion, the authors argue that aside from the perceptual aspects of a phone (e.g., colourful messages and vibrations), which can trigger engagement in the device when in visual range, social context and mental states may also prompt a driver to use her phone even when it is outside of her view (e.g., looking for a phone inside a purse). Due to their automaticity, habits may not impose high demands on mental capacities; however, it is likely that visual and manual resources may be utilized by their performance, potentially removing resources necessary for the safe operation of a vehicle. Consequently, it is possible that habitual cell phone-related behaviours may already be significant contributors to vehicle crashes, but due to the automatic nature, their effects may be significantly underreported.

Each type of distraction (i.e., voluntary, involuntary, or habitual) can occur independently or jointly. A driver can voluntarily divert attention to a secondary task (e.g., engage in a phone conversation) or the source of an involuntary distraction can lead to a voluntary diversion of attention (e.g., a fly inside the vehicle involuntarily captures the driver's attention leading the driver to attempt to throw it out of the window) (Regan et al., 2011). Similarly, habitual responses can often lead to voluntary distractions. A recent study by Oulasvirta et al. (2011) on the use of smartphones identified 'checking habits', such as touching the home screen for one second, as instances in which users will briefly and repetitively inspect content on their smartphone. Authors argued that in many instances, 'checking habits' served as gateways to other interactions, e.g., opening an application after noticing a notification when checking the phone. In the context of driving, these secondary checks can be extremely dangerous. Often, drivers report engaging in distracting activities when they perceive driving conditions to be less demanding and safer, e.g., when stopped at a red light (Schroeder et al., 2013). However, if the driver unintentionally interacts with a device for longer than intended, s/he may lose the ability to accurately predict changes in driving conditions, as the conditions that were present when the interaction started may change during this time. This loss of situational awareness can result in a vehicle crash.

Overall, these findings highlight the importance of distinguishing between different types of driver distraction, as well as the need for a clear definition and operationalization of these constructs. The distinction between voluntary, involuntary, and habitual distractions can provide a deeper understanding of driver distraction by revealing motivations for drivers' engagement in secondary tasks while driving, and the mechanisms that govern involuntary and habitual distraction. This understanding can in turn be used to assess new in-vehicle technology in terms of its influence on different types of distraction and to develop distraction mitigation strategies targeted to individual driver's needs based on their susceptibility to each type of distraction.

2.2 Self-Report Studies on Driver Distraction

Understanding drivers' susceptibility to different types of distraction requires significant amount of research. Unfortunately, driver distraction studies are limited by time and resources available, making it difficult, or in most cases, impossible to investigate all constructs of interest. One way to get around this issue is by using self-report measures. These measures are usually less expensive to implement than on-road, simulator, or naturalistic studies and allow for the collection of large amounts of data. In addition, when investigating the role of different distraction types on driving performance, self-report measures can help recruit participants from the tail-end of a distribution of susceptibility to distraction, i.e., participants that are more susceptible to each type of distraction, thus narrowing down the sample size and the resources necessary to test these effects. Self-report studies are also useful for examining social and psychological factors (e.g., attitudes) that cannot be assessed by direct observation. This information can later be used to assess the reasons underlying such behaviours and even whether drivers are aware of their distractibility.

Survey methods have been previously used to investigate driver distraction. For example, the National Survey of Distracted Driving conducted in 2012 (Schroeder et al., 2013) examined a wide variety of distracted driving behaviours as well as drivers' attitudes toward these behaviours. Based on the frequency of engagement in several distraction-related activities, this study identified two distinct types of drivers: distraction-prone and distraction-averse. Drivers classified as distraction-prone tended to be younger and more affluent, and to have more formal education. The study also found that driver type was highly predictive of attitudes toward distractions. For example, distraction-averse drivers reported being much more likely to feel very unsafe as passengers in a car driven by someone talking on the phone, texting, or emailing, and being more likely to intervene compared to their distraction-prone counterparts. Furthermore, although the majority of respondents supported laws banning talking on hand-held devices while driving, support was much higher among distraction-averse drivers. This survey is consistent with previous research demonstrating the contributing role of attitudes towards risky driving behaviours, such as speeding (Paris & Van De Broucke, 2008; Parker, Manstead, Stradling, & Reason, 1992; Warner & Åberg, 2008) and violating traffic rules (Parker et al., 1992), highlighting the importance of targeting attitudes within intervention strategies to increase their effectiveness.

Another survey examined the frequency of engagement in distracting activities and their associations with self-reported driving errors and crashes (McEvoy, Stevenson, & Woodward, 2006). The study identified a number of common distractions that contribute to crashes, including lack of concentration, adjusting in-vehicle equipment, talking to passengers, and distractions from outside people, objects, or events. Surprisingly, although talking to passengers was one of the most commonly reported secondary tasks which have contributed to a crash, seven in 10 drivers surveyed did not consider it to be a dangerous activity (McEvoy et al., 2006). In addition, the authors found that young drivers (18-30 years) were significantly more likely to report engaging in distracting activities, to perceive them as being less dangerous, and to have crashed as a result of distraction. This finding further contributes to the literature showing that perceived risk is an important factor in distracted driving behaviours.

Research focusing on adolescents' engagement in distracted driving behaviours also reveals perceived risk to be an influential factor. For example, a U.S. nationwide telephone survey of 403 parent-teen dyads examined the contributions of social normative influences (parents and peers), risk perception, and sensation seeking on adolescent distracted driving behaviours (Carter, Bingham, Zakrajsek, Shope, & Sayer, 2014). Consistent with the results mentioned earlier, findings of this survey revealed that risk perception is the strongest predictor of distracted driving behaviours in adolescent populations. This finding is also consistent with research showing young drivers to report lower risk levels for high-risk driving situations (Deery, 1999) and to underestimate the consequences associated with high-risk behaviours (Taubman-Ben-Ari, Mikulincer, & Iram, 2004). Furthermore, young males tend to overestimate their driving skills in hazardous driving situations (DeJoy, 1992). These findings suggest that adolescents' misperceptions of their abilities and of the driving environment may be contributing factors to their engagement in driver distraction. Carter et al.'s (2014) work also highlighted the importance of understanding social norms in distracted driving. Perceived parental and peer engagement in driver distraction (i.e., descriptive norms), but not perceived approval (i.e., injunctive norms), were predictive of adolescent engagement in distracted driving. Interestingly, adolescents reported that their friends engaged in driver distraction more often than themselves, which points once again towards the need to correct adolescents' misperceptions around driver distraction and crash risk (Carter et al., 2014).

While these questionnaires provide valuable information regarding drivers' degree of involvement in various distractions and assess some of the underlying mechanisms for doing so (e.g., attitude, social norms, and risk perception), to our knowledge, no questionnaire has made the effort to distinguish between voluntary, involuntary, and habitual engagement in driver distraction.

2.3 Social and Psychological Factors of Driver Distraction

Over the past few years, interest in driver distraction has boomed, bringing with it innumerable campaigns to raise awareness of dangers of driving while distracted. These come in a variety of different ways including T.V. ads, radio announcements, and billboards. Some of the most common campaigns include "*Click it or Ticket",* "*It Can Wait*", "*No Phone Zone*", and "*Just Drive.*" In addition, many places in the United States and Canada have implemented bans on the use of mobile devices while driving and have gained significant support, in particular those banning talking on hand-held devices, texting, or emailing while driving (Schroeder et al., 2013).

Despite increased awareness and support for banning laws, drivers continue to engage in distractions while driving. Research in Australia found that drivers report engaging in some type of distracting activity once every six minutes while driving (McEvoy et al., 2006). In addition, of these activities, cell phone-related distractions appear to be the most prevalent. A recent survey by the National Highway Traffic Safety Administration shows that at any given daylight moment approximately 660,000 drivers are using cell phones or manipulating electronic devices while driving (National Highway Traffic Safety Administration, 2013). These findings raise the question of why, despite knowing the dangers, do people continue to engage in behaviours that could lead to driver distraction?

Over the years, research has investigated the psychosocial predictors for engaging in distraction while driving. Most of this research has focused on the use of mobile phones and points at a complex mixture of various constructs (Atchley, Atwood, & Boulton, 2011; Nemme & White, 2010; Walsh, White, Hyde, & Watson, 2008; White, Hyde, Walsh, & Watson, 2010; Zhou, Wu, Rau, & Zhang, 2009). For example, research by Horrey and colleagues used video-based training interventions to attempt to mitigate driver distraction (Horrey & Lesch, 2008; Horrey, Lesch, Kramer, & Melton, 2009; Horrey & Lesch, 2009). As part of this research, participants were surveyed on their willingness to engage in distractions before and after the training. Findings showed that self-reported willingness to engage in distractions was related to numerous factors including past behaviour, confidence in dealing with distractions, sensation seeking, and perceived risk of distractions.

As previously mentioned, risk perception has been established as one of the major predictors of engagement in risky driving behaviours by adolescents (Carter et al., 2014), with texting and driving being one of the most common behaviours. In a study conducted on young drivers by Atchley et al. (2011) examining the role of perceived risk of different texting behaviours (i.e., initiating, replying, and reading), young drivers reported texting and driving (both initiating and replying) to be a very risky behaviour. However, when modelled, perceived risk was found to be a predictor of initiating texting, but not of reading texts or replying to them. The authors argued that when it comes to replying, young drivers might disregard risk given the presence of social pressure to respond. These results indicate that consideration of risk may only play a role when the driver feels s/he is making a choice to text. Another interesting finding from Atchley et al. (2011) pertains to differences in risk assessment of young drivers' texting behaviours in different road conditions: perception of risk associated with texting behaviours changed based on whether drivers initiated or responded to a message; when young drivers initiated the texting behaviour, they perceived road conditions as being safer than when they replied or read a text message. It is possible that these young drivers engage in texting behaviours when they deem the road conditions to be less demanding. However, the authors also suggest that this pattern of responding may be the result of cognitive dissonance: young drivers are aware of the risk involved in texting and driving, thus to reduce the tension associated with engaging in such a behaviour, they justify their actions by altering their beliefs of the driving conditions, in this case deeming them to be safer. The possibility that behaviours alter risk perception in the context of driving highlights the complexity involved in investigating the facilitators for engaging in voluntary distractions.

2.3.1 The Theory of Planned Behaviour

One of the most common theories for understanding underlying motivations for engaging in an intentional behaviour is the Theory of Planned Behaviour (TPB) (Ajzen, 1991). This theory states that intention is the main determinant of behaviour and it can be influenced by attitudes (positive or negative evaluations of the behaviour), social norms (perceived social pressure to engage in the behaviour), and perceived behavioural control (ease or difficulty associated with engaging in the behaviour).

This theory has been successfully applied in numerous contexts (Armitage & Conner, 2001) including driving. Within this domain, TPB has been used to examine a number of behaviours such as violation of traffic laws (Parker et al., 1992), compliance with speed limits (Elliott, Armitage, & Baughan, 2003; Forward, 2009; Paris & Van De Broucke, 2008; Warner & Åberg, 2008), drinking and driving (Åberg, 1993), and intentions to use pedestrian's road crossings (Evans & Norman, 2003). Overall, these studies suggest that TPB is a promising framework for understanding intention to engage in driver distraction.

Recently, TPB has been used as a framework for understanding mobile phone use while driving (Bayer & Campbell, 2012; Nemme & White, 2010; Walsh et al., 2008), in particular, to understand differences in intentions to engage across different mobile device activities. For example, Walsh et al. (2008) used a series of questionnaires to examine the differences between calling and texting behaviours across different driving scenarios varying in risk (e.g., driving fast and being in a hurry or being stopped at a red light and not being in a hurry). Across all scenarios, they found that after controlling for participant's characteristics (e.g., age and gender), TPB accounted for additional variance of 39-42% in intentions to call and 11-14% in intentions to text while driving. In addition, of the TPB constructs, attitudes were the only significant predictor for both calling and texting intentions across all scenarios. On the other hand, perceived behavioural control and social norms were significant predictors of calling intentions, but not of texting intentions, and their contributions varied across scenarios: perceived behavioural control was a significant predictor of calling intentions in scenarios when the driver was stopped at a traffic light while running late and when not running late, as well as when driving 100km/h without time pressure. Interestingly, social norms were only a significant predictor for calling intentions in scenarios when the driver was time pressured (i.e., running late), suggesting that drivers may be more susceptible to normative pressure when other people or time commitments are involved.

Similarly, Nemme and White (2010) investigated the efficacy of TPB in predicting different intentions across texting behaviours (reading and sending text messages). Findings of this study revealed significant differences across texting behaviours, with reading texts while driving rated as more positive, having greater approval from others, and greater intentions for engagement in the future, compared to sending text messages. Further analyses revealed attitudes to be a predictor of intentions to both read and send text messages while driving. However, subjective norms and perceived behavioural control only predicted intentions to send, but not to read text messages, suggesting that individuals with greater perceptions of the acceptability of and control over sending texts while driving will have stronger intentions to do so.

Based on the results presented by Walsh et al. (2008) and Nemme and White (2010), future interventions should discourage positive attitudes toward mobile phone use while driving and challenge drivers to consider whether the advantages arising from using a mobile phone while driving (e.g., using time effectively) outweigh the increased risk of crashing. In addition, incorporating social influences by emphasizing disapproval from family and peers could also increase effectiveness of an intervention. Finally, since the roles of the influencing factors vary across different mobile device activities (i.e., calling, texting, reading messages), interventions should consider these activities differently and target them individually in order to increase their effectiveness.

The use of TPB within these studies provides valuable insights into drivers' motivations for engaging in cell phone-related distractions while driving. In addition, findings from these studies suggest TPB to be a potentially useful framework for understanding drivers' engagement in other distractions besides cell phones. Therefore, the studies described within this thesis incorporate TPB to examine the effect of attitudes, perceived behavioural control, and perceived social norms on a broader range of distractions.

2.3.2 The Central Executive

Executive functions are processes that control and coordinate cognitive abilities, including working memory, divided and sustained attention, mental flexibility, and motor sequencing (Miller, Bruce & Cummings, Jeffrey, 2007). These processes are vital for the optimal functioning of an individual and are necessary for performance of complex daily activities. Driving is a complex task that requires a high degree of executive function due to its demands on perceptual, cognitive, and motor processes (Groeger, 2000). To understand how drivers vary in their ability to safely operate a vehicle, it is necessary to examine the mental processes required for the performance of this task.

Executive functions are primarily associated with the frontal lobe, more specifically with the pre-frontal cortex (Ashby & Valentin, 2007). Much of the research conducted on executive functions has been motivated by the desire to understand patients with frontal lobe damage (e.g., Phineas Gage) (Miyake et al., 2000). Although damage to the frontal lobe has been shown to have no significant effects on traditional IQ scores (Shallice & Burgess, 1991), patients still demonstrate impairments in everyday functioning. In particular, damages to the frontal areas are characterized by problems with planning (Owen, Downes, Sahakian, Polkey, & Robbins, 1990; Shallice, 1982), with response initiation and inhibition (Baldo, Shimamura, Delis, Kramer, & Kaplan, 2001; Demakis, 2004; Simmonds, Pekar, & Mostofsky, 2008), failure to identify rules, inability to use feedback, and cognitive inflexibility (responsible for perseveration) (Godefroy, 2003). Impairments in these areas are generally measured using cognitive tasks including the Wisconsin card sorting test (Berg, 1948), Stroop task (Stroop, 1935), and trail-making test (“Army Individual Test Battery,” 1944).

One of the most prominent theories of executive function is Baddeley’s (1986) model of working memory. This process introduces a central executive system that actively regulates the distribution of limited attentional resources and coordinates information between two specialized systems of verbal and spatial memory—the phonological loop and the visuospatial sketchpad (Miller, Bruce & Cummings, Jeffrey, 2007; Miyake et al., 2000). This concept of working memory is similar to Norman and Shallice’s (1988) Supervisory Attentional System, which introduces the executive function as a monitoring system that oversees and controls responses to novel situations and that overrides automatic behaviours resulting from habitual responses (Miller, Bruce & Cummings, Jeffrey, 2007).

Despite many years of research on the central executive, two theoretical issues remain. The first pertains to how cognitive processes are controlled and coordinated during the performance of complex cognitive tasks. The second entails the long-standing controversy brought about by Teuber (1972) on the diversity and unity of frontal lobe functions: more specifically, whether executive functions are part of the same underlying mechanism or whether each function individually contributes to the overall functioning of the central executive. Recently, Miyake et al. (2000) used a latent-variable analysis to address these issues. The authors focused on three of the most frequently postulated executive functions in the literature, i.e., Shifting, Updating, and Inhibition, with the goal of identifying the extent to which these functions are unitary or separable and what their role is in the performance of complex executive tasks. These functions are described in detail below.

Shifting refers to the ability to shift between multiple tasks, operations, or mental sets (Miyake et al., 2000). This function involves adaptive changes in attentional control based on task demands. The process requires shifting the allocation of attention to remain focused on task-relevant stimuli. Generally, the process is measured by the shifting cost (i.e., the time required to disengage from an irrelevant task set and to subsequently activate a relevant task set). Shifting tasks used by Miyake et al. (2000) include the plus-minus task (Jersild, 1927), the number-letter task (Rogers & Monsell, 1995), and the local-global task (Miyake et al., 2000; Navon, 1977).

Updating refers to the ability to update and monitor relevant information in working memory. This process requires assessing information in working memory for its relevance to the current task, and then appropriately revising it by replacing that which is no longer relevant, with newer, more relevant information (Morris & Jones, 1990). It is important to stress that Updating goes beyond passive storage by requiring active manipulation of information in working memory (Lehto, 1996; Morris & Jones, 1990). Tasks used by Miyake et al. (2000) to measure Updating include the keep-track task (Yntema, 1963) and the letter memory task (Morris & Jones, 1990).

Inhibition has been described as the “ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary” (Miyake et al., 2000, pp 57). This process requires attentional control to prevent disruption or interference from task-irrelevant stimuli or responses (Eysenck, Derakshan, Santos, & Calvo, 2007). Some of the tasks that are associated with Inhibition include the Stroop task (Stroop, 1935), antisaccade task (Hallett, 1978), and stop-signal task (Logan & Cowan, 1984).

Overall, Miyake et al. (2000) found that although functions of Shifting, Updating, and Inhibition are clearly distinguishable from each other, they are still only partially separable, as they share, to some extent, an underlying commonality. This notion was supported by their findings that each function (e.g., Shifting or Inhibition) contributes differentially to the performance of common neuropsychological tasks, despite their moderate correlations with each other.

2.3.2.1 The Role of Executive Function in Driving

Research suggests that executive functions play an important role in driving performance. Previous research shows that impairments in cognitive function are associated with performance decrements in driving in both older (Adrian, Postal, Moessinger, Rascle, & Charles, 2011; Baldock, Mathias, McLean, & Berndt, 2007; Daigneault, Joly, & Frigon, 2002; Stutts, Stewart, & Martell, 1998) and younger populations (Isler, Nicola, Starkey, & Drew, 2008; Jongen, Brijs, Komlos, Brijs, & Wets, 2011; Mäntylä, Karlsson, & Marklund, 2009; Ross et al., 2015). This decrease in executive function may be related to cognitive declines that occur during the aging process or the underdevelopment of the frontal lobe in young adults. For older adults, aging is associated with atrophy in both gray and white matter of the prefrontal cortex, which in turn is associated with slowed neurotransmission. According to Kensinger (2010), it is possible that white matter changes may mediate the cognitive slowing that occurs during healthy aging. On the other end of the spectrum, imaging studies show that the prefrontal cortex is one of the brain areas that takes the longest to fully develop. In fact, research shows that this area does not fully develop until well into our twenties (Lenroot & Giedd, 2006; Sowell, Trauner, Gamst, & Jernigan, 2002) and its connections are extensively remodelled during adolescence (Blakemore & Choudhury, 2006; Giedd et al., 1999).

The cognitive skills needed to drive have been studied extensively in older drivers, usually in an attempt to accurately evaluate their fitness to continue driving (Adrian et al., 2011; Baldock et al., 2007; Daigneault et al., 2002). Research using classical tests of inhibition, shifting, and updating abilities show that performance on these tasks is related to crash involvement (Daigneault et al., 2002; Stutts et al., 1998) and poor driving performance (Adrian et al., 2011) among older drivers. For example, among drivers 65 years and older, those with a history of crashes had poorer executive functions compared to the crash-free counterparts (Daigneault et al., 2002). Similarly, a recent study in New Zealand investigating the relationship of executive functions and cognitive abilities to driving-related assessments in younger adults found that each function contributed to different aspects of driving, with higher working memory related to better scanning behaviours, switching abilities related to better speed choice, better directional control, and greater hazard detection, and inhibition abilities related to higher number of actions to hazards (Isler et al., 2008). Additionally, individual differences in executive function, particularly in inhibition and updating of working memory, have also been related to standard deviation of lateral position, as well as detection of, reaction to, and crashes with road hazards in simulated driving environments (Jongen et al., 2011; Mäntylä et al., 2009; Ross et al., 2015).

2.3.2.2 The Role of Executive Function in Driver Distraction

Based on Miyake et al.'s (2000) model, driving requires multiple competing tasks, including inhibiting irrelevant information, shifting attention between spatial locations, tasks, and sensory modalities, as well as maintaining and updating information about the surroundings (e.g., such as speed limit signs or a vehicle in the blind spot). Mental flexibility allows drivers to cope with dynamic traffic situations by switching continually between all activities essential for safe driving (verifying and adjusting speed, changing gears, etc.), as well as irrelevant information or distractions. Finally, inhibition seems to be required to ignore distracting external events or task-irrelevant stimuli.

Given the complexity of the driving task, it is possible that diminished capabilities in any of the abovementioned functions can contribute to the severity of driver distraction experienced by individuals. As mentioned previously, driver distraction can be of three different forms, i.e., voluntary, involuntary, and habitual. The extent to which each of these distractions will affect driving will depend on a driver's capacity in each of the executive function at play. For example, drivers with lower inhibition capacities may be more susceptible to involuntary distraction, as they are unable to restrain themselves from attending to stimuli that are irrelevant to the driving task. Driving environments can be highly complex and contain numerous objects that afford attending to. However, in order to safely operate a vehicle, drivers must selectively attend to goal-relevant stimuli (e.g., traffic signals or pedestrians) and ignore irrelevant stimuli (e.g., roadside advertisements). In fact, laboratory-based selective attention tasks have been found to predict traffic crashes (Arthur & Doverspike, 1992). Although research on inhibitory deficiencies have focused on older adults, and have continually shown that older adults are more susceptible to distraction and interference compared to younger adults (Hasher & Zacks, 1988; Lustig, Hasher, & Tonev, 2006; McDowd, Oseas-Kreger, & Filion, 1995; Tipper, 1991), young adults can also be vulnerable to distractions by irrelevant stimuli, as demonstrated by greater compatibility effects in a flanker task (Green & Bavelier, 2003; Roper, Cosman, & Vecera, 2013), meaning that it took participants longer to respond to a centrally presented stimulus in the presence of an incongruent distractor compared to a congruent distractor. This pattern of response indicates that the distractors are processed even though they are irrelevant to the task.

Similarly, drivers who demonstrate difficulties in inhibiting automatic responses may be more susceptible to habitual distractions. As previously mentioned, one of the main characteristics of habits is automaticity, meaning that behaviour occurs without deliberate intention (Verplanken & Orbell, 2003). One of the most common measures of inhibition of automatic behaviour is the Stroop task (Miyake et al., 2000; Tzelgov, Henik, & Leiser, 1990), which requires participants to name the colour of the ink in which an incongruent word is presented (e.g., the word RED printed in blue ink). In this task, the automatic reading behaviour interferes with the naming of the colour of a written word, resulting in slowed responses (Stroop, 1935). Thus, successful completion of this task requires inhibition abilities to avoid interference from prepotent responses. Therefore, participants who are deficient in inhibition may have greater difficulty inhibiting habitual responses.

Voluntary distractions require an intentional engagement in a secondary task. Executive functions are critical for such multi-tasking behaviours, as they allow information and goals related to one task to be maintained in working memory during the performance of a secondary task (Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013). Therefore, drivers' working memory capacities may contribute to the extent to which distractions will affect driving performance. Lavie's Load Theory (Lavie, Hirst, de Fockert, & Viding, 2004) posits that active maintenance of goal-directed behaviour (e.g., driving) in the presence of interference (i.e., distraction) depends on working memory capacity. Indeed, driving performance, as measured by the Lane Change Task (Mattes, 2003) in simulated environments, has been shown to be sensitive to working memory capacity (Engström & Markkula, 2007; Fofanova & Vollrath, 2011; Harbluk, Burns, Lochner, & Trbovich, 2007; Mäntylä et al., 2009; Ross et al., 2014). In these studies, inducing distraction by taxing working memory resulted in poor Lane Change Task performance. For example, drivers with lower working memory updating capacities, as measured by the n-back task and matrix monitoring tasks, made greater lateral deviations in a simulated driving study than their counterparts (Mäntylä et al., 2009).

Overall, research suggests that executive functions play an important role in driver distraction. Therefore, investigating the underlying mental processes that govern distraction can provide a better understanding of drivers' susceptibility to different types of distraction.

2.4 Summary

This literature review highlighted the relevant research concerning the different types of driver distraction, as well as the theories that will be used in this thesis to understand the facilitators of distraction engagement while driving, namely the Theory of Planned Behaviour (Ajzen, 1991) and Miyake et al.'s (2000) model of the central executive.

Chapter 3

3 Susceptibility to Driver Distraction Questionnaire (SDDQ)

This chapter presents a brief description of the Susceptibility to Driver Distraction Questionnaire (SDDQ), which was developed to assess drivers' engagement in different types of distractions. The development of the original SDDQ is outside the scope of this thesis work. The validation studies on and the revisions made to the original SDDQ were performed as part of this thesis (Figure 1). In this chapter, the findings from these validation studies are briefly presented along with the revised SDDQ. The details of the validation studies on the original SDDQ as well as a follow-up validation study on the revision are presented in Chapters 4 and 5.

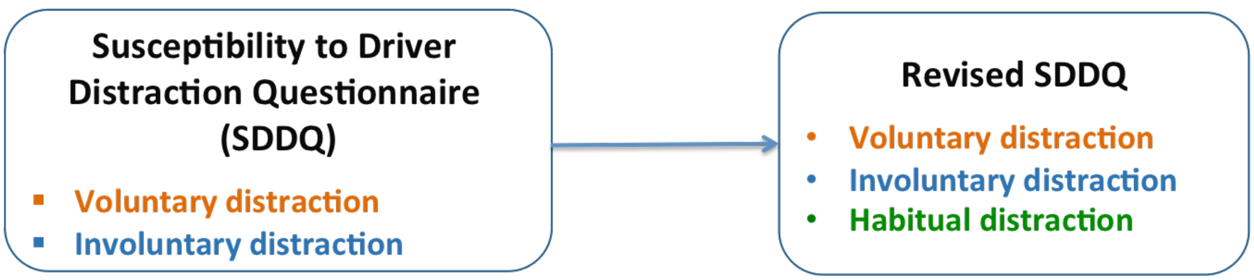

Figure 1: Components of the original and the revised SDDQ

3.1 Original SDDQ

The Susceptibility to Driver Distraction Questionnaire (SDDQ) was developed in an effort to better understand driver distraction and the factors that lead to engagement in secondary tasks while driving (See Table 1). SDDQ is a self-report measure aimed specifically at understanding driver distraction by distinguishing between voluntary and involuntary distraction.

Distraction within the context of SDDQ adopts the definition of driver distraction most commonly used for crash reporting and regulation purposes in which distraction is defined as "any activity that could divert a person's attention away from the primary task of driving" (National Highway Traffic Safety Administration, n.d.). Contrary to other definitions that suggest that competing activities become distractions when they coincide with activities critical for safe driving (Foley et al., 2013; Lee, Young, & Regan, 2008), the current definition recognizes that driver distraction may divert attention away from driving which may or may not lead to an increase in crash risk, depending on whether the diversion is away from activities critical for safe driving or not.

In addition, SDDQ uses the Theory of Planned Behaviour (Ajzen, 1991) as a framework to capture the underlying motivations that guide voluntary driver distraction. More details on the development of SDDQ can be found in Feng et al. (2014a).

SDDQ is comprised of 39 items measuring six different constructs or subscales: (1) distraction engagement, (2) attitudes towards distractions, (3) perceived control of driving while engaged in distractions, (4, 5) descriptive and injunctive social norms associated with distraction engagement, and (6) susceptibility to involuntary distractions. Overall, the questionnaire is divided into three major sections as follows:

Section 1: Engagement in distraction while driving

The first section assesses self-reported frequency of distraction engagement (construct 1) by collecting responses on seven driver distractions: have phone conversations, manually interact with a phone (e.g., sending text messages), adjust the settings of in-vehicle technology (e.g., radio channel or GPS), read roadside advertisements, visually dwell on roadside accident scenes if there are any, chat with passengers if there are any, and daydream. Responses on this section are collected on a 5-point Likert scale comprised of 'never', 'rarely', 'sometimes', 'often', and 'very often'. For scoring purposes, these anchors are assigned points from 1 (never) to 5 (very often) and the points are then averaged across the seven distractions to create an overall section score.

Section 2: Attitudes and beliefs about voluntary distraction

The second section of the questionnaire investigates facilitators of voluntary distraction through the Theory of Planned Behaviour (Ajzen, 1991). This section covers constructs 2-5: attitudes, perceived control, and perceived descriptive norms and injunctive norms. Descriptive norms refer to an individual's belief about other peoples' behaviours, while injunctive norms describe the perceived expectations of how an individual ought to behave (Cestac, Paran, & Delhomme, 2014). Each construct is probed for the same list of distractions used in Section 1, except for ‘daydream’, as it is not a distraction that can be voluntarily engaged in by drivers. Responses in this section are collected using a 5-point Likert scale anchored at ‘strongly disagree’ (1), ‘disagree’, ‘neutral’, ‘agree’, and ‘strongly agree’ (5). A score for each of the four constructs is calculated by averaging the responses to the six distractions.

Section 3: Susceptibility to involuntary distraction

The final section of the questionnaire investigates susceptibility to involuntary distraction (construct 6) based on drivers’ self-reported ability to suppress stimuli brought about by technologies (i.e., phone and radio), passengers, distractions external to the vehicle, and daydreaming. Distraction in these items is hypothesized to originate from the content of the stimuli (e.g., music or audio alert) rather than the action itself. For example, with respect to the item “While driving, I find it distracting when I listen to music”, the action of turning on music is voluntary (i.e., having the radio “on” or “off”), but once the music is being played, the driver may be paying attention to the music involuntarily. Responses for this section measure agreement to relevant statements using a 6-point scale of ‘strongly disagree’ (1), ‘disagree’, ‘neutral’, ‘agree’, ‘strongly agree’ (5), and ‘never happens’. For scoring purposes, responses across all eight items are averaged excluding responses of ‘never happens.’

Table 1: Susceptibility to Driver Distraction Questionnaire (SDDQ)

Headings in brackets (e.g., [Attitude]) are not presented to the respondents

[Section 1: Distraction Engagement]	Never	Rarely	Sometimes	Often	Very Often
When driving, I:					
a. have phone conversations					
b. manually interact with a phone (e.g., sending text messages).					
c. adjust the settings of in-vehicle technology (e.g., radio channel or GPS).					
d. read roadside advertisements.					
e. visually dwell on roadside accident scenes if there are any.					
f. chat with passengers if there are any.					
g. daydream.					

[Section 2: Attitudes and Beliefs about Voluntary Distraction]	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

[Attitude] ***I think it is all right to drive and:***

a. have phone conversations
b. manually interact with a phone (e.g., sending text messages).
c. adjust the settings of in-vehicle technology (e.g., radio channel or GPS).
d. read roadside advertisements.
e. visually dwell on roadside accident scenes if there are any.
f. chat with passengers if there are any.

[Perceived control] ***I believe I can drive well even when I:***

a. have phone conversations
b. manually interact with a phone (e.g., sending text messages).
c. adjust the settings of in-vehicle technology (e.g., radio channel or GPS).
d. read roadside advertisements.
e. visually dwell on roadside accident scenes if there are any.
f. chat with passengers if there are any.

[Perceived social norms 1] ***Most drivers around me drive and:***

a. have phone conversations
b. manually interact with a phone (e.g., sending text messages).
c. adjust the settings of in-vehicle technology (e.g., radio channel or GPS).
d. read roadside advertisements.
e. visually dwell on roadside accident scenes if there are any.
f. chat with passengers if there are any.

[Perceived social norms 2] ***Most people who are important for me think, it is all right for me to drive and:***

a. have phone conversations.
b. manually interact with a phone (e.g., sending text messages).
c. adjust the settings of in-vehicle technology (e.g., radio channel or GPS).
d. read roadside advertisements.
e. visually dwell on roadside accident scenes if there are any.
f. chat with passengers if there are any.

[Section 3: Susceptibility to Involuntary Distraction]	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Never Happens

While driving, I find it distracting when

a. my phone is ringing.
b. I receive an audio alert from my phone (e.g., incoming text message).
c. I am listening to music.
d. I am listening to talk radio.
e. there are roadside advertisements.

f. there are roadside accident scenes.
g. a passenger speaks to me.
h. I daydream.

3.2 Revised Version of SDDQ

An online study and a laboratory study (presented in Chapter 4) were conducted to assess the validity and reliability of SDDQ. Findings from these studies motivated the revision of SDDQ. The entire revised questionnaire can be found in Appendix A.

The revised questionnaire consists of four sections: (1) frequency of engagement, (2) voluntary distraction, (3) involuntary distraction, and (4) habitual distraction. The first three sections are similar to those used in the original SDDQ. The last section was added to investigate the role of habits in driver distraction. This new section will be explained in detail in section 3.2.4. Overall, there are a total of 233 items in the revised SDDQ as this revision is exploratory in nature. An online survey study is currently being conducted outside the scope of this thesis, results of which will be used to select an efficient set of items through factor analysis.

3.2.1 Item Expansion

One of the main changes in the revision of SDDQ was the expansion of the distraction list. The original SDDQ only used seven distractions with items that had generally vague wording, e.g., “manually interacting with a phone (e.g., sending text messages)”. It is possible that the wording of such an item may elicit responses for activities other than the example provided (e.g., using a cell phone as a musical device), thus forcing respondents to narrow down different activities to a single response. For the example provided, the broadness of the statement may generate responses that are biased towards most recent activities rather than the respondents’ overall experience with cell phones. To address this issue, new distraction items referred to specific activities, such as dialling or texting.

The new distractions were based on several sources, including common distractions identified in NHTSA’s crash databases (National Highway Traffic Safety Administration, 2014), Regan et al.’s (2008) taxonomy of driver distraction, and various multi-tasking theories. In particular, Multiple Resource Theory (Wickens, 1984) provides a foundation for understanding driver distraction, as it accounts for the interference produced when performing multiple tasks concurrently. This model posits that the degree to which tasks can be performed effectively at the same time can be predicted by the degree to which they overlap in demand for common resources. For driver distraction, the greater the extent to which a secondary task shares the same resources as driving, the greater the degree of interference that engaging in it will have on driving.

Driving is considered to be primarily a visual-spatial-motor task: drivers must monitor the road, use their spatial working memory to perceive position and nearby vehicles around, and steer, accelerate or brake in response to changing circumstances. Thus, based on multiple-resource models of divided attention, tasks involving visual-spatial-motor input, such as texting, should interfere considerably with driving. On the other hand, auditory-verbal-vocal tasks, such as talking on a hands-free mobile phone, should not interfere with driving, because the resources needed to complete these tasks do not compete with the resources required for safe driving. This concept, however, was recently challenged by studies demonstrating the disruptive effects of hands-free cell phone conversations on driving performance. Findings show that conversing on a hands-free cell phone impairs the recognition memory for objects on the road as well as the detection and reaction to traffic signals, and delays reaction to brake lights (Strayer, Drews, & Johnston, 2003; Strayer & Johnston, 2001). These findings demonstrate that auditory-verbal tasks, although not competing directly with visual or manual resources necessary for driving, can also interfere with it. As a result of these findings, a new framework for conceptualizing sources of driver distraction has emerged which includes cognitive interference as an additional source of distraction (Strayer, Watson, & Drews, 2011). Overall, based on this new framework, impairments in driving arise from three main sources: (1) visual competition, by which drivers take their eyes off the road, (2) manual competition, by which drivers remove their hands from the steering wheel, and (3) cognitive interference, which occurs when attention is directed somewhere other than to the mental processes required for safe driving.

Based on this evidence, a holistic approach was used in selecting the distractions for the revised questionnaire. Distractions included varied in the degree of visual/manual and cognitive workload imposed on the driver. In addition, to keep with Regan et al.'s (2008) taxonomy of sources of driver distraction, new distraction items include technology-based (e.g., adjusting the audio system using voice commands) and non-technology-based tasks (e.g., talking to passengers), as well as tasks internal to the driver (i.e., daydreaming). Similar to the original SDDQ, the revised questionnaire incorporates distractions that are representative of the technologies currently used in vehicles (e.g., radio, navigation systems, and cell phones). However, in contrast to SDDQ's item on phone conversations, where the type of device was not specified, the revised version distinguishes between hand-held and hands-free devices. This distinction aims to capture any differences in willingness to engage in phone-related distractions resulting from legislation differences between the two devices. Some states in the U.S. as well as all provinces in Canada permit the use of hands-free devices while driving. It is possible that this exception alters drivers' attitudes towards engaging in these distractions, due to the sense of safety that it instils.

Although the list of distractions included in the revised SDDQ is not exhaustive, these tasks are believed to be representative of common activities that can lead to driver distraction:

- Phone conversation on hand-held device
- Phone conversation on hands-free device
- Dial a number on a cell phone manually (not available on speed dial)
- Dial a number using voice commands
- Send text messages on a cell phone
- Read text messages on a cell phone
- Read emails on a hand-held device
- Update or check social media (e.g., Facebook, or Instagram) on a hand-held device
- Adjust in-vehicle systems manually
- Adjust in-vehicle systems using voice commands
- Enter an address on a built-in or mounted navigation system
- Enter an address onto a navigation app on a smartphone that is not mounted
- Talk to passengers if there are any
- Listen to any audio entertainment
- Drink a hot beverage
- Personal grooming

3.2.2 Section 1: Frequency of Engagement

The engagement section consists of 16 distractions, measured using a 5-point Likert scale, anchored at 'never', 'rarely', 'occasionally', 'often' and 'very often.' An additional option of 'I don't use this technology' is provided for 12 of the 16 items. This option helps differentiate respondents who own the technology but do not use it while driving from those who do not own it. If a participant indicates that they do not use a particular technology, then items related to this technology is excluded from later sections. Hence, the minimum number of possible items in the questionnaire is 134. For the purpose of scoring, responses on this section are averaged across the 16 items to create an overall section score, excluding those responses of 'I don't use this technology'.

3.2.3 Section 2: Voluntary Distraction

Similar to the original SDDQ, the revised questionnaire continues to rely on the Theory of Planned Behaviour (Ajzen, 1991) for investigating underlying motivations for voluntary distraction engagement. Therefore, this section is composed of questions assessing attitudes, perceived behavioural control, and perceived social norms. Although the constructs assessed remain the same across the two questionnaires, the number of questions used to assess each construct was expanded in the revised questionnaire, thus allowing for the assessment of various dimensions of a single construct. Although this revision may significantly increase the length of the questionnaire, making it more likely to induce fatigue, this revision was thought to be necessary, as a single question may not be sufficient to capture the complexity of a construct.

Attitudes: This revision was particularly valuable for the attitudes construct, as the original SDDQ measured attitudes towards distractions using "I think it is all right to drive and…" which only assesses the negative evaluation of engaging in distractions. However, there are many reasons why drivers may engage in distractions (e.g., convenience). Hence, the revised questionnaire replaces the Likert scale rating of generic statements about attitudes with semantic differential scales. For each distraction item probed, the respondent is asked to choose their position on a scale of 1 to 5 between the paired bipolar adjectives: 'safe' versus 'dangerous', 'pleasant' versus 'unpleasant', and 'wise' versus 'unwise.' Further, the value of convenience, a potential benefit that drivers may associate with engaging in a secondary task (e.g., "it is good use of my time to drive and groom"), and an explicit evaluation of the alternative behaviour (e.g., "I lose respect for people who drive and send text messages on their mobile phone") are probed using 5-point Likert scales, ranging from strongly disagree to strongly agree.

Perceived behavioural control: Similar to the attitudes, perceived behavioural control was measured using a single question (i.e., "I believe I can drive well even when I…") in the original SDDQ. This question was believed to be associated more with risk perception than with the assessment of the perceived ease or difficulty of performing the behaviour of interest. As a result, this section was redesigned in the revised questionnaire to differentiate two kinds of perceived behavioural control: self-efficacy and controllability. *Self-efficacy* is measured by the perceived difficulty of engaging in distractions while driving (e.g., "while driving, I have no difficulty reading emails on a hand-held device"). *Controllability* refers to self-assessment of the driver's ability to control *if and when* they engage in distractions while driving and it is measured using items such as "Circumstances determine if I drive and talk on the phone using a hands-free device".

Perceived social norms: descriptive and injunctive norms. The revised questionnaire continues to distinguish between descriptive and injunctive social norms. *Descriptive norms* refer to how individuals perceive other drivers behave on the road (e.g., "most drivers drive and at the same time read their email on a mobile phone or tablet"). *Injunctive norms* refer to individuals' perceived approval by those who are important to them (e.g., "people who are important to me would approve of me driving and at the same time holding a phone conversation on a hand-held device"). As will be presented later in Chapter 4 as part of the laboratory validation study findings, there were low test-retest reliability issues observed for the injunctive norms subscale of the original SDDQ. These issues were addressed in the revised version by excluding, from the injunctive norms subscale, the distractions that were unlikely to have strong social norms attached to them. These distractions included: read roadside advertisements, visually dwell on roadside accident scenes, and adjust the audio system using controls on the console/voice commands.

3.2.4 Section 3: Involuntary Distraction

In order to capture involuntary distraction, the revised questionnaire examines items in which drivers assess the difficulty of ignoring common distractions. This question is surveyed across 9 different distractions including roadside accident scenes and conversations amongst passengers in the backseat. In addition, respondents are probed on feelings of compulsiveness to engage in cell phone-related distractions using 4 items. Overall, these two questions are measured on a 5-point Likert scale with anchors assigned at ‘not at all’, ‘small extent’, ‘moderate extent’, ‘large extent’, and ‘extremely large extent.’ A score for each question is calculated by averaging the responses across the 9 or 4 items. In addition, this section also probes drivers on how often they find themselves engaging in non-driving related tasks for longer than intended or realized (including being lost in thought), as an indicator of their ability to disengage their attention from these tasks. Five different items are probed using a 5-point Likert scale of frequency ranging from ‘never’ (1) to ‘very often’ (5).

3.2.5 Section 4: Habitual Distraction

One of the most notable revisions to SDDQ is the addition of a habitual distraction section. The revised questionnaire explores habitual distraction around cell phone behaviours, as certain behaviours around these devices may have become automatic due to the prevalence of mobile technology. For example, glancing at the mobile phone to check for updates, which was originally goal-oriented, may have become a habit for some individuals in various contexts and environments.

The revised questionnaire adopts the Self-Report Habit Index (SRHI; Verplanken & Orbell, 2003). Four questions following the SRHI format are used to evaluate four potential cell phone-related habitual distractions: (1) checking cell phone for new notifications, (2) answering a phone call, (3) responding to notifications, and (4) checking navigational system to verify current route. An average for each question is calculated by averaging responses across the 10 items used in the SRHI questionnaire to assess features of habits (e.g., automaticity, lack of control and awareness, and efficiency).

3.2.6 Environmental Context

Drivers' decision to engage in a non-driving task and the amount of attentional capacity they may have in dealing with stimuli in the driving environment largely depend on the context. Driving environments can differ dramatically in the amount of stimuli present, which may influence the level of perceived risk associated with engaging in a secondary task. For example, drivers report being less willing to answer a phone call when approaching a turning manoeuvre (e.g., U-turn or left turn) than when stopped at a traffic signal (Lerner & Boyd, 2005). Providing a context may help drivers to answer questions more accurately. In the revised questionnaire, two different scenarios are used to examine driver responses across high and low workload situations: (1) driving straight along a 4-lane highway in a rural environment where local lanes are divided by a barrier, traffic conditions are low and there is good weather, and (2) driving straight along on a 3-lane urban road with heavy traffic, high pedestrian flow, and where traffic lights are expected. The two scenarios were based on scenarios used in a NHTSA report investigating voluntary distractions (Lerner & Boyd, 2005) and were modified for the purpose of the current research focus. A written description of each scenario was presented with an image representing the driving scenario to provide participants with sufficient detail and a clear image of the environment of interest (See Figures 2 and 3).

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.

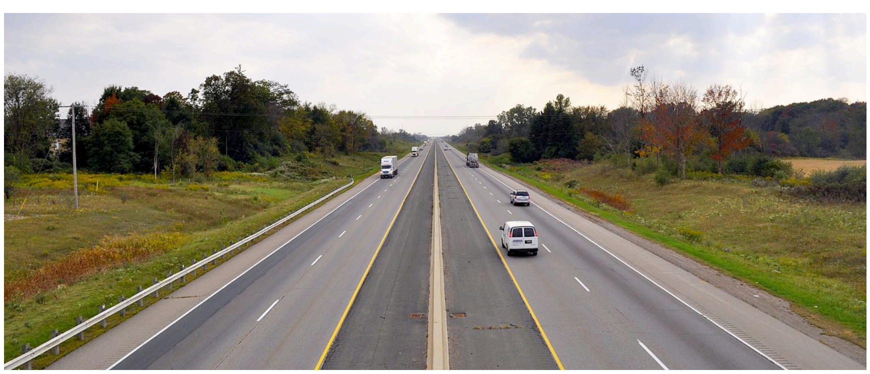

Figure 2: Description of rural scenario presented in the revised questionnaire

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 3: Description of urban scenario presented in the revised questionnaire

Chapter 4

4 Validation Studies on the Original SDDQ

Questionnaires are a common technique for acquiring data. This method allows for the collection of large amounts of data with minimal effort and cost. However, consideration should be given to the questionnaire's design, including wording, appropriateness of content, and length, to ensure that the questionnaire does in fact measure the construct intended upon its development. In addition, the method of administration can lead to bias and affect precision (Streiner & Norman, 2008).

The validity and reliability of SDDQ must be established to ensure that data are useful and meaningful. Litwin (1995b) defined validity as the degree to which items comprising a questionnaire reflect the constructs they were designed to measure (e.g., susceptibility to voluntary and involuntary distraction). Various forms of validity can be used to assess the performance of a questionnaire: content, criterion, and construct validity. Content validity is established through experts' review of the degree to which items comprising the questionnaire measure the desired construct. Criterion validity compares the questionnaires' measures with other well-established measures. This type of validity exists in two forms: (1) concurrent validity, where the questionnaire being examined and the other measures are completed at the same time; and (2) predictive validity, which is concerned with the questionnaire's ability to forecast future responses or behaviours. Finally, construct validity is a measure of how meaningful the questionnaire is for practical use, i.e., generalizable across different times and settings.

To achieve content validity, SDDQ items were constructed based on prevalent distractions: conversations with passengers are reported by NHTSA as the distraction drivers most frequently engage in (Schroeder et al., 2013); cell phone use and in-vehicle technologies are also distractions identified in NHTSA's crash databases (National Highway Traffic Safety Administration, 2014). Furthermore, following the taxonomy from Regan et al. (2008), distractions from different kinds of sources were also included: inside (e.g., in-vehicle technology) and outside (e.g., roadside advertisements and accident scenes) the vehicle;

technology-based (e.g., cell phones) and non-technology based (e.g., passengers); and internal (e.g., daydreaming) and external to the driver. In addition, suggestions brought about by experts in driver distraction, through blind reviews in other publications (Feng et al., 2014a, 2014b), were also incorporated in the questionnaire to enhance its content validity. The other types of validity were assessed through the two studies reported in this chapter.

According to Litwin (1995a), reliability refers to the degree to which responses on a self-report measure are reproducible. Reliability is assessed in three forms: test-retest, alternate-form, and internal consistency. Test-retest reliability is a measure of the stability of responses over time. This form of reliability is typically measured by administering the survey at two different points in time to the same group of respondents. Alternate-form reliability uses different versions (e.g., wording or order of items) of the same questionnaire to assess the same attribute. Internal consistency measures how well a group of items in the questionnaire measures the same construct.

This chapter presents the initial evaluation of the validity of the Susceptibility to Driver Distraction Questionnaire (SDDQ). This evaluation was performed in two steps: an online survey and a laboratory study (Experiment 1). The online survey assessed the internal consistency and concurrent validity of the questionnaire, while the laboratory study was conducted to validate the questionnaire using measures of selective attention and working memory capacity, and to examine test-retest reliability.

4.1 Online Survey

As part of this thesis work, an online survey was conducted to investigate the relationship of SDDQ to well-established self-report measures of unsafe driving behaviours, distractibility, and personality traits of impulsiveness and sensation seeking (see Appendix B for the additional questionnaires), as means to evaluate SDDQ's concurrent validity. The internal consistency of SDDQ was also evaluated.

Over a one-month period, 305 survey responses were collected. Among these, only 254 respondents completed all questions and were thus included in subsequent analyses. The sample of 254 participants consisted of 126 males and 114 females. The age of the respondents ranged from 18 to 60 years. For analysis purposes, the respondents were divided into 3 age groups: young adult (age 18-25, n=125), young mid-age (age 26-40, n=76), and old mid-age (age 41-60, n=39).

Internal consistency was assessed using Cronbach's alpha and the concurrent validity of SDDQ was examined using Pearson product moment correlations to well-established measures of unsafe driving behaviours, personality traits, and attentional capacities. Unsafe driving behaviours were measured using the Manchester Driver Behaviour Questionnaire (DBQ; Reason, Manstead, Stradling, Baxter, & Campbell, 1990). The DBQ is divided into 4 different categories: (1) *aggressive violations* – violations of safe driving associated with aggression; (2) *ordinary violations* – violations of safe driving not related to aggression; (3) *errors* – mistakes that conflict with desired driving goals; (4) *lapses* – unintentional deviations from a planned driving action. To assess the effects of personality, the Arnett Inventory of Sensation Seeking (AISS; Arnett, 1996) and the Eysenck Impulsiveness Questionnaire (I7 Questionnaire; Eysenck, Pearson, Easting, & Allsop, 1985) were used. Finally, items from the distractibility subscale of the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald, & Parkes, 1982) and the Adult Attention Deficit and Hyperactivity Disorder (ADHD) Self-Report Scale (ASRS; Kessler et al., 2005) were used to assess self-reported attentional capacity.

The results were published in the following paper and will not be presented in detail in this thesis. A summary of results is provided in the next section.

> Feng, J., Marulanda, S., & Donmez, B. (2014). Susceptibility to Driver Distraction Questionnaire (SDDQ): Development and relation to relevant self-reported measures. *Transportation Research Record*, *2423*, 26–34.

4.1.1 Summary of the Online Validation Study Results

The internal consistency of SDDQ was found to be moderate to high, with Cronbach's alpha ranging from 0.66-0.80 across the different sections of the questionnaire. Given the relatively small number of items within each section (6-8 items), the moderate-to-high levels of Cronbach's alpha indicate that SDDQ is generally reliable.

Findings showed moderate correlations between self-reported engagement and other unsafe driving behaviours, in particular with aggressive and ordinary violations. Personality traits of sensation seeking and venturesomeness were found to be associated with positive attitudes and beliefs that motivate voluntary engagement in distractions. The study also found that susceptibility to involuntary distraction is related to subjective assessment of cognitive limitations, as measured by the CFQ. Overall, these correlations to existing and well-established measures provided support that SDDQ was useful in differentiating between voluntary and involuntary aspects of distraction. The desired separation between voluntary and involuntary aspects of distraction was evident in that items related to voluntary distraction were associated with unsafe driving behaviours (particularly ordinary and aggressive violations) and personality traits of impulsiveness and sensation seeking, while those related to involuntary distraction were associated with cognitive measures (i.e., driving errors, lapses, and cognitive failures).

Overall, SDDQ fared well against known scales of risky driving behaviours, personality, and cognitive limitations, and its internal consistency was demonstrated to be satisfactory. Further analysis of these data, although outside the scope of this thesis, has shown that the subscales on psychosocial factors (i.e., TPB subscales) are useful in predicting self-reported engagement in voluntary distractions (Chen, Donmez, Hoekstra-Atwood, & Marulanda, in review) providing support for the underlying framework of TPB. Based on the evidence presented above, SDDQ has demonstrated potential to be a useful tool for investigating driver distraction.

4.2 Laboratory Validation Study (Experiment 1)

Up to this point, the validation for SDDQ has been based on other self-report instruments, which, despite their sound psychometric properties, are vulnerable to biases. For this reason, computer-based cognitive tests were incorporated into the validation process, as these tests may provide an objective measure of the constructs targeted in SDDQ. Since SDDQ is divided into a voluntary and an involuntary section, two different tasks were chosen based on the higher order cognitive abilities that were believed to distinctly target the voluntary and involuntary distractions. These tasks were the operation span task (ospan; Turner & Engle, 1989) and a modified flanker task (Lavie & Cox, 1997), respectively.

4.2.1 Voluntary Distraction

Voluntary distraction requires that drivers intentionally engage in a secondary task while driving. This behaviour requires a driver to hold information about the driving task in his working memory (e.g., speed of the car, position on the lane, surrounding vehicle) and, while performing the secondary task, repeatedly update the information based on changes in the environment. Continually updating information in working memory is believed to be governed by the central executive (Miyake et al., 2000).

The ospan task was selected for examining the working memory component of executive function. The ospan task assesses the ability of subjects to maintain memory representations, such as goal states or task-relevant stimuli, in an active state in the face of interference (Kane & Engle, 2002). This task has been previously used as a measure of multi-tasking ability, as it requires that participants simultaneously perform two independent tasks that compete for attentional capacity (Watson & Strayer, 2010), i.e., solve mathematical operations while trying to remember words. As a result of attention's limited capacity (Kahneman, 1973), it is expected that during attention-demanding tasks, performance on one task will suffer in the presence of the other. These findings are evident in driving research. Numerous studies have found that engagement in secondary tasks while driving leads to degraded driving performance and subsequently increased crash risks (Beanland, Fitzharris, Young, & Lenné, 2013; Horberry, Anderson, Regan, Triggs, & Brown, 2006; Ranney, 2008; Wierwille, 1993; Young, Regan, & Hammer, 2007).

4.2.2 Involuntary Distraction

The impact of involuntary distraction on driving performance may vary across individuals depending on drivers' attentional and perceptual capabilities. For example, inhibiting irrelevant stimuli, which is associated with an individual's selective attention capacity, may be a critical ability for safe driving, as individuals with poorer ability to suppress distracting information may be more susceptible to involuntary distraction while driving.

Previous research has shown that salient stimuli capture attention automatically. For example, abrupt appearance, novelty, or motion of objects all capture attention, even when they are irrelevant to the task at hand (Franconeri & Simons, 2003). Furthermore, the ability to suppress irrelevant information or responses varies significantly among individuals (Murphy, 2002). To examine the inhibitory control of participants in suppressing responses to irrelevant information, attentional tasks are often used. One standard attentional task is the flanker task (Eriksen & Eriksen, 1974). The flanker task measures the selective attention capacity of a participant. This task requires a fast response to a centrally presented stimulus that is flanked by distractors that generally activate the same response channel as the target. Studies have found that response times are greater when the flanker stimuli are incongruent as opposed to congruent, indicating that the flanker stimuli are processed even though they are supposedly irrelevant. This is known as the *flanker compatibility effect*.

Lavie & Cox (1997) modified the original flanker task to incorporate elements of visual search, and demonstrated an inhibiting effect of having a high perceptual load on the flanker compatibility effect. Their theory is that visual information is processed in order of relevancy. When the perceptual load of the task exceeds the visual information processing capacity, there are insufficient resources for the irrelevant information to be processed. In the context of flanker task, this means that an individual will be less affected by the flanker stimuli when the perceptual load is high. Relating back to the driving task, the effect of perceptual load on the flanker compatibility effect may translate to driver susceptibility to involuntary distraction in different driving environments, where the visual complexity may vary widely (for example, rural versus urban roads). The current experiment incorporated a modified version of the flanker task as used by Roper et al. (2013) to assess selective attention.

4.3 Methodology

4.3.1 Participants

This experiment was conducted concurrently with a driving simulator study (which is outside the scope of this thesis) and the sample of participants was shared between the studies. Thirty-eight participants (19 females and 19 males) were recruited for this study. Of these participants, 28 were recruited using online advertisements and posts at local communities and the remaining ten were recruited from the pool of participants who took part in the online survey study described in Section 4.1. Participants ranged from 25 to 39 years of age, with a mean age of 29.4 years and a standard deviation of 4.04.

An additional 25 participants (8 females, 17 males) were recruited solely for the cognitive-task portion of the experiment, resulting in a total sample size of 63 participants (27 females and 36 males) for this validation experiment. The additional data served to strengthen the power of the study and for examining the consistency of hypothesized effects with current literature on ospan and flanker task performance. This additional sample size of 25 was determined through a power analysis based on the data collected from the first 38 participants. This additional sample had an age range of 25-38 years old (M=29.76, SD=4.54).

To be eligible for this study, participants had to be between the ages of 25-39 years old, have a valid full driver's license, and have normal or corrected vision. In addition, participants were selected and separated into three categories (i.e., high, medium, and low) based on their level of self-reported propensity to engage in driver distractions, as measured by the self-reported engagement section of SDDQ completed during the screening process. This selection method allowed us to recruit more participants from the tail ends of the engagement distribution. Table 2 shows the breakdown of all participants recruited by gender and the distraction engagement level they were assigned to.

Table 2: Participants categorized by self-report engagement score in driver distractions

Self-report Engagement Group	**Males**	**Females**	**Total**
Participants recruited for both simulated driving and cognitive tasks			
Low: [1, 2.6)	7	7	14
Medium: [2.8, 3.2)	5	6	11
High: [3.5, 5)	7	6	13
Total	19	19	38
Additional participants recruited for only cognitive tasks			
Low: [1, 2.8)	11	6	17
Medium: [2.8, 3.2)	2	1	3
High: [3.2, 5)	4	1	5
Total	17	8	25

4.3.2 Experimental Procedures

4.3.2.1 Cognitive tasks and driving simulator experiment

From the sample of 38 participants that were recruited for the current experiment and the driving simulator study, 28 participants completed an eligibility questionnaire that included SDDQ. The ten additional participants, who were invited based on their participation in the previous SDDQ validation study (the online study), filled out an eligibility questionnaire without the SDDQ component, as they had already completed SDDQ in the previous experiment. All participants were provided with written and verbal information about the experimental tasks and setup, and a consent form was signed prior to beginning the experiment (Appendix B).

All 38 participants first completed the flanker task for assessing selective attention, followed by the simulated driving scenarios, and concluded with the ospan task for assessing working memory capacity. A questionnaire on perceived multi-tasking ability was administered after the ospan task, in addition to a repetition of SDDQ (to assess test-retest reliability). The flanker task demands high attention, thus employing it first ensured that the participants were not fatigued from completing other parts of the experiment. The experiment took approximately 3 hours and participants were compensated $50.

Completing the SDDQ a second time allowed for the assessment of the questionnaire's test-retest reliability. A brief summary of this analysis is presented in this chapter. A complete description of the results on test-retest reliability are presented in the following journal article:

> Marulanda S., Chen, H. Y. W., & Donmez, B. (in press). Test-retest reliability of the Susceptibility to Driver Distraction Questionnaire (SDDQ). *Transportation Research Record*.

4.3.2.2 Additional participants for cognitive tasks experiment

The additional 25 participants who were recruited to complete the cognitive tasks alone followed the same procedures but did not participate in the simulated driving portion of the study (i.e., SDDQ, flanker task, ospan, multi-tasking questionnaire). This smaller study took approximately an hour to complete and participants received $15 as compensation.

4.3.3 Apparatus

For the computer-based attentional tasks, stimuli were displayed on a 24-inch Dell UltraSharp monitor (U2412M), set at a resolution of 1920x1200 pixels. The experiment was controlled using MATLAB software with Psychophysics Toolbox (Brainard, 1997). For the selective attention task, a head/chin rest was used to keep participants at a viewing distance of 22 cm from the monitor to ensure consistent visual angles (Figure 4). The head/chin rest was not used for the ospan task. Participants completed both tasks in a dimly lit room.

Figure 4: Computer-based attentional task setup, including the head/chin rest

4.3.4 Flanker Task Stimuli and Procedures

Figures 5 and 6 depict the stimuli used in the flanker task. The choice of non-targets in this experiment was based on Roper, Cosman, and Vecera (2013). In the low target/non-target similarity condition (low perceptual load), distractors were circles with a gap to one of four sides (see Figure 5). In the high target/non-target similarity condition (high perceptual load), distractors were the letter “L” with equal-length line segments, displayed at 0°, 90°, 180°, or 270° (see Figure 6). However, the original ‘T’ target symbol was replaced by a ‘greater than (>)’ or ‘less than symbol (<)’ pointing to the left or to the right, because participants, during pilot testing of the task, had difficulty agreeing which end of the ‘T’ symbol was the correct side to report. Targets appeared randomly at one of the 6 fixed locations and both targets and non-targets subtended a visual angle of 3°x3°. The flanker, which was the distractor, was the same symbol as the target and could point either to the same direction as the target (congruent flanker) or in the opposite direction as the target (incongruent flanker). Non-targets varied according to the experimental condition (low or high perceptual load).

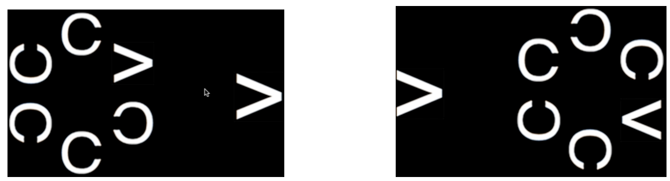

Figure 5: Example displays of the low perceptual load task in the flanker task: Low target/non-target similarity with congruent flanker (Left) and incongruent flanker (Right)

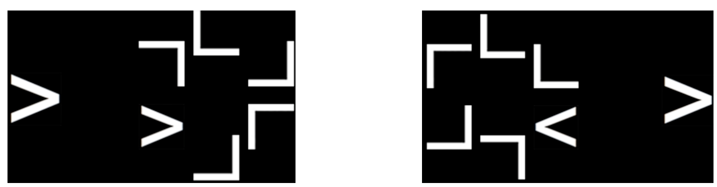

Figure 6: Example displays of the high perceptual load task in the flanker task: High target/non-target similarity with congruent (Left) and incongruent flanker (Right)

The stimuli were presented in a uniform black screen. Each trial began with a fixation cross, subtending a visual angle of 3°x3° at the center of the screen, presented for 600ms. The stimulus display then appeared containing one target, one distractor (flanker), and five non-targets. The flanker subtended a visual angle of 3.48°x3.48° to compensate for the reduced acuity resulting from increased distance and was located 14° to the right or the left of the fixation cross. The position of the flanker on screen was also randomized.

The stimulus display was presented for 100ms. Participants were asked to indicate the identity of the target by pressing a corresponding key on the keyboard, ‘x’ if the target is pointing left or ‘n’ if target is pointing right. The next trial started 1s after a response was made. Participants were instructed to respond both as quickly and as accurately as they could. Accuracy and response time were recorded. Prior to the start of each experimental condition, participants completed a practice session consisting of 10 trials.

The flanker task session was divided into 2 blocks of trials (low vs. high perceptual load condition), each consisting of 3 repetitions of 48 distinct trials (2 target directions x 2 congruencies x 6 target locations x 2 positions of the flanker on the screen), for a total of 144 trials in each block. In each trial, the orientation of the non-targets was randomized, with the restriction that the same non-target orientation never appeared more than twice on each trial. The experiment was counterbalanced by ensuring that half of the participants completed the low-perceptual load block first, and the other half completed the high-perceptual load block first. Participants took a break after each block.

4.3.5 Operation Span Task Stimuli and Procedures

Participants performed an automated version of the ospan task developed by Turner and Engle (1989). This experimental paradigm consists of two concurrent tasks: memorization and arithmetic. Participants were asked to remember a list of 2 to 5 letters, with each letter interspersed with a simple math verification problem (e.g., 6/2 – 1 = 2). For each pair presented, participants were asked to indicate whether the solution provided for the math problem was true or false and to remember the letter following the problem. A trial consisted of a recall test following n number of letter/math pairs, where n ranges from 2 to 5. During the recall test, participants selected the letters in the same order that they were presented from a list of randomly ordered letters.

Prior to the experimental session, participants performed a mandatory practice session of 3 trials of $n = 2$ or 3 or 4 or 5 to ensure they understood the task procedure. In the experiment, there were 4 blocks of trials, with each block containing four trials: $n = 2, 3, 4$, and 5 (letter/math pairs). Within each block, trials were presented in a randomized order that was counterbalanced across the blocks. Each participant received at the end of the ospan task an *absolute ospan score*, which is the sum across trials of the number of letters correctly recalled in the correct position, only for those perfectly recalled trials (Unsworth, Heitz, Schrock, & Engle, 2005). In other words, for each trial or set of words to be recalled, the n associated with that trial is added to the score if the recall was done correctly. The maximum score possible was therefore 4 x (2+3+4+5) = 56.

4.3.6 Perception and Multi-tasking Ability Questionnaire

Participants were administered a brief questionnaire to assess their beliefs of their multi-tasking abilities (Appendix B). Participants ranked their multi-tasking ability on a percent scale anchored at *0%-below average*, *50%-average*, or *100%-above average* relative to people of their same age and of the general population. Similarly, participants reported on the perceived difficulty of performing multiple tasks simultaneously on 5 point Likert scales anchored by *much less difficulty than average* and *much more difficulty than average*, relative to people of their same age and of the general population, respectively. As per Sanbonmatsu et al. (2013), the two percentage estimates of relative ability were averaged to create the primary measure of perceived multi-tasking ability used in the analyses.

4.4 Hypotheses

4.4.1 Involuntary Distraction

Involuntary distraction occurs when a driver engages in a secondary cognitive process because of an inability to ignore irrelevant stimuli. Individuals with poorer ability to suppress irrelevant information (an important aspect of selective attention) may be more likely to be distracted by abrupt stimuli. Hence, the underlying hypothesis about selective attention was that participants who self-report to be prone to involuntary distraction on SDDQ will have more difficulty inhibiting irrelevant information. As a result, they would demonstrate a higher flanker compatibility effect in the flanker task than those who score low on involuntary distraction. The flanker compatibility effect refers to the difference in response times between congruent and incongruent trials. A higher flanker compatibility effect means that participants take relatively longer to perform the incongruent conditions compared to the congruent ones.

It was expected to see a greater flanker compatibility effect when the perceptual load was lower in both groups of participants (i.e., those prone and those not prone to involuntary distraction), but a greater effect in the group prone to involuntary distraction, as they would have more difficulty inhibiting the irrelevant stimuli. When the perceptual load was high, it was hypothesized that not only would the flanker compatibility effect diminish due to the difficulty associated with distinguishing the target from the non-target distractors, but the difference between the two groups of participants would also become smaller or cease to exist. In other words, a significant interaction between distractibility (high vs. low involuntary) and perceptual load on the flanker compatibility effect was expected.

4.4.2 Voluntary Distraction

Voluntary distraction, as defined in this work, requires that a user intentionally engage in a secondary task. Individuals with a greater control of executive attention over multiple tasks may, in general, have a positive experience in multi-tasking situations. Thus, these individuals may perceive themselves as being able to handle multiple tasks and, as a result, be more willing to engage in driver distraction, through the mechanism of perceived control in TPB (Ajzen, 1991). The effective and efficient multi-taskers should be those who are able to exercise a high level of executive control. Therefore, the main hypothesis was that participants who report to be prone to voluntary distraction on SDDQ would perform better (more accurately and more efficiently) in the ospan task than those who report to be less likely to engage in distraction voluntarily. In addition, a significant relation between performance on the ospan task and perceived behavioural control was expected, with those who score higher on the ospan task to report greater ability to drive while distracted.

4.5 Results

4.5.1 Flanker Task

Only trials in which participants responded correctly were included in the response time (RT) analysis, following Roper et al. (2013). RT data were excluded from analyses if they were below 100ms or were more than 2.5 standard deviations above the mean of a participant's data in a particular experimental condition (e.g., congruent and low perceptual load). Additionally, data from participants in any one condition were excluded when their accuracy on that condition was below 60%. Finally, data were normalized using an inverse transformation on the RTs.

In total, 14 data points were excluded from the analyses due to low accuracy in any of the 4 conditions. As data from all 4 conditions were removed from one participant, sample size for analyses went down to 62. 79% of the data deleted belonged to the high perceptual load condition and 64% were from incongruent trials. Data excluded from the high perceptual load conditions averaged at 746.11ms (SD: 526.29), which was 259.49ms longer than the mean of data analyzed for these conditions (Mean= 486.62, SD= 259.77). Data excluded from the low perceptual load conditions had an average of 262.79ms (SD: 82.25), which was lower than the data that were analyzed in these conditions (Mean=384.05, SD=197.15). Excluded data belonged to 3 males and 4 females, with an average age of 31.28 (SD=4.34). Average self-report engagement in this sample was 2.88 (SD=0.53), which seemed close to that of the data analyzed (Mean= 2.83, SD=0.54).

Negative Compatibility Effects (NCE), as described in Bavelier, Deruelle, and Proksch (2000), were found in both perceptual load conditions. Participants showing this effect had higher response times in congruent trials compared to incongruent trials (or negative response time differences for incongruent minus congruent trials). Of the 62 participants whose data were analyzed, 29% showed NCEs in the low perceptual load condition, and 45% in the high perceptual load condition. There were approximately equal numbers of males (16) and females (19) showing this effect, with females concentrated in the low perceptual load condition (12 females out of 18 participants). Self-report engagement scores of these participants tended to be low (Mean=2.80, SD=0.55).

In addition to the four sets of mean RTs, Table 3 also includes the resulting flanker compatibility effects (difference between congruent and incongruent trials) for both high and low perceptual load conditions. A visual representation of the relationship between perceptual load condition and stimulus type (i.e., congruent and incongruent) can be found in Figure 7.

Table 3: Average RT (and standard deviation, ms) for the flanker task conditions and the resulting flanker compatibility effects for low and high perceptual loads

Perceptual Load	Congruency		Flanker Compatibility Effect
	Incongruent	Congruent	
Low	396.93 (193.42)	392.16 (206.53)	4.77
High	462.59 (212.74)	454.96 (200.63)	7.63

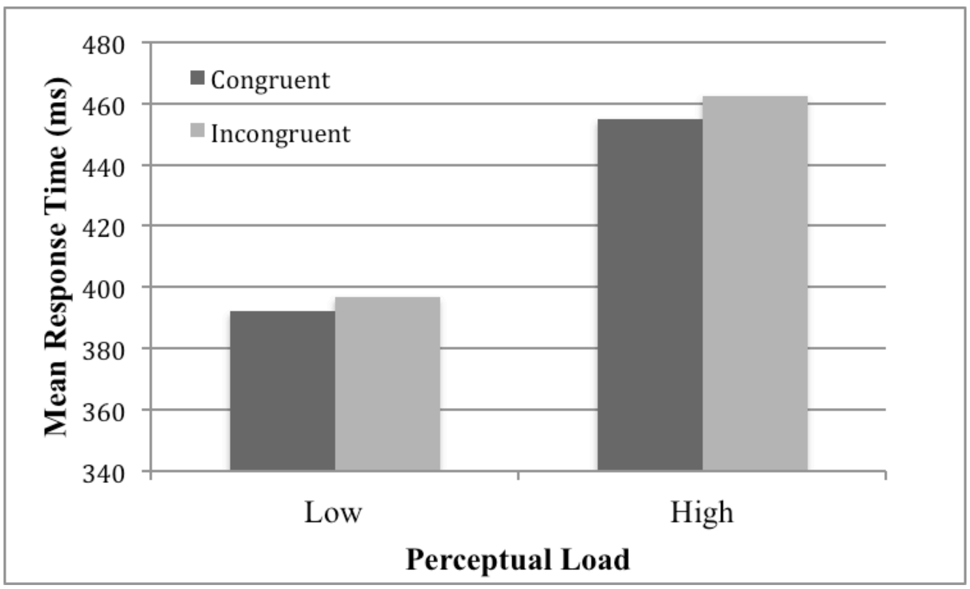

Figure 7: Flanker effect demonstrated in mean response times (RTs) by perceptual load

RTs were analyzed using a 2x2 repeated measures ANOVA with the factors of perceptual load (low vs. high) and congruency (incongruent vs. congruent). There was a significant main effect for perceptual load, $F(1, 58)=98.78$, $p<.0001$, indicating that RTs in the low perceptual load were faster than those in the high perceptual load. There was no significant effect of congruency, $F(1,60)=2.57$, $p=.11$, or of the interaction between perceptual load and congruency, $F(1,55)=0.48$, $p=.49$. However, the particular contrast of interest, the flanker compatibility effect for low perceptual load, was marginally significant with an estimated difference of 13.3ms, $t(55)= 1.66$, $p=.10$.

Error rates were also analyzed using a 2x2 repeated measures ANOVA with perceptual load and congruency as independent factors. Results showed a significant main effect of perceptual load, $F(1,58) = 49.55$, $p < .001$. High perceptual load led to increased error rates as compared to low perceptual load. No other effects reached significance.

Pearson's correlation was used to examine the association between involuntary distraction, as measured by SDDQ and flanker compatibility in the low perceptual condition. Contrary to the hypothesis, the resulting correlation was not significant, r(61)=-.13, p=.32.

4.5.2 Operation Span Task

Based on the perception of multi-tasking ability questionnaire, the mean self-assessed percentage estimate of multi-tasking ability was 60.66 (SD= 17.50), relative to other people of the same age and of the general population. This was significantly higher than average (i.e., 50 percent on the ranking scales), t(60)=4.75, p<.001, indicating that participants tended to estimate their ability to be significantly higher than average. Out of the 61 participants who completed this questionnaire, eight participants estimated that their ability was below average, 22 estimated that they were exactly average, and 31 estimated that they were above average on their multi-tasking ability.

Ospan performance was marginally correlated with perceived multi-tasking ability, r(59)=.23, p=.078. This result suggests that participants who believed that they were more capable than others at multi-tasking may generally be better at doing so, as measured by the ospan task.

In relation to SDDQ, ospan score was analyzed with respect to the three levels of self-reported distraction engagement, as described in Section 4.3.1. Ospan scores were normalized using a squaring transformation to address the negative skew observed in the data. There were no significant differences in ospan scores between participants in any of the groups $F(1,60)$=0.22, p=0.64. This may be the result of a ceiling effect on the task.

Furthermore, there was a significant relation between performance in the flanker task and performance in the ospan task, r(59)=.41, p=.001, suggesting that those who perform well on one of the tasks tend to perform badly on the other. In other words, those who are better at multi-tasking may be worse at suppressing irrelevant stimuli. In addition, no significant correlations were found between performance on the ospan task and the SDDQ measures hypothesized to be relevant (Table 4).

Table 4: Pearson correlations between ospan and measurements of SDDQ (n=61)

Measure 1	***Measure 2***	***Correlation coefficient (p-value)***
Ospan	Engagement	0.09 (0.47)
	Perceived control	0.13 (0.33)

4.6 Summary of Findings of the Test-Retest Reliability of SDDQ

Of the sample recruited for the laboratory experiment, forty-three participants (25 males and 18 females), with an age range between 25-39 years (Mean= 29, SD=4.2), were included in the test-retest analyses. As mentioned earlier, participants completed SDDQ for the first time (test condition) as part of the eligibility questionnaire prior to the study, and once again after the completion of the study (retest condition). The average time between test and retest conditions of SDDQ was 20 days (range: 1 - 83 days, median=8.97).

The ten additional participants who had been recruited from the pool of participants of the online survey study described earlier Section 4.1 were asked to participate by completing SDDQ for a second time. Although this additional sample was small in size, it provided the opportunity to conduct preliminary analysis on the reliability of SDDQ responses across longer periods of time. This sample had a test-retest period of 7.92 months (range: 4.2 - 10.8 months, median=7.78 months). Data from these participants were analyzed separately.

4.6.1 Subscale Reliability

Intra-class correlation coefficients (ICC) (Type 1,1) were computed to assess the test-retest reliability at the subscale level (Weir, 2005). For the sample of 43 participants, who were retested within approximately 20 days on the average, fair to excellent test-retest reliability was demonstrated for most subscales of SDDQ (Engagement ICC=0.77; Attitudes ICC=0.74; Perceived control ICC=0.59; Descriptive social norms ICC=0.63). Only two of the subscales, i.e., injunctive social norms and involuntary distraction, were found to have poor ICCs, 0.35 and

0.37, respectively. Similarly, for the additional 10 participants, who were retested after several months, ICCs for descriptive and injunctive social norm subscales were poor. However, for the remaining subscales of self-reported distraction engagement, attitudes toward distractions, and perceived behavioural control, ICCs in both samples were excellent, good, and fair, respectively.

4.6.2 Item Reliability

Due to the poor ICCs found in the sample of 43 participants for the injunctive social norms and involuntary distraction subscales, items surveyed for these two subscales were investigated separately using weighted kappa statistics (Cohen, 1968). Agreement ratings suggested by Landis and Koch (1977) were used to interpret kappa values: less than 0 are poor, between 0 And 0.2 are slight, between 0.21 and 0.4 are fair, between 0.41 and 0.6 are moderate, between 0.61 and 0.8 are substantial, and between 0.8 and 1 are almost perfect. Weighted kappa statistics were not calculated for the sample of additional 10 participants, due to the small sample size. In general, the reliability of the individual items comprising the injunctive norms and involuntary distraction subscales was between fair and substantial (weighted kappa ranged between 0.23 and 0.64). However, items of ‘read roadside advertisements’ and ‘visually dwell on roadside accident scenes’ had the lowest weighted kappa values, $\kappa=0.37$ and $\kappa=0.35$, respectively, and were thus deemed responsible for the low ICC value in the injunctive social norms scale. It is possible that these items lack strong social norms and are thus not representative of the injunctive social norms construct.

4.7 Discussion

4.7.1 Flanker Task

While the main effect of flanker congruency was not significant, participants showed a flanker difference in the low perceptual load condition of approximately 13ms, meaning it took them that much longer to make a response when the trial was incongruent than when it was congruent. Contrary to the hypotheses, no significant correlations were found between flanker performance and measures of involuntary distractions in SDDQ.

Results for the flanker task may have been affected by changes in the target shape from ‘sideways Ts’, as used by Roper et al. (2013), to ‘ > ‘ (more than) and ‘ < ’ (less than) symbols.

Given that the non-target distractors in the low perceptual load condition are ‘C’s and reverse ‘C’s, the new targets may not have been sufficiently different from the non-target distractors in this condition to elicit a large enough flanker compatibility effect. These changes may have led to the high proportion of participants showing a negative compatibility effect in the low perceptual load condition. According to Bavelier et al. (2000), NCE occurs when attentional resources have been exhausted and selective attention is necessary for target selection. When this occurs, participants are not attending to the target and distractor at the same time, and thus no conflict is brought upon by their opposing representations in the incongruent trials.

This theory may explain our finding that a larger proportion of NCEs occurred in the high perceptual load condition compared to the low perceptual load condition. According to Bavelier et al.’s (2000) theory, when selective attention is needed to locate a target, participants are unable to attend to the target and the distractors simultaneously; thus the effect of opposing representations between the two (as found in an incongruent trial) does not result in a conflicting response as usual. In other words, the perceptual load of the *low* perceptual load condition might have been higher than it was intended to be.

Approximately 40% of those who had a NCE in the high perceptual load condition also had it in the low perceptual load condition, indicating that these participants’ attentional capacity for simultaneously processing targets and non-target distractors went beyond their maximum capacity already in the low perceptual load. These participants may have the lowest attentional capacity in general.

Most of the participants showing NCEs in either condition had lower self-report engagement scores compared to other participants. It may be the case that these participants are aware of their attentional limitations and consequently self-regulate their engagement in distractions while driving. In other words, these participants who demonstrated NCEs might be aware of their lower capacity in selective attention, or lower attentional capacity in general, and possibly limit their own voluntary distractions to focus on the driving task.

4.7.2 Operation Span Task

Findings from the operation span task provide an understanding of the multi-tasking abilities of individuals who are more likely to engage in secondary tasks while driving. Generally, individuals who considered themselves to be better at multi-tasking than the average person, as reported using the multi-tasking ability questionnaire, performed better in the ospan task. This suggests that participants may have a fair assessment of their own multi-tasking abilities.

Lack of significant differences in the ospan score among self-reported engagement levels and perceived behavioural control may be the result of a ceiling effect in the ospan score, meaning that a large proportion of subjects scored very highly on the task. This ceiling effect makes it difficult to discriminate these participants based on their ospan performance. It is possible that the task was not challenging enough for participants in the age range sampled (25-39 years).

Several limitations arose in this study with respect to the cognitive tasks, making it impossible to validate SDDQ with measures of selective attention and multi-tasking abilities. It is possible that the cognitive tasks selected or the manner in which they were altered, rendered them to not be particularly useful for the purposes of the study: results of the ospan task showed evidence of ceiling effects, potentially due to the young age of the participants, and the alteration of the flanker task's target stimuli drastically increased the difficulty of the low perceptual load condition.

Insights gained from this laboratory study were incorporated in the design of a second laboratory study (Experiment 2) to validate the revised SDDQ. This study is described in detail in Chapter 5. In this new study, the number of cognitive tasks was expanded to include new measures of executive function, as individuals within the age of the current sample may show more variability in other executive functions (e.g., shifting and inhibition), thus preventing ceiling effects. To measure updating ability, the n-back task (Kirchner, 1958), a commonly used measure of working memory (Owen, McMillan, Laird, & Bullmore, 2005), was used. Furthermore, the flanker task was again used to measure selective attention; however, this time no alterations were made to the original symbols used by Roper et al. (2013).

4.7.3 Test-retest Reliability

Overall, this study demonstrated that SDDQ has good test-retest reliability for most of its subscales and provided valuable insights for the revision of the injunctive norms and involuntary distraction subscales. Findings from weighted kappa analysis suggest that some distractions used in the injunctive norms lacked strong social norms (i.e., ‘read roadside advertisements’ and ‘visually dwell on roadside accident scenes’), and hence were not appropriate for measuring this construct. Without a firm belief of society’s approval or disapproval associated with engaging in these particular distractions, drivers’ opinions about how they ought to behave are more likely to change over time, resulting in response inconsistencies. Therefore, in the revised SDDQ, only distractions that have strong social norms are included in the injunctive social norms section.

Poor ICC values for the involuntary distraction subscale are thought to be due to a lack of context within SDDQ. Context is an important factor in understanding susceptibility to involuntary driver distraction, as the perception of how distracting a stimulus is may change depending on the environment. This insight was incorporated in the revised SDDQ through the use of two separate road conditions varying in perceptual load (i.e., urban and rural). One of the two scenarios was presented at the beginning of the questionnaire and participants were instructed to respond to all questions based on their experiences in a similar scenario.

It is also possible that vague wording in some of the distractions led to inconsistencies in responses across different periods of time, in particular, items lumping different distractions into a single statement, e.g., ‘manually interact with a phone (e.g., sending text messages).’ These items may have resulted in memory biases, as they can elicit responses for activities besides the one specified in the statement; respondents may base their answers on activities they performed recently rather than their general interactions with cell phones. To avoid such biases, distraction items in the revised questionnaire were designed to prompt specific distractions such as ‘dialling a phone number using voice commands’ and ‘entering text messages on a hand-held device.’

Chapter 5

5 Laboratory Study for Validating the Revised SDDQ (Experiment 2)

This chapter presents the validation of the revised version of SDDQ (Appendix A) that was developed to address the issues found in the previous validation studies (Chapter 4). The aims of the current study were two-fold: first, to investigate the psychosocial factors influencing the decision to engage in distractions while driving. Using the TPB framework, the roles of attitudes, subjective norms, and perceived behavioural control were examined in the prediction of intentions to engage in voluntary distractions. The second aim was to validate the revised questionnaire using measures of executive function. Participants were presented with various tasks designed to measure their selective attention, inhibition, shifting, and updating abilities.

5.1 Methodology

5.1.1 Participants

The sample consisted of 60 participants (31 male and 24 female) with an age range of 21 to 35 years old (M=26.31, SD=3.74). Of the 60 participants recruited for this validation study, 25 were recruited as part of a driving simulator study that was taking place at the same time. The remaining 35 participants were recruited solely for the purpose of this study. The sample was restricted to those participants who met the following eligibility criteria: native English speaker, hold a valid full driver's license (i.e., G license in Ontario), normal or corrected-to-normal vision, and not colour blind.

5.1.2 Experimental Procedure

After reading an information sheet and consenting to participating in the experiment (Appendix C), all participants (i.e., those recruited as part of the simulator study and those recruited for the executive function tasks alone) were asked to complete one of the two versions (i.e., urban scenario or rural scenario) of the revised questionnaire. After the questionnaire, participants were given a colour blind assessment using a 15-plate Ishihara test (Ishihara, 1972) to ensure eligibility for the executive function tasks. Participants who were not colour blind were invited to continue with the executive function tasks.

There were a total of 5 executive function tasks. Participants recruited as part of the simulator study completed 3 of the 5 executive function tasks followed by the simulator study, and then completed the remaining 2 executive function tasks. For the additional participants who did not take part in the simulator study, all 5 executive function tasks were presented consecutively. For both groups of participants, the order of the tasks did not vary: flanker task (Roper et al., 2013), Stroop task (Stroop, 1935), number-letter task (Rogers & Monsell, 1995), n-back task (Kirchner, 1958), and Wisconsin card sorting test (Berg, 1948). The stimuli were presented in a 20.1 inch Dell 2005FPW monitor and their presentation was controlled using the Psychology Experiment Building Language (PEBL) version 0.14 (Mueller, 2014) (Figure 8). Each experimental session took approximately 1.5 hours excluding the simulated driving portion, which took approximately the same amount of time.

Figure 8: Experimental setup for executive function tasks, including head/chin rest used in the flanker task

5.1.3 Revised SDDQ

The revised questionnaire, introduced in Chapter 3, was used to investigate voluntary, involuntary, and habitual driver distraction. The questionnaire collects data on self-reported engagement, TPB constructs (i.e., attitudes, perceived behavioural control, and perceived social norms), habitual distraction, and involuntary distraction. Furthermore, the revised questionnaire presents a written description of a scenario (i.e., rural and urban), alongside an image of a driving environment with similar characteristics, to provide participants with sufficient detail and a clear image of the context in which they must answer the questions. The study was counterbalanced such that half of the participants responded to the urban scenario and the other half responded to the rural scenario. In addition, driving history was collected using questions concerning type of licensure, driving frequency in different environments (e.g., city versus highway), and ages of frequent passengers. Participants were also asked about their tech-savviness and their attitudes on technology adoption.

An additional 8 items from the distractibility subscale of the Cognitive Failures Questionnaire (Broadbent et al., 1982) were included to investigate the association between involuntary distraction and cognitive failures resulting from inattention. Distractibility items in CFQ measure a person's likelihood of committing an error in everyday tasks due to inattention. CFQ has been previously used to assess the role of cognitive failures in traffic crashes (Allahyari et al., 2008) and was found to be positively correlated with ratings of involuntary distraction in our earlier validation study for the original SDDQ (Chapter 4). Each item on CFQ is measured on a frequency scale from 0 to 4 anchored at 'never', 'rarely', 'sometimes', 'often', and 'very often.' Thus, for scoring purposes, a sum score is calculated by adding responses across all items. Higher values correspond to greater distractibility.

5.1.4 Measures of Executive Function Abilities

5.1.4.1 N-Back Task

The n-back task is commonly used as a measure of working memory capacity, as it requires on-line monitoring, updating, and manipulation of remembered information (Owen et al., 2005). The task requires participants to monitor a series of stimuli and to respond whenever a stimulus presented matches the one presented *n* trials previously, where *n* is a predefined number. The current experiment used four conditions to vary working memory load incrementally from zero to three items. In the 0-back condition, participants responded to a pre-specified target letter (e.g., "H"). This condition places no load on working memory, but is instead used as a measure of a participant's sustained attention to the task. In the 1-back condition, the target is any letter that is identical to the one seen immediately previously (i.e., one trial back). For this condition, the participant has to remember the previous letter and assess if it is a match to the current letter she is presented with. Similarly, for the 2-back and 3-back conditions, the target is a letter identical to one presented 2 and 3 trials back, respectively (Figure 9). Therefore, for the 2-back (or 3-back) condition, the participant has to remember the letter that was presented to her 2 (or 3) trials back and assess if it is a match with the current letter. The stimuli consisted of 8 capital letter consonants that were presented on the centre of the screen for 500ms with an inter-stimulus interval of 2500ms. Prior to testing, participants' completed 25 practice trials for each of the 1-, 2-, and 3-back tasks and 10 practice trials for the 0-back task in increasing order of difficulty (0-, 1-, 2-, and 3-back). To ensure that participants understood the tasks, participants were forced to repeat the practice block if their scores were below 75% for either the 0- or the 1-back tasks.

For testing, participants first completed in a random order the four n-back tasks (e.g., 3-, 1-, 0-, and 2-back), with each task itself including the following number of trials completed back-to-back: 25 trials for the 0-back, 26 trials for the 1-back, 27 trials for the 2-back, and 28 trials for the 3-back task. The participants then repeated this procedure one more time (with an additional set such as 1-, 0-, 3-, and 2-back). Target letters appeared 33% of the time for each task. Participants responded to targets by pressing a key on the keyboard (i.e., <left shift key>) and another key (i.e., <right shift key>) for non-targets. Accuracy was calculated as the proportion of correct responses (i.e., hits and correct rejections) of all trials within each n-back condition:

1. Hit: responded "yes" to an n-back target
2. Correct rejection: responded "no" to a non-target

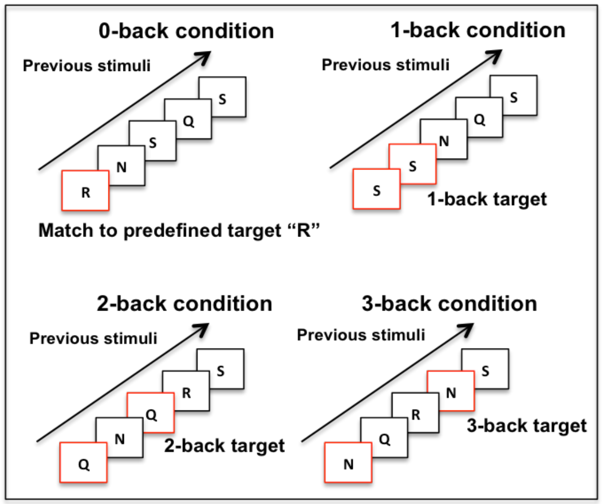

Figure 9: n-back task conditions

5.1.4.2 Number-Letter Task

The number-letter task is used as a measure of shifting abilities by examining the time and error costs resulting from reconfiguring mental processes when shifting from one task to another (Gold, Powell, Xuan, Jicha, & Smith, 2010; Miyake et al., 2000). The current experiment used a modified version of the number-letter task designed by Rogers and Monsell (1995) that was implemented by Miyake et al. (2000). A number-letter pair (e.g., "E3") was presented in one of four quadrants on the computer screen. If the number-letter pair was presented on the top two quadrants participants were required to indicate whether the letter was a consonant (i.e., G, K, M, R) or a vowel (i.e., A, E, I, U), and if the pair was presented on the bottom two quadrants, participants indicated whether the number was odd (i.e., 3, 5, 7, 9) or even (i.e., 2, 4, 6, 8). For the first block of 32 trials (plus 10 practice trials), the number-letter pairs were presented only on the top two quadrants, alternating from left to right quadrant in each trial. In the next block of 32 trials (plus 10 practice trials), the number-letter pairs were presented only on the bottom two quadrants, again alternating from left to right quadrant in each trial. For the final block of 128 trials (plus 24 practice trials), the number-letter pairs were presented in a clockwise rotation across the quadrants. Thus, in the first two blocks, no task switching was required, whereas in the last block, 64 trials involved switching and 64 did not. The stimuli were presented for a maximum of 5 seconds and had a response-stimulus interval of 150ms. Participants responded to each stimulus by pressing the <left shift key> for vowels and odd numbers and <right shift key> for consonants and even numbers.

Reaction times (RTs) were calculated for all trials. Performance was measured as the difference between the average RTs of the trials in the third block that required a mental shift (trials from the upper left and lower right quadrants) and the average RTs of the trials from the first two blocks in which no shift was necessary. RTs for trials with errors as well as on trials following errors were eliminated. In addition, only RTs greater than 200ms were analyzed, and from those, RTs greater or less than three times the standard deviation of a participant's mean RT for each block (i.e., top quadrants alone, bottom quadrants alone, and all quadrants rotating clockwise) were excluded from further analysis, as per Miyake et al. (2000).

5.1.4.3 Wisconsin Card Sorting Test

Shifting ability was assessed using Berg's card sorting test (Berg, 1948), which is a version of the Wisconsin card sorting test, provided by Mueller and Piper (2014). The Wisconsin card sorting test is one of the most frequently used measures of cognitive flexibility, which is the ability to alter responses in the presence of changing circumstances (Diamond, 2013; Monchi, Petrides, Petre, Worsley, & Dagher, 2001). Participants are presented with four stimulus cards. The objects on the cards can differ in colour (red, green, yellow, or blue), quantity (1, 2, 3, or 4), and shape (triangle, star, cross, or circle) (Figure 10). In each trial, participants are provided with an additional card and asked to choose which one of the four original cards conforms to the same category as the additional card. The correct answer depends upon a classification rule (i.e., quantity, colour, or shape), which is not explicitly provided to the participants. Instead, participants must figure out the classification rule based on feedback provided to them ("correct" or "incorrect") after sorting each card. The additional card is presented for a maximum of three seconds. If no response is provided within that time, the phrase 'too slow' appears on the screen. The classification rule changes after 8 cards are consecutively sorted under the correct rule. Although participants are aware that the category might change, they are not explicitly told the number of correctly sorted cards that must be achieved prior to the change. The task finishes when a participant completes 9 different rules or 128 trials, whichever comes earlier. Prior to testing, participants practice with 30 cards. To complete the practice, participants must correctly sort 5 cards for 3 categories (1 of shape, 1 of number, and 1 of colour).

The dependent variable was a measure of perseverative errors, which refer to the number of times participants fail to change the sorting principle after a category change, but instead continue to use the previous sorting rule.

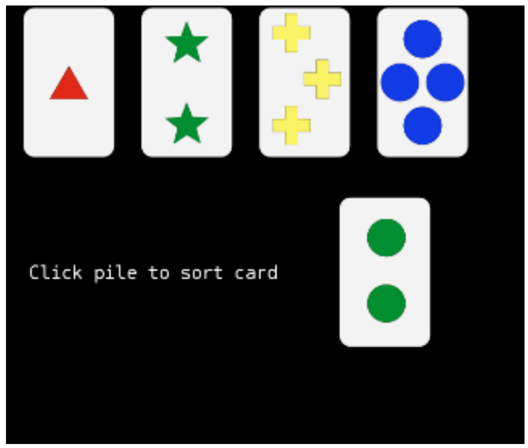

Figure 10: Screenshot from the PEBL computerized version of the Wisconsin Card Sorting Test

5.1.4.4 Flanker Task

The flanker task (Roper et al., 2013) was used to examine the inhibitory control of participants by examining their ability to suppress responses to irrelevant information. This paradigm is the same as the flanker task used in Chapter 4, but slight modifications were included to address the issues that were found with the previous version of the task used in Experiment 1.

Figures 11 and 12 depict the stimuli used in the flanker task. The choice of targets and non-targets in this experiment was based on Roper et al. (2013). In the low perceptual load condition, distractors were incomplete circles with a gap to one of four sides (Figure 11), while in the high perceptual load condition, distractors were the letter "L" with equal-length line segments, displayed at 0°, 90°, 180°, or 270° (Figure 12). Both the target and non-targets subtended a visual angle of 3°x 3°. Unlike the previous version of the task used in Experiment 1, where targets were changed to lower than- and greater than-signs, the current experiment used the original target symbols used by Roper et al. (2013). The target was a ‘sideways T’ pointing to the left or to the right, which randomly appeared at one of the 6 fixed locations. The distractor could be congruent (i.e., point in the same direction as the target) or incongruent (i.e., point in the opposite direction as the target). Non-targets varied according to the experimental condition (low or high perceptual load).

Figure 11: Example displays of the low perceptual load condition in the revised flanker task: Low target/non-target similarity with incongruent flanker (Left) and congruent flanker (Right)

Figure 12: Example displays of the high perceptual load condition in the flanker task: High target/non-target similarity with congruent flanker (Left) and incongruent flanker (Right)

Participants sat approximately 55 cm from the monitor in a dimly lit room. For each session, the stimuli were presented on a uniform white screen. The stimulus display then appeared containing one target, one distractor (flanker), and five non-targets. The flanker subtended a visual angle of 3.48°x 3.48° to compensate for the reduced acuity resulting from increased distance and was located 3.14° to the right or the left of the centre of the screen. The position of the flanker on screen was also randomized. The stimulus display was presented for 100ms. Participants were asked to indicate the identity of the target by pressing a corresponding key on the keyboard, <left

shift key> if the head of the target 'T' was facing left or <right shift key> if the head of the target 'T' was facing right. The next trial started 1s after a response was made. The participants had to provide a response for the next trial to begin. Participants were instructed to respond as accurately and as quickly as they could. Accuracy and response time were recorded. Prior to the start of each experiment condition (e.g., low perceptual load), participants completed a practice session consisting of 6 trials.

The flanker task session was divided into 2 blocks of trials (low vs. high perceptual load condition), each consisting of 96 trials, i.e., 2x48 distinct trials (2 target directions x 2 congruencies x 6 target locations x 2 positions of the flanker on the screen). On each trial, the orientation of the non-targets was randomized, with the restriction that the same non-target orientation never appeared more than twice in each trial. The experiment was counterbalanced by ensuring that half of the participants completed the low perceptual load block first and the other half completed the high perceptual load block first.

The dependent variable was the difference in reaction time in the low perceptual load trials where the flanker was pointing in the opposite direction as the target (incongruent) and trials where the flanker was pointing in the same direction as the target (congruent). Mean correct reaction times were computed for each participant as a function of perceptual load condition and congruency. Reaction times beyond ±2.5 SD from each participantXcondition mean were excluded from the analysis following Roper et al. (2013).

5.1.4.5 Stroop Task

The Stroop task was developed to measure inhibitory control (Stroop, 1935). Participants completed a block of 120 trials consisting of 3 different types of trials: (1) 48 neutral trials in which the stimuli was a string of asterisks (i.e., ****) printed in different colour fonts (red, blue, green, and yellow), (2) 48 incongruent trials, in which a colour word was printed in a different font (e.g., red printed in yellow font), and (3) 24 congruent trials in which a colour word was printed in the same font colour (e.g., red printed in red font) with the different trial types intermixed (i.e., non-blocked). Participants responded using the '1', '2', '3', and '4' keys on the keyboard, which corresponded to a font colour (i.e., 1= red, 2= blue, 3= green, 4= yellow). The keys were marked using coloured stickers representing the corresponding colour.

Prior to testing, participants practiced the mapping of the keys to the colours. This practice block consisted of 16 trials (4 trials for each font colour) of neutral stimuli presented in random order, following the constraint that no particular colour was presented twice in a row. To ensure that participants had memorized the mapping of the keys, they were required to achieve an average accuracy score greater than 85%. In the case that they did not achieve this threshold, they had the chance of repeating the practice block a second time. Following this block, participants were provided with a second practice block of 15 trials, this time containing all three types of stimuli (5 congruent, 5 incongruent, and 5 neutral) with varying font colours.

As per Miyake et al. (2000), only correct trials longer than 200ms were analyzed. The dependent measure was the difference in average reaction times between the trials in which the word and the colour were incongruent and the trials that consisted of asterisks.

5.1.5 Hypotheses

Based on the TPB framework, it was expected that higher self-reported engagement in distractions would be related to positive attitudes towards distractions, higher perceived behavioural control, and positive perceived social norms (i.e., descriptive and injunctive) for engaging in distractions while driving. In addition, the recently added measure of habitual distraction was expected to be associated with self-reported engagement in distractions, as repeated engagement in a behaviour is required for the development of a habit. In addition, a possible relation between habitual distraction and ratings on the involuntary distraction scales of the revised SDDQ was expected, as responses to stimuli associated with a habitual behaviour are often unintentional and difficult to inhibit.

In terms of the relationship between executive functions and the revised questionnaire, it was hypothesized that lower levels of inhibition ability would be related to greater susceptibility to involuntary distractions. In particular, lower abilities to inhibit irrelevant stimuli, as measured by the flanker task, would correlate with reports of difficulty ignoring distractions while driving. Similarly, inhibition of a dominant response, which is partially responsible for the Stroop interference effect, was expected to relate to drivers' reports of compulsion to engage in distractions; interference resulting from the inability to inhibit dominant responses may relate to drivers' difficulty overriding strong urges to engage in distractions.

In addition, it was expected that people who report higher perceived behavioural control and higher engagement in distractions would have better updating and shifting abilities. This hypothesis stems from the expectation that drivers who have better abilities to maintain information about different tasks in working memory and flexibly switch from one task to another may perceive themselves as being better able to multi-task, and hence will do so more often.

Finally, stronger cell phone habits were expected to relate to lower performance on the Stroop task, as indicated by larger interference effects. It is possible that individuals who form stronger habits around cell phones may have difficulty inhibiting responses to stimuli as their actions are governed more strongly by automatic responses. This may be reflected in their performance on the Stroop task because inhibiting the dominant response of reading a word when required to name the ink colour is necessary for successfully completing this task.

5.2 Analyses

Five participants were excluded from the analyses due to failure to comply with the instructions of the executive function tasks. Consequently, the following results reflect the final sample size of 55 participants, 29 in the rural scenario, and 26 in the urban scenario.

Independent t-tests were used to investigate the differences in responses across the different scenarios (i.e., urban and rural) as well as gender differences on responses to the questionnaire and on performance in the executive function tasks. Although some differences were found between the scenarios, which will be discussed in detail later in this chapter, these were not sufficiently practical to justify analysing the scenarios separately. Therefore, responses on the scenarios were merged to create a single set of data. Pearson product moment correlations were used to investigate associations between the scales of the questionnaire, as well as associations between the scales and measures of executive function.

A small distribution of accuracy scores on the 0-, 1-, and 2-back conditions suggest the presence of ceiling effects, making it difficult to differentiate individuals' working memory abilities at these levels of difficulty. As a result, only performance on the 3-back condition was used in subsequent analyses.

Negative Compatibility Effects (NCE), introduced in Chapter 4, were also present in the revised version of the flanker task but to a much lesser extent. Only four participants, compared to 18 participants in Experiment 1, exhibited this pattern of responding on the low perceptual load condition, meaning that reverting to the original target symbols (i.e., sideways Ts) introduced by Roper et al. (2013) dramatically reduced the perceptual load compared to the first laboratory study (Chapter 4).

5.3 Results

5.3.1 Driving History and Experiences with Technology

Of the 55 people analyzed, 51% reported driving a few days a week to almost every day. In terms of kilometers driven within the last year, 30% reported driving under 5,000km and 47% reported driving between 5,001 km and 25,000 km. Of the remaining 22%, half drove above 25,000km, and the other half did not know. In addition, 41% of participants reported driving alone often to very often, although while driving with passengers, 63% reported that 20-35 year olds are their most frequent passengers. Finally, 61% of participants reported spending less than 40% of their driving time driving on the highway, while ~50% reported spending more than 60% of their driving time driving in the city.

In terms of experiences with technology, tech-savviness was measured on a 10-point scale anchored at “very inexperienced” to “very experienced.” Scores on this scale ranged from 7 to 10 (M=8.81, SD=1.00), with only 7 participants rating themselves below a 7. Technology adoption had a larger variation, ranging from scores of 2 to 10 (M=6.76, SD=2.25) on a scale anchored at “avoid technology as long as possible” to “try new technology as soon as possible.” These questions were designed and used by Reimer, Mehler, Dobres, and Coughlin (2013) to assess drivers’ experiences with technology for evaluating a voice-command interface.

5.3.2 Reliability of the Revised SDDQ

To ensure that participants were responding adequately to the questionnaire, one question that was presented at the beginning of the questionnaire was repeated at the end of the questionnaire. The question required participants to rate themselves on a scale of 1 to 10 on their “tech-savviness”. Responses on the two questions were compared using a weighted kappa coefficient to calculate the inconsistencies in the responses to the two questions. Results of this analysis revealed that the data collected was substantially reliable (kappa=0.77,CI: 0.58-0.95), as suggested by Landis and Koch (1977).

The internal consistency of the questionnaire's scales was assessed using Cronbach's alpha. For almost all scales, alpha met the well-established threshold of 0.70 (Nunnally, 1978). The first exception was the semantic differential measure of attitudes related to updating social media (α=0.66), listening to audio entertainment (α=0.62), and talking to passengers (α=0.51). Second, within the involuntary distraction scale, items measuring instances of looking away for longer than intended also failed to meet the desired threshold (α=0.67).

Due to the issues previously identified with the injunctive norms and the involuntary distraction scales (Chapter 4), all questions within these scales were subjected to further analyses to ensure that the new items used to measure these constructs were suitable. Results of the additional analyses on the injunctive norms scales revealed that the items 'listen to audio entertainment (e.g., radio, audiobooks)' and 'talking to passengers if there are any' were negatively associated with the overall measure of the scale, showing that engaging in these behaviours while driving may be perceived as being acceptable and approved by others. Furthermore, it was recommended that dropping items of 'talk to passengers if there are any' and 'talk on the phone using a hands free device (e.g., Bluetooth headset)' from the scale would increase alpha from 0.84 to 0.85. However, such a small increase did not justify dropping the items from subsequent analyses, as these items may reveal some of the underlying reasons for driver's engagement in distractions.

Similarly, within the involuntary distraction subscales, analyses showed that within the subscale of compulsiveness to respond to distracting stimuli, dropping the item 'read an advertisement fully once you see it' would result in an increase of alpha from 0.80 to 0.86, and within the subscale measuring instances of looking away for longer than intended, dropping the item 'how often do you turn off your cell phone/tablet before driving to reduce distractions' would result in an increase in alpha from 0.67 to 0.80. This latter item was included to reflect a driver's potential compensatory behaviour resulting from her knowledge of her own distractibility. Due to their lack of relation to other items in their respective subscales, these two items were removed from all subsequent analyses. Despite their removal from the subscales, these items should continue to be used in the revised questionnaire, as they may provide valuable information regarding drivers' compensatory behaviours as well as distractions related to roadside advertisements.

Due to the small sample within the current analyses (n=55), the results presented above are exploratory in nature and represent only a small portion of an ongoing study, outside the scope of this thesis, aimed at finding the items within the revised questionnaire that most efficiently capture voluntary, involuntary, and habitual distractions. Thus, for the purposes of this thesis, no other analyses were performed on the reliability the questionnaire.

5.3.3 Descriptive Statistics for Scales of the Revised SDDQ

Some of the distractions used in the revised questionnaire are legally banned and hence it is expected that drivers would perceive these distractions to be dangerous regardless of their actual demand and effect on crash risks. The remaining distractions are legal and as a result may be perceived by drivers to pose less of a risk or no risk, and may thus generate different engagement patterns and beliefs. Given this distinction, the following analyses were conducted by splitting distractions into two levels: illegal and legal. Since the majority of our respondents were from Ontario, Canada, the legality was identified using traffic laws of this province. This categorization enabled us to take a deeper look into participant responses rather than analyzing them at an aggregate level for all distractions surveyed.

- **Illegal:** This category includes distractions that have been identified as being illegal in the province of Ontario under section 78.1 of the Highway Traffic Act, R.S.O. 1990, c. H.8. This category is composed of the following 7 distractions: (1) talk on the phone using a hand-held device, (2) dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone), (3) manually enter text messages on a hand-held device (e.g., cell phone), (4) read text messages on a hand-held device (e.g., cell phone), (5) read emails on a hand-held device (e.g., cell phone), (6) update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone), and (7) manually enter an address into a navigational app on a smartphone that is NOT mounted inside the vehicle.

- **Legal:** This level consists of 9 legal distractions: (1) talk on the phone using a hands-free device (e.g., Bluetooth headset), (2) dial a number using voice commands, (3) adjust the audio system using voice commands, (4) manually enter an address on built-in or mounted navigational system, and (5) groom (i.e., comb hair, apply makeup, floss) (6) manually adjust the audio system using controls on the console, (7) chat with passengers if there are any, (8) listen to audio entertainment (e.g., radio, audiobooks), and (9) drink a hot beverage.

Means and standard deviations of SDDQ measures for the distractions within each of the two categories are presented in Table 5. Results show that participants report engaging more often in legal distractions compared to illegal distractions. In addition, they report more negative attitudes, lower perceived behavioural control, lower normative pressures for illegal distractions compared to legal distractions. In addition, they also report that those who are important to them would approve less of them engaging in illegal distractions compared to engaging in legal distractions. Note that lower scores in the semantic differential scales represent more positive attitudes.

Table 5: Means and standard deviations obtained from the laboratory study on revised SDDQ scales relating to different distraction categories

Revised SDDQ Scale	**Illegal Mean (SD)**	**Legal Mean (SD)**
Engagement	1.89 (0.66)	2.96 (0.53)
Attitudes 1 (Semantic Differential Scales)	4.21 (0.65)	2.60 (0.44)
Attitudes 2 'It is good use of my time to drive and…'	1.85 (0.82)	3.38 (0.62)
Attitudes 3 'I lose respect for people who drive and…'	3.75 (0.83)	1.87 (0.44)
Self-efficacy 'While driving, I have no difficulty…'	2.37 (0.92)	3.66 (0.58)

Controllability 1 'I decide whether I drive and…'	4.17 (1.00)	4.33 (0.62)
Controllability 2 'Circumstances determine if I…'	2.88 (1.19)	2.98 (0.88)
Descriptive norms 'Most drivers in such a scenario drive and…'	3.21 (0.68)	3.80 (0.49)
Injunctive norms 1 'People who are important to me would approve of me driving and…'	1.85 (0.79)	3.44 (0.58)
Injunctive norms 2 'People who are important to me would think it is okay for me driving and…'	1.89 (0.67)	3.66 (0.51)

Means and standard deviations of the remaining SDDQ measures are presented in Table 6.

Table 6: Mean and standard deviation of habitual and involuntary distraction scales of the revised SDDQ

Revised SDDQ Scale	Mean (SD)
Cell phone-related habits	3.05 (0.78)
Involuntary 1 Difficulty ignoring distractions	2.68 (0.66)
Involuntary 2 Compulsiveness to respond to cell phone alerts	2.81 (1.02)
Involuntary 3 Looking away for longer than intended	2.17 (0.58)

5.3.4 Correlations between the Scales of the Revised SDDQ

Correlations between self-reported engagement and TPB constructs for each distraction category are presented in Appendices D and E. Results of these analyses were as expected within the TPB framework for both categories. Engagement in distractions while driving was found to be associated with facilitators of voluntary distraction; drivers who reported engaging more frequently in distractions reported higher self-efficacy, which is an aspect of perceived behavioural control, as measured by perceived difficulty to drive while engaging in distractions (illegal: r(53)=0.76, *p*<.001; legal: r(53)=0.37, *p*=.01) and often held more positive attitudes towards engaging in distractions while driving (illegal: r(53)=-0.65, *p*<.001; legal: r(53)=-0.46, *p*<.001), as measured by semantic differential scales of pleasantness, safety, and wisdom. As mentioned earlier, higher scores on the engagement section represent more frequent engagement, while lower scores on the semantic differential scales represent more positive attitudes towards distractions. Therefore, the correlation coefficients between these two measures were generally negative. Only drivers reporting frequent engagement in illegal distractions perceived (higher) normative positive pressures for engaging in distractions from other drivers, r(53)=0.31, *p*=.02. Further, drivers reporting frequent engagement in illegal distractions perceived higher approval from significant others, as measured by the item 'while driving, people who are important to me would think it is okay for me to drive and...', r(53)=.26, *p*=.050, while those reporting frequent engagement in legal distractions reported higher approval from significant others, as measured by the item 'while driving, people who are important to me would approve of me driving and...', r(53)=0.27, *p*=.04. Finally, lower controllability, as measured by the item 'circumstances force me to drive and at the same time...' was associated with frequent engagement in illegal distractions, r(53)=0.58 *p*<.001.

Correlations between the remaining scales (i.e., involuntary and habitual distractions) are presented in Appendix F. Findings of theses analyses reveal that drivers reporting greater habitual distractions also reported greater difficulty ignoring distractions, r(53)=0.31, *p*=.02, feelings of compulsiveness to respond to cell phone alerts, r(53)=0.53, *p*<.001, and frequent instances of looking away for longer than intended, r(53)=0.49, *p*<.001.

5.3.5 Relations between Executive Function Tasks and Scales of the Revised SDDQ

This section presents the results of the correlational analyses between the executive function tasks and the scales of the revised SDDQ. Mean scores and standard deviations for performance on the five executive function tasks are presented in Table 7. The results of the correlational analyses between these tasks and the scales of the revised SDDQ are presented in the following sections.

Table 7: Mean and standard deviation of executive function task performances

Executive function task	Measure	Mean (SD)
Flanker task	Difference in reaction time averages between congruent and incongruent conditions	26.24 msec (19.40)
Number-letter task	Difference in reaction time averages between switch and non-switch conditions	353.82 msec (184.46)
3-back	Accuracy rate (percentage)	75.75% (10.94)
Wisconsin card sorting test	Frequency of perseverative errors	13.31 (4.43)
Stroop task	Difference in reaction time averages between neutral and incongruent conditions	134.32 msec (85.35)

5.3.5.1 Correlations of Engagement and Voluntary Distraction Scales to Measures of Executive Function

Correlations between scales of the revised SDDQ and measures of executive function for items of the two distraction categories are presented in Appendices D and E. It was hypothesized that drivers who performed well on the n-back, the number-letter task, and the WCST would report higher frequency of engagement in distractions across both categories and higher self-efficacy. However, contrary to our hypothesis, no significant relationships were found between these constructs and the aforementioned tasks. Drivers who reported higher frequency of engagement in illegal distractions ($r(53)=0.41$, $p<.001$) as well as those reporting higher self-efficacy for engaging in legal distractions had lower performances on the Stroop task (i.e., greater difference) ($r(53)=.29$, $p=.03$). These findings suggest that engagement in cell phone-related distractions may be due to an inability to inhibit prepotent responses, while engagement in legal distractions, although possibly due to lower inhibition levels, may be modulated by drivers' self-efficacy mechanism.

5.3.5.2 Correlations between Involuntary Distraction Scales of the Revised SDDQ and Executive Function Measures

There were two separate hypotheses for the involuntary distraction scale of the revised questionnaire. First, it was expected that performance on the Stroop task would be related to compulsiveness to engage in cell phone-related distractions. Second, it was hypothesized that performance on the flanker task would be associated with greater difficulty ignoring distractions. Correlations between involuntary distraction scales and measures of executive function can be found in Appendix F. As expected, drivers who reported greater feelings of compulsiveness to respond to cell phone alerts also tended to have difficulty inhibiting responses, as measured by lower performance on the Stroop task, r(53)=0.28, *p*=.04. However, contrary to our hypothesis, there was no significant relationships between the flanker task and responses on the involuntary distraction section. An interesting finding pertained to items related to looking away from the road for longer than intended. Higher reported instances of this behaviour were associated with lower performance on the WCST, r(53)=0.28, *p*=.04, suggesting that participants who have difficulty shifting mental sets also tend to have difficulties flexibly shifting between different tasks while driving.

Significant correlations were found between responses on the CFQ and two scales of the involuntary distraction section. Greater reported frequency of cognitive failures was associated with greater difficulty ignoring distracting stimuli, r(53)=0.36, *p*=.01, and greater instances of looking away for longer than intended, r(53)=0.36, *p*=.01 (Appendix F). These findings highlight the influence distractibility can have on driving.

5.3.5.3 Correlations between Habitual Distraction Scales and Executive Function Measures

Several associations were found between habitual distractions and executive function measures, as defined by performance on the executive function tasks and scores on CFQ (Appendix F). Drivers who reported more habitual distractions tended to perform more poorly on the n-back task, r(53)=-0.33, *p*=.01, the Stroop task, r(53)=032, *p*=.02, and the WCST, r(53)=0.27, *p*=.050, suggesting that people with lower working memory abilities, as well as higher difficulty in inhibiting responses and shifting mental sets, may tend to report greater cell phone habits.

Finally, habitual engagement in distractions was also associated with greater cognitive failures, as measured by CFQ, r(53)=0.42, $p<.001$.

5.3.6 Differences between Urban and Rural Scenarios

Two different scenarios were introduced in the revised SDDQ, which varied in perceptual demand. The analyses revealed a significant difference in attitudes for illegal distractions, with these distractions being perceived more negatively (i.e., dangerous, unpleasant, and unwise) when driving in a rural scenario (M=4.39) than when driving in an urban scenario (M=4.00) (t(53)=-2.28 $p=0.03$). It is possible that drivers' attitudes towards engaging in these distractions are influenced by the speed difference between the scenarios (i.e., greater speed in rural environments). Furthermore, controllability scores also differed across scenarios for the legal distractions, with drivers perceiving greater control over the decision to engage in these distractions when driving in a rural scenario (M=4.55) than when driving in an urban scenario (M=4.08), t(53)=-2.89, $p=0.01$).

5.3.7 Gender Comparisons in Executive Function Tasks and Scales of the Revised SDDQ

No gender differences were found on performance on any of the executive function tasks. However, there were significant differences between males and females on various scales of the questionnaire. Males reported higher engagement in illegal distractions (M=2.06) than females (M=1.67), t(53)=2.20, $p=.03$, and tended to have more positive attitudes towards engaging in these distractions (M=4.04) compared to their female counterparts (M=4.42), t(53)=-2.25, $p=.03$. In addition, males reported greater self-efficacy on illegal distractions (M=2.68) (t(53)=3.06, $p<.01$) than females (M=1.97). Similarly for legal distractions, males reported higher levels of self-efficacy (M=3.80) than females (M=3.49). However, this relationship did not reach significance (t(53)=1.96, $p=.06$). Finally, males also had lower controllability scores on illegal distractions (M=3.27) than females (M=2.36), t(53)=2.97, $p<.01$. Further, females reported greater normative pressures from other drivers on legal distractions (M=3.97) than males (M=3.67), t(53)=-2.29, $p=.03$.

5.4 Discussion

This chapter presented the results of the validation of the revised version of SDDQ using various measures of executive function. In addition, the TPB framework was used to investigate the influence of attitudes, perceived social norms, and perceived behavioural control on intentions to engage in distractions.

5.4.1 Internal Consistency of the Revised SDDQ

In general, results of the validation study indicate that the questionnaire appears to be a promising measure of voluntary, involuntary, and habitual engagement in distractions while driving. The internal consistency of almost all subscales was above the acceptable threshold level. However, attitudes within the semantic differential scales for items of updating social media, talking to passengers, and listening to audio entertainment were the exception. ‘Talking to passengers’ and ‘listening to audio entertainment’ were rated as pleasant and safe but unwise activities to engage in while driving, hence leading to inconsistencies within the three scales. Although the drivers rated ‘updating social media’ as being unpleasant and dangerous, their responses were not as negative for the scale assessing wisdom. These results suggest that there are many dimensions to drivers' attitudes toward distractions and their evaluations of these dimensions are not always consistent. This inconsistency may lead to conflicting motivations to engage in a distraction while driving.

Further analyses on the injunctive social norms and involuntary distraction scales were performed to investigate whether the changes made to these scales successfully addressed the issues presented in Chapter 4. Results of these analyses revealed that two items within the involuntary distraction section were responsible for the low internal consistency of two of the subscales: ‘read an advertisement fully once you see it’ in the compulsiveness to respond to distractions subscale and ‘turn off your cell phone/tablet before driving to reduce distractions while driving’ in the subscale measuring instances of looking away for longer than intended were not highly correlated with other items on the subscales. Due to the small sample size of the current experiment (i.e., N=55), these items were removed from the correlation analyses to the executive function tasks. Despite their removal from the analyses, these items remain valuable to the understanding of individual differences in susceptibility to distractions and their efficacy will be further analyzed at a later stage with a larger sample size.

Similarly, for the injunctive social norms scale, discrepancies occurred due to the majority of items being perceived as unacceptable by others, while only a few items being perceived as the exception. Positively perceived items included talking on a hands-free device, dialling with voice commands, drinking a hot beverage, talking to passengers, and listening to audio entertainment. These findings are extremely valuable as they reveal drivers' perceptions of social norms for some common distractions. Finally, drivers' injunctive norms regarding hands-free devices are consistent with their attitudes that talking on hands-free devices is safer than doing so in hand-held devices. It is possible that this difference is due to legislation (such as in Ontario, Canada, where many of our survey respondents reside in) that permits the use of hands-free devices while condemning the use of hand-held devices.

5.4.2 Efficacy of the Theory of Planned Behaviour

The TPB was shown to be a useful framework for understanding some of the underlying motivators for engaging in driver distraction. Most of the relations between scales of the revised SDDQ were as expected: self-reported driver distraction engagement was associated with positive attitudes towards engaging in secondary tasks while driving, greater perceptions of the ability to drive while distracted, and positive perceptions of social norms, both descriptive and injunctive, for engaging in distractions.

An interesting finding relates to the importance of controllability in drivers' intention to use a mobile phone while driving. Drivers reporting greater engagement in cell phone behaviours while driving tended to assign responsibility for doing so to outside circumstances rather than to themselves. It is possible that this behaviour is related to the normative pressure to respond to cell phones alerts. Cell phones have become a critical aspect of people's social interactions, as well as a business tool that enables contact with clients on the move (Eost & Galer Flyte, 1998). A recent survey from the Automobile Association (2013) reports that 15% of drivers feel pressured to answer their hands-free work mobile phone while driving and 7% feel pressured to pick up their hand-held work mobile phone while driving. Normative pressure to use cell phones can also be present outside of work circumstances. According to the Jed Foundation (2010), 85%

of college students reported that it is necessary to answer a text message immediately and nearly 60% reported spending time analyzing the reason for a non-response if someone does not immediately reply to a text message they have sent. Although this situation occurs outside the driving environment, the social pressure surrounding the behaviour may still be sufficient to cause young drivers to use their cell phones while driving. As a result of the intense normative pressure, drivers may feel that using their phones while driving is beyond their control.

Further analyses on the revised SDDQ revealed that lower feelings of controllability were associated with feelings of compulsiveness to check a cell phone after receiving a notification and greater perception of approval for engaging in cell phone-related distractions while driving. Feelings of compulsiveness may be associated with the need to be socially connected at all times, while normative pressure for responding may be related to the desire to avoid violating social conventions. In addition, a greater perception of approval when engaging in an aberrant behaviour is consistent with research showing injunctive norms as a significant contributor to intentions to use cell phone while driving in the presence of time commitments (Walsh et al., 2008). Unfortunately, lower feelings of controllability may prevent drivers from taking the initiative to change their unsafe behaviour, as they may perceive themselves as passively responding to the circumstances rather than being in control of the behaviour. Future interventions should encourage others to reward drivers who do not answer messages or calls while driving, and therefore reinforce the idea that others do not expect drivers to jeopardize their safety and that of others on the road by answering their phone.

Another key finding shows that close to 50% (n=25) of respondents reported strong cell phone-related habits. However, contrary to the initial hypothesis, there was no significant association between habits and self-reported engagement in cell phone-related distractions. This might be attributed to the generally low reports of engagement in cell phone-related distractions. It is possible that social desirability bias was an issue within the study, as participants completed the questionnaire in a laboratory setting while in the presence of an experimenter. As a result, it is possible that participants may have underreported their engagement in distractions while driving. Consequently, more research is needed to determine the role of habits on engagement in cell phone-related distractions in a driving context.

5.4.3 Validation Using Executive Function Tasks

As expected, lower performance on the Stroop task was associated with cell phone-related habits and compulsiveness to respond to cell phone alerts. In addition, lower performance on the Stroop task was also related to the frequency of engagement in cell phone-related distractions. Together, these findings suggest that lower levels of inhibition ability may be a contributing factor to the use of cell phones while driving. Similar findings were reported by Ophir, Nass, and Wagner (2009) when examining information processing styles of chronic media multi-taskers. This study revealed that multi-taskers were more susceptible to interference than their counterparts and less effective in suppressing the activation of irrelevant task sets. The rapid increase of media technology in society, along with the normative pressure of responsiveness, are placing new demands on cognitive processing and creating expectations of constant multi-tasking. It is possible that constantly performing several tasks simultaneously has resulted in an inability to focus on a single task. Interestingly, drivers with low performance on the Stroop task tended to assign responsibility for engaging in cell phone-related distractions to outside circumstances rather than to themselves, suggesting that these drivers are unaware that their engagement may be due to poor inhibition abilities.

The relation between habits and lower inhibition ability also highlights the automatic nature of habits, providing support for the newly added construct of habitual distraction to the revised SDDQ. Furthermore, cell phone-related habits were also positively associated with performance on the WCST, potentially demonstrating the rigidity of habitual behaviours. Overall, it appears that the SHRI scale could be a useful method of assessing the strength of cell phone habits in the context of driving.

Contrary to our hypotheses, results showed no association between the n-back task, the number-letter task, and WCST to self-reported engagement or perceived behavioural control. As a result, it is not possible to conclude whether drivers' engagement in distractions is due to knowledge of their working memory and shifting abilities, or rather due to an overestimation of these.

In terms of the involuntary distraction scale, it was expected that drivers who had more difficulty suppressing irrelevant distractions, as measured by the flanker task, would report greater difficulty ignoring distractions. Contrary to our hypothesis, there was no significant association between these constructs. The absence of this relationship may be due to a lack of sensitivity of the involuntary distraction items for detecting the effect of selective attention on driving. When prompted, most participants reported that they had no difficulty ignoring the distractor item during the flanker task even though results showed significant compatibility effects, suggesting that participants cannot accurately judge the extent to which they are distracted. Accordingly, their responses to the involuntary distraction items are most likely inaccurate. Thus, it is necessary to reword the questions comprising the involuntary distraction section to facilitate the participants' judgment of their selective attention abilities.

Furthermore, although outside of the scope of the hypothesis, poorer performance on the WCST was related to greater instances of looking away for longer than intended. This finding suggests that mental flexibility may be necessary to shift rapidly from performing a secondary task to the primary task of driving.

5.4.4 Gender Effects

Although no gender effects were found for performance on the executive function tasks, there were significant differences across the revised questionnaire. Results showed that males reported higher frequency of engagement in illegal distractions than females. This difference may be due to the fact, as shown in our results, that males held more positive attitudes for engaging in such distractions and perceived themselves as having a greater ability to drive while engaging in both distractions. Interestingly, males also tended to perceive outside circumstances to have a greater influence on their engagement in illegal distractions than females did. Together, these findings provide other potential reasons for males' increased risk for motor vehicle crashes besides well-known factors of sensation seeking (Jonah, 1997), violations of safe driving (De Winter & Dodou, 2012), and lower motivations to comply with traffic rules (Yagil, 1998). There was also a significant difference for descriptive social norms, with females reporting that they perceive other drivers to engage more often in legal distractions.

5.4.5 Study Limitations

Various limitations were present in this study. First, it is possible that fatigue might have affected participants' responses to the questionnaire and performance on the cognitive tasks, especially since many of them also completed a driving simulator study. In addition, social desirability bias might have played a role in participants' underreporting of unfavourable behaviours such as texting and driving. We also recognize that the categorization of distractions into legal and illegal distractions may not be fully representative of the larger population, as legislation on cell phone distractions vary across provinces and states. In addition, the categorization may also not represent the crash risks associated with engaging in these distractions.

With regards to the addition of context to the questionnaire, it is possible that, even after providing a written and visual description of the driving scenarios, respondents may have still had difficulty picturing their behavior while driving in that environment; in particular, inexperienced drivers who may have limited experiences driving in different environments. In this case, the mental model of their distracted experiences, in any particular scenario, may not accurately reflect their behavior, making them more likely to report what they think their experiences should be rather than their actual experiences. In regards to the executive function tasks, the limited number of relations found between the voluntary distraction scale and measures of shifting and updating may indicate that although some drivers may have the capacities to engage in distractions, they may still choose to avoid doing so. However, contrary to voluntary distraction in which an intentional component is critical in determining drivers' engagement in distractions, involuntary distraction is directly guided by drivers' ability to inhibit irrelevant stimuli, thus a lack of correlation with executive tasks of inhibition may indicate a lack of sensitivity by this scale.

Overall, this study revealed that the revised exploratory questionnaire is a promising tool for understanding drivers' susceptibility to voluntary, involuntary, and habitual distractions. In addition, many of the findings highlight the role that normative pressure of both multi-tasking and constant responsiveness play in drivers' engagement in cell phone distractions. These findings can be used to inform the development of mitigation strategies to target attitudes and social norms around cell phone behaviors. Finally, findings of this study provided support for the addition of the habitual distraction section to the revised SDDQ. Further research will focus on reducing the number of questions on the questionnaire through factor analysis to reduce fatigue and increase response rate, as well on validating the questionnaire using measures of distracted driving behaviors.

Chapter 6

6 Conclusion

The research presented in this thesis aimed at developing a psychometrically-sound questionnaire to examine drivers' proneness to different types of distractions (i.e. voluntary, involuntary, and habitual distractions). More specifically, the thesis presented the findings of multiple studies examining the validity and reliability of the newly developed SDDQ.

The validation and refinement of SDDQ started with an online survey that was conducted to assess its internal consistency as well as its construct validity by comparing SDDQ responses to well-established measures of unsafe driving behaviours, personality, and cognitive failures. Findings of this study revealed moderate internal consistency and good concurrent validity. Most importantly, the desired separation between voluntary and involuntary distraction was successful, as items related to voluntary distraction were associated with personality traits of impulsiveness and sensation seeking, while those related to involuntary distraction were associated with self-report cognitive measures. Furthermore, findings supported the use of TPB as a framework for understanding drivers' underlying motivations for engaging in voluntary distractions. Drivers reporting frequent engagement in distractions tended to hold positive attitudes towards distracted driving, had greater perceived behavioural control, and perceived more normative pressures and approval for engaging in distractions while driving.

A laboratory study (Experiment 1) was later used to validate SDDQ through objective measures of the constructs assessed within the questionnaire (i.e., susceptibility to voluntary and involuntary distraction). Performance on two measures of executive function i.e., selective attention and working memory capacity, were correlated with responses on SDDQ. However, due to ceiling effects and alterations to the cognitive tasks, it was impossible to determine if the items comprising SDDQ accurately reflected the constructs of interest. In spite of these issues, the laboratory study provided the opportunity to assess the test-retest reliability of SDDQ. Consistency of responses on SDDQ across time was satisfactory, with most scales having good to excellent test-retest reliability. However, the scales of injunctive norms and involuntary distraction appeared to be the weakest. In terms of the injunctive norms scale, some of the items used within the scale did not adequately reflect the construct of interest due to lacking strong social norms. In addition, driving context was also lacking, making it difficult for respondents to consistently narrow down their behaviours across different environments. These, and other issues are discussed in detail in Marulanda et al. (in press).

Insights discovered in these validation studies as well as other findings from the literature were used to improve SDDQ. Expanding on recent findings by Bayer & Campbell (2012) showing that habits are a contributing factor for engagement in texting and driving, the revised version of SDDQ incorporated a new component of habitual distractions in addition to the already existing voluntary and involuntary distraction sections. Furthermore, distraction items were expanded to include activities that would impose various degrees of visual/manual and cognitive demand, as were the number of questions used to assess the constructs of interest. Finally, two versions of the questionnaire were developed, each with a different scenario (i.e., urban and rural), to assess differences in self-reported engagement based on the environment.

A laboratory study (Experiment 2) was conducted to validate the revised SDDQ. Internal consistency checks and correlations to performance on various measures of executive function were used as a means to understand the role of individual differences in cognition on drivers' susceptibility to voluntary, involuntary, and habitual distractions. This study used Miyake et al.'s (2000) framework of the central executive to determine the best measures for validating each of the sections of the revised SDDQ. The cognitive tasks chosen were meant to reflect three main components of the central executive—Inhibition, Shifting, and Updating. Based on findings of Experiment 1, the flanker task was redesigned and incorporated as a measure of Inhibition abilities. The other tasks included the Stroop task, the number-letter task, the n-back task, and the Wisconsin card sorting test.

In general, the revised questionnaire appears to have excellent internal consistency, with scales exceeding the acceptable Cronbach's alpha threshold. Results of Experiment 2 provided support for the use of the Theory of Planned Behaviour to understand the underlying motivations for drivers' voluntary distracting behaviours. Self-reported engagement in distractions while driving appears to be motivated by positive attitudes, high perceived behavioural control, and positive perceptions of social norms surrounding distracting behaviours. These findings are extremely valuable, as they provide specific areas to address in the development of mitigation strategies against driver distraction.

Contrary to expectations, no relationship was found from the scales of self-reported engagement and self-efficacy to measures of working memory and shifting abilities. Thus, it is impossible to say whether drivers who engage more frequently in distractions do so as a result of greater updating and shifting capacities. Interestingly, analyses of the executive function tasks revealed an automatic component to engagement in cell phone-related distractions. Lower performance on the Stroop task was moderately associated with frequent engagement in cell phone distractions and cell phone-related habits. These findings suggest an automatic component for engaging in cell phone distractions while driving. In addition, they provide support for the new habitual distraction section, as they demonstrate that the section is able to capture automaticity of behaviours. Additional support for the habitual distraction section comes from the WCST. Drivers who reported more cell phone-related habits tended to have greater perseverative errors. This finding potentially highlights the rigid nature of habits, as perseveration is generally regarded as a measure of cognitive inflexibility.

Finally, higher reports of involuntary distraction were also associated with deficiencies in inhibition abilities, as measured by the Stroop task, meaning that participants who had more difficulty inhibiting prepotent responses tended to report greater compulsiveness to respond to cell phone alerts while driving. This finding suggests that strong feelings of compulsiveness to engage in cell phone distractions may lead to doing so involuntarily. Furthermore, there were no significant associations between the flanker task and measures of involuntary distraction, in particular to the difficulty associated with ignoring distracting stimuli. It is possible that people have a great deal of difficulty accurately judging their distractibility levels or that the flanker task is not relevant to driver distraction.

6.1 Contributions to Research and Application

This thesis presents a new framework for understanding driver distraction by distinguishing intentional engagement in distractions from unintentional engagement. In addition, unintentional engagement is further divided into distraction brought about by innate mechanisms common to all humans and acquired habits. Although analyses within this thesis do not include correlations between responses on SDDQ to measures of actual driving behaviours, which is a necessary step to fully validate the questionnaire, they still further the understanding of driver distraction. Having a psychometrically sound SDDQ would be a valuable contribution to driver distraction research, as it can further the understanding of drivers' susceptibility to different types of distraction which can be used to evaluate new in-vehicle technology with respect to its influence on each type of distraction. In addition, this understanding can help guide distraction mitigation strategies that target individual drivers' needs, thus increasing their effectiveness. This measure can also help recruit participants from the tail end of a distribution of susceptibility to each distraction, significantly decreasing the time and resources necessary to investigate the effects of different types of distractions on driving performance. Finally, a valid SDDQ can help understand the social and psychological facilitators for engaging in driver distraction, as many of these are not easily observed (e.g., attitudes).

6.2 Research Limitations

It should be noted that due to its self-report nature, the validity of SDDQ is limited to respondents' introspective ability, their understanding of the rating scales, and their social and memory biases. Most predominantly, as a self-report measure of aberrant behaviour, socially desirable responding was likely to bias respondents, potentially leading to under-reporting in some items, especially those regarding the use of cell phones, which are legally banned in the U.S. and Canada for certain types of interactions. In addition, recruitment of the sample through online posts may have introduced self-selection bias, as it is possible that people who chose to take part in the study may have differed in their motivations or characteristics from those who chose not to participate. In addition, several of the participants recruited also completed a driving simulator experiment. Thus, it is possible that their responses to the questionnaire may have been affected by their experiences in our laboratory. It is also possible that respondents may have suffered fatigue due to the length of the revised questionnaire as well as their participation in the cognitive tasks and the driving simulator experiments. Finally, due to the large number of tests that were conducted, it is possible that family-wise error may have affected the results of the current experiment, and it is therefore recommended that these tests be conducted using a larger sample size along with corrections for overall Type I error.

Despite the promising results, further validation of the questionnaire with respect to distraction behaviour frequency and responses to involuntary distractions is still necessary. However, this process is beyond the scope of this thesis and will be discussed in a future publication. This step would be a key component to the validation process as it may provide evidence that the questionnaire on its own can represent drivers' voluntary distraction, as well as clarify whether drivers can accurately judge and self-report their ability to ignore distractions while driving. The questionnaire's habitual distraction section should also be validated with behavioural measures. One possible way of doing so consists of observing the number of glances drivers' make towards their cell phone in the absence of a notification.

6.3 Future Research

Future research will focus on creating a more concise version of SDDQ through the use of factor analysis. This analysis will identify the best items for capturing voluntary, involuntary, and habitual distraction, thus significantly shortening the questionnaire. This in turn will help prevent future studies from being confounded by participant fatigue issues. Finally, based on findings from the final laboratory study, the involuntary section may be revised to increase its sensitivity in detecting the role of selective attention on driving.

Furthermore, the predictive validity of SDDQ will be established using performance in a driving simulator with a self-paced secondary task, as well as in the presence of potentially involuntary distractions. Data collected from these studies will be subjected to rigorous analysis to continue to establish the validity and reliability of the questionnaire.

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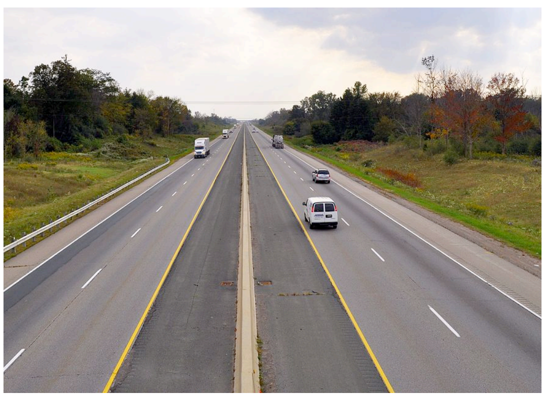
Appendices

Appendix A: Revised SDDQ

Instructions: In the following section we ask you to answer questions in the context of the scenario depicted below. Think back about your experiences over the last year while driving in similar scenarios. Please answer according to your actual experience rather than what you think your experience should be. Some of the questions may appear to be similar, but they do address somewhat different issues. Please read each question carefully.

[The participant would be presented with one of the two driving scenarios below]



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.

SECTION 1: Frequency of Engagement

(Section headings, e.g., Frequency of Engagement, Attitudes, were not presented to the participant).

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?	**I don't use this technology**	**Never**	**Rarely**	**Occasionally /Sometimes**	**Often**	**Very often**
talk on the phone using a hand-held device						
talk on the phone using a hands-free device (e.g., Bluetooth headset)						
dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)						
dial a phone number using voice commands						
manually enter text messages on a hand-held device (e.g., cell phone)						
read text messages on a hand-held device (e.g., cell phone)						
read emails on a hand-held device (e.g., cell phone)						
update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)						
manually adjust the audio system using controls on the console						
adjust the audio system using voice commands						
manually enter an address on a built-in or mounted navigational system						
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle						
chat with passengers if there are any						
listen to audio entertainment (e.g., radio, audio books)						
drink a hot beverage						
groom (i.e., comb hair, apply makeup, floss)						

SECTION 2: Voluntary Distraction

Semantic Differential Scales for Measuring Attitudes

For this page: Please answer each of the following questions by circling the number that best describes your opinion. For example, if you were asked to rate "The Weather in Toronto" on the following scale,

good:____1____:____2____:____3____:____4____:____5____: bad

1 would correspond to good, 5 would correspond to bad, and 3 would correspond to neither good nor bad.

For me, driving in a similar environment and…	
talking on the phone using a hand-held device is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
talking on the phone using a hands-free device (e.g., Bluetooth headset) is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
manually entering text messages on a hand-held device (e.g., cell phone) is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
reading text messages on a hand-held device (e.g., cell phone) is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
reading emails on a hand-held device (e.g., cell phone is)	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
updating social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone) is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
manually entering an address on a built-in or mounted navigational system is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
manually entering an address into a navigation app on a smartphone that is NOT mounted inside the vehicle is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
chatting with passengers if there are any is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
listening to audio entertainment (e.g., radio, audio books) is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
drinking a hot beverage is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
grooming (i.e., comb hair, apply makeup, floss) is	Pleasant:__1__: __2__ : __3__ : __4__ : __5__: Unpleasant
For me, driving in such a scenario and	
talking on the phone using a hand-held device is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
talking on the phone using a hands-free device (e.g., Bluetooth headset) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
dialling a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
dialling a phone number using voice commands is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
manually entering text messages on a hand-held device (e.g., cell phone) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
reading text messages on a hand-held device (e.g., cell phone) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous

reading emails on a hand-held device (e.g., cell phone) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
updating social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
manually adjusting the audio system using controls on the console is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
adjusting the audio system using voice commands is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
manually entering an address on a built-in or mounted navigational system is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
manually entering an address into a navigation app on a smartphone that is NOT mounted inside the vehicle is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
chatting with passengers if there are any is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
listening to audio entertainment (e.g., radio, audio books) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
drinking a hot beverage is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
grooming (i.e., comb hair, apply makeup, floss) is	Safe:__1__: __2__ : __3__ : __4__ : __5__: Dangerous
For me, driving in such a scenario and	
talking on the phone using a hand-held device is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
talking on the phone using a hands-free device (e.g., Bluetooth headset) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
dialling a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
dialling a phone number using voice commands is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
manually entering text messages on a hand-held device (e.g., cell phone) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
reading text messages on a hand-held device (e.g., cell phone) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
reading emails on a hand-held device (e.g., cell phone) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
updating social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
manually adjusting the audio system using controls on the console is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
adjusting the audio system using voice commands is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
manually entering an address on a built-in or mounted navigational system is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
manually entering an address into a navigation app on a smartphone that is NOT mounted inside the vehicle is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise

chatting with passengers if there are any is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
listening to audio entertainment (e.g., radio, audio books) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
drinking a hot beverage is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise
grooming (i.e., comb hair, apply makeup, floss) is	Wise:__1__: __2__ : __3__ : __4__ : __5__: Unwise

Attitudes

For this and the following page: Please indicate to what extent you agree or disagree with each statement by marking the box that represents your opinion. Please continue to use the scenario described earlier as the context for these statements.

While driving, it is good use of my time to drive and	**I don't use this technology**	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
talk on the phone using a hand-held device						
talk on the phone using a hands-free device (e.g., Bluetooth headset)						
manually enter text messages on a hand-held device (e.g., cell phone)						
read text messages on a hand-held device (e.g., cell phone)						
read emails on a hand-held device (e.g., cell phone)						
update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)						
groom (i.e., comb hair, apply makeup, floss)						
listen to audio entertainment (e.g., radio, audio books)						
drink a hot beverage						

I lose respect for people who drive and	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
talk on the phone using a hand-held device					
talk on the phone using a hands-free device (e.g., Bluetooth headset)					
dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)					

dial a phone number using voice commands					
manually enter text messages on a hand-held device (e.g., cell phone)					
read text messages on a hand-held device (e.g., cell phone)					
read emails on a hand-held device (e.g., cell phone)					
update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)					
manually adjust the audio system using controls on the console					
adjust the audio system using voice commands					
manually enter an address on a built-in or mounted navigational system					
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle					
chat with passengers if there are any					
listen to audio entertainment (e.g., radio, audio books)					
drink a hot beverage					
groom (i.e., comb hair, apply makeup, floss)					

Self-efficacy

While driving, I have no difficulty…	**I don't use this technology**	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
talk on the phone using a hand-held device						
talk on the phone using a hands-free device (e.g., Bluetooth headset)						
dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)						
dial a phone number using voice commands						
manually enter text messages on a hand-held device (e.g., cell phone)						

read text messages on a hand-held device (e.g., cell phone)						
read emails on a hand-held device (e.g., cell phone)						
update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)						
manually adjust the audio system using controls on the console						
adjust the audio system using voice commands						
manually enter an address on a built-in or mounted navigational system						
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle						
chat with passengers if there are any						
listen to audio entertainment (e.g., radio, audio books)						
drink a hot beverage						
groom (i.e., comb hair, apply makeup, floss)						

<u>Descriptive Social Norms</u>

Most drivers in such a scenario drive and:	**Strongly disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
talk on the phone using a hand-held device					
talk on the phone using a hands-free device (e.g., Bluetooth headset)					
dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)					
dial a phone number using voice commands					
manually enter text messages on a hand-held device (e.g., cell phone)					
read text messages on a hand-held device (e.g., cell phone)					
read emails on a hand-held device (e.g., cell phone)					

update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)					
manually enter an address on a built-in or mounted navigational system					
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle					
chat with passengers if there are any					
listen to audio entertainment (e.g., radio, audio books)					
drink a hot beverage					
groom (i.e., comb hair, apply makeup, floss)					

Injunctive Social Norms

While driving in such a scenario, people who are important to me would approve of me driving and	**Strongly disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
talking on the phone using a hand-held device					
talking on the phone using a hands-free device (e.g., Bluetooth headset)					
dialling a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)					
dialling a phone number using voice commands					
manually entering text messages on a hand-held device (e.g., cell phone)					
reading text messages on a hand-held device (e.g., cell phone)					
reading emails on a hand-held device (e.g., cell phone)					
updating social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)					
manually entering an address on a built-in or mounted navigational system					

manually entering an address into a navigation app on a smartphone that is NOT mounted inside the vehicle					
chatting with passengers if there are any					
listening to audio entertainment (e.g., radio, audio books)					
drinking a hot beverage					
grooming (i.e., comb hair, apply makeup, floss)					

While driving in such a scenario, people who are important to me would think it is okay for me to drive and	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
talk on the phone using a hand-held device					
talk on the phone using a hands-free device (e.g., Bluetooth headset)					
dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)					
dial a phone number using voice commands					
manually enter text messages on a hand-held device (e.g., cell phone)					
read text messages on a hand-held device (e.g., cell phone)					
read emails on a hand-held device (e.g., cell phone)					
update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)					
manually enter an address on a built-in or mounted navigational system					
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle					
chat with passengers if there are any					
listen to audio entertainment (e.g., radio, audio books)					
drink a hot beverage					
groom (i.e., comb hair, apply makeup, floss)					

Controllability

Instructions: For the following questions, please indicate to what extent you agree or disagree with each statement. You DO NOT have to base your answers on the scenario described above.

I decide whether I drive and	I don't use this technology	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
talk on the phone using a hand-held device						
talk on the phone using a hands-free device (e.g., Bluetooth headset)						
dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)						
dial a phone number using voice commands						
manually enter text messages on a hand-held device (e.g., cell phone)						
read text messages on a hand-held device (e.g., cell phone)						
read emails on a hand-held device (e.g., cell phone)						
update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)						
manually adjust the audio system using controls on the console						
adjust the audio system using voice commands						
manually enter an address on a built-in or mounted navigational system						
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle						
chat with passengers if there are any						
listen to audio entertainment (e.g., radio, audio books)						
drink a hot beverage						
groom (i.e., comb hair, apply makeup, floss)						

Circumstances determine if I	I don't use this technology	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
talk on the phone using a hand-held device						
talk on the phone using a hands-free device (e.g., Bluetooth headset)						
dial a phone number (not available through speed dial) using the key pad of a hand-held device (e.g., cell phone)						
dial a phone number using voice commands						
manually enter text messages on a hand-held device (e.g., cell phone)						
read text messages on a hand-held device (e.g., cell phone)						
read emails on a hand-held device (e.g., cell phone)						
update social media (i.e., Facebook, Instagram or Twitter) on a hand-held device (e.g., cell phone)						
manually adjust the audio system using controls on the console						
adjust the audio system using voice commands						
manually enter an address on a built-in or mounted navigational system						
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle						
chat with passengers if there are any						
listen to audio entertainment (e.g., radio, audio books)						
drink a hot beverage						
groom (i.e., comb hair, apply makeup, floss)						

SECTION 3: Involuntary Distraction

Instructions: For the following questions, please indicate to what extent you agree or disagree with each statement. You DO NOT have to base your answers on the scenario described above

While driving, to what extent would you have difficulty ignoring	Not at all	Small extent	Moderate extent	Large extent	Extremely large extent
the ringing of a cell phone (e.g., incoming call), which you do not intend to answer					
conversation amongst passengers in the backseat					
a fly that got into your vehicle					
roadside advertisements					
loud music from another vehicle					
an alert from your cell phone about an update on social media					
an alert from your cell phone of a new message, or an incoming call (excluding social media)					
a roadside accident scene					
an itch on your back					

While driving, to what extent do you feel compelled to	Not at all	Small extent	Moderate extent	Large extent	Extremely large extent
check your phone when you receive a notification from social media					
check your phone when you receive a notification of a new message					
check your phone when you receive a notification of an incoming call					
read an advertisement fully once you see it					

How often do you…	Never	Rarely	Occasionally /Sometimes	Often	Very often
find yourself having looked away from the road for longer than you intended to?					
find yourself being surprised by what you see on the road, after having looked away from the road?					
look away from the road and are surprised by how fast/slow you are going when you glance back at the speedometer?					
find yourself having drifted out of your lane because you looked away from the road?					
turn off your cell phone/tablet before driving to reduce distractions while driving?					

SECTION 4: Habitual Distraction

Instructions: For the following questions, please indicate to what extent you agree or disagree with each statement. You DO NOT have to base your answers on the scenario described above

Checking my phone for new notifications is something…	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
I do automatically					
I do without having to consciously remember					
I do without thinking					
I start doing before I realize I am doing it					
I have no need to think about doing					
I do without meaning to do it					
That would require effort not to do it					
That I would find hard not to do					
That is typically 'me'					
That belongs to my daily routine					

Answering a phone call is something…	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
I do automatically					
I do without having to consciously remember					
I do without thinking					
I start doing before I realize I am doing it					
I have no need to think about doing					
I do without meaning to do it					
That would require effort not to do it					
That I would find hard not to do					
That is typically 'me'					
That belongs to my daily routine					

Responding to notifications on my cell phone is something…	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
I do automatically					
I do without having to consciously remember					
I do without thinking					
I start doing before I realize I am doing it					
I have no need to think about doing					
I do without meaning to do it					
That would require effort not to do it					
That I would find hard not to do					
That is typically 'me'					
That belongs to my daily routine					

Checking my navigational system (e.g., GPS) to verify if I am on route is something…	**Strongly disagree**	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
I do automatically					
I do without having to consciously remember					
I do without thinking					
I start doing before I realize I am doing it					
I have no need to think about doing					
I do without meaning to do it					
That would require effort not to do it					
That I would find hard not to do					
That is typically 'me'					
That belongs to my daily routine					

Appendix B: Online and Laboratory Study 1 Experiment Documentation

Participant Consent Form

Title: Designing feedback to help induce safer driving behaviours

Investigators: Liberty Hoekstra-Atwood (519.807.6848; lha@mie.utoronto.ca)

Maryam Merrikhpour (416.978.0881; maryam.merrikhpour@utoronto.ca)

Susana Marulanda (647.376.3536; smarulan@mie.utoronto.ca)

Jaquelyn Monis Rodriguez (416.978.0881; j.monisrodriguez@mail.utoronto.ca)

Dr. Birsen Donmez (416.978.7399; donmez@mie.utoronto.ca)

You are being asked to take part in a research study. Before agreeing to participate in this study, it is important that you read and understand the following explanation of the proposed study procedures. The following information describes the purpose, procedures, benefits, discomforts, risks and precautions associated with this study. In order to decide whether you wish to participate or withdraw in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is known as the informed consent process. Please ask the investigator to explain any words you don't understand before signing this consent form. Make sure all your questions have been answered to your satisfaction before signing this document.

Purpose

This study aims to understand driver behaviour under the presence of distracting conditions. As a participant you will be asked to:

1. Fill out a series of questionnaires
2. Participate in basic attention tasks
3. Drive through a simulated traffic environment
4. Fill out a short exit questionnaire

Procedure

There are four parts to this study. In the first part you will fill out a questionnaire to provide your demographic information, as well as some information on your driving habits. In the second part you will be directed to complete some interactive visual tasks on a computer. In the third part you will drive through experimental scenarios. We ask that you attempt to treat the simulation just like you were driving your own car, thinking of all elements of the simulation as if they were encountered in the real world. Before driving, approximately 25 minutes will be used to configure the eye-tracker and introduce you to the simulator; you will be given time to test it and become comfortable driving with it. Next, there will be three driving scenarios of 10 minutes each, with small five minute breaks in between. In the final part, you will fill out a short exit questionnaire.

Risks

There are no major risks involved with this experiment, the tasks are not physiologically demanding, psychologically stressing, and there is no manipulation or deception involved. We want to make you aware of the possibility of simulator sickness (a form of motion sickness specific to simulators), however. Especially upon first using a driving simulator, there is a small chance of feeling dizzy, nauseous, or fatigued. If you feel any of these symptoms appear, please immediately stop the experiment and inform the investigator. The investigator will also monitor for any signs of simulator sickness.

Benefits

There are several benefits to conducting this study. The most important benefit is your contribution to research in traffic safety, which will guide the development of methods to encourage long term improvements in driver performance. You will also gain experience with academic research and be able to use and test out a state of the art driving simulator.

Compensation

You will receive $15/hr for your participation plus a $5 experiment completion bonus at the end of this study.

Confidentiality

All information obtained during the study will be held in strict confidence. You will be identified with a study number only, and this study number will only be identifiable by the primary investigator. No names or identifying information will be used in any publication or presentation. No information identifying you will be transferred outside the investigators in this study.

Please be advised that we video-record the experimental trials with four small web-cameras. One camera will be pointed at you, one will capture the steering wheel, one the pedals, and the final camera the overall scene. We will use four other cameras on and near the dashboard to track and record where you are looking during the experiment. The videos will only be seen by the investigators, the primary investigator's research assistant, and research collaborators. Faces will be blurred in any video used in public presentations.

Participation

Your participation in this study is voluntary. You can choose to not participate or withdraw at any time.

Questions

If you have any general questions about this study, please call 416.978.0881 or email lha@mie.utoronto.ca.

Consent

I have had the opportunity to discuss this study and my questions have been answered to my satisfaction. I consent to take part in the study with the understanding I may withdraw at any time. I have received a signed copy of this consent form. I voluntarily consent to participate in this study.

____________________________ ___________________ ___________________

Participant's Name (please print) Signature Date

I confirm that I have explained the nature and purpose of the study to the participant named above. I have answered all questions.

____________________________ ___________________ ___________________

Investigator's Name Signature Date

Additional Participant Consent Form

Title: Designing feedback to help induce safer driving behaviours

Investigators: Susana Marulanda (647.376.3536; smarulan@mie.utoronto.ca)

Liberty Hoekstra-Atwood (519.807.6848; lha@mie.utoronto.ca)

Maryam Merrikhpour (416.978.0881; maryam.merrikhpour@utoronto.ca)

Dr. Birsen Donmez (416.978.7399; donmez@mie.utoronto.ca)

You are being asked to take part in a research study. Before agreeing to participate in this study, it is important that you read and understand the following explanation of the proposed study procedures. The following information describes the purpose, procedures, benefits, discomforts, risks and precautions associated with this study. In order to decide whether you wish to participate or withdraw in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is known as the informed consent process. Please ask the investigator to explain any words you don't understand before signing this consent form. Make sure all your questions have been answered to your satisfaction before signing this document.

Purpose

This study aims to understand driver behaviour under the presence of distracting conditions. As a participant you will be asked to:

1. Participate in basic cognitive tasks
2. Fill out a short exit questionnaire

Procedure

The study will take approximately 1 hour. There are three parts to this study. In the first part you will fill out a questionnaire to provide your demographic information, as well as some information on your driving habits. In the second part you will be directed to complete some interactive cognitive tasks on a computer. In the final part, you will fill out a short exit questionnaire.

Risks

There are no major risks involved with this experiment, the tasks are not physiologically demanding, psychologically stressing, and there is no manipulation or deception involved.

Benefits

There are several benefits to conducting this study. The most important benefit is your contribution to research in traffic safety, which will guide the development of methods to encourage long-term improvements in driver performance. You will also gain experience with academic research and learn of your cognitive abilities.

Compensation

You will receive $15 upon completion of the entire study.

Confidentiality

All information obtained during the study will be held in strict confidence. You will be identified with a study number only, and this study number will only be identifiable by the primary investigator. No names or identifying information will be used in any publication or presentation. No information identifying you will be transferred outside the investigators in this study.

Participation

Your participation in this study is voluntary. You can choose to not participate or withdraw at any time. However, the study is pro-rated at $15/hr.

Questions

If you have any general questions about this study, please call 647.376.3536 or email smarulan@mie.utoronto.ca.

Consent

I have had the opportunity to discuss this study and my questions have been answered to my satisfaction. I consent to take part in the study with the understanding I may withdraw at any time. I have received a signed copy of this consent form. I voluntarily consent to participate in this study.

______________________________ ____________________ ____________________

Participant's Name (please print) Signature Date

I confirm that I have explained the nature and purpose of the study to the participant named above. I have answered all questions.

______________________________ ____________________ ____________________

Investigator's Name Signature Date

Driving Experiment Screening Questionnaire

You are invited to participate in a driving experiment conducted by the Human Factors and Applied Statistics Lab (Director: Prof. Birsen Donmez) at the Department of Mechanical and Industrial Engineering, University of Toronto. Before you can participate in our driving experiment, you must fill out the below questionnaire so we can determine your eligibility.

The goal of this study is to understand human driving behaviours and make our roads safer. If you choose to participate, you will be presented with questions about yourself and your driving behaviours.

Please note that all information collected will be held in the strictest confidentiality. Personal data will be stored securely in the Human Factors and Applied Statistics Lab at the University of Toronto, separately from the results of the following research survey. Under no circumstances will personal data be revealed to any third party, for any purpose.

If you have any questions or concerns you would like addressed before or after completing this questionnaire, please contact the researchers at driverfeedback.hfast@gmail.com or 416.978.0881.

1. What is your first name?
2. What is your last name?
3. What is your e-mail address?
4. What is your phone number?
5. Choose your preferred method of contact

a. E-mail

b. Phone
c. Either

6. If you are interested in participating in future research at the Human Factors and Applied Statistics Lab, please indicate below (if you are not interested, you can skip this question).

7. What is your age?

8. What is your sex?
   a. Male
   b. Female

9. Do you ordinarily wear corrective lenses of any kind?
   a. Yes
   b. No

10. If you do have corrected vision, are you able to wear contact lenses during the experiment?
   a. Yes
   b. No

11. Are you right handed?
   a. Yes
   b. No

12. Do you currently hold a valid government issued driver's license?
   a. Yes
   b. No

13. What are your current driver's licenses?
   a. Full license (e.g. G license in Ontario)
   b. Learner's license (e.g. G1 and G2 licenses in Ontario)
   c. Motorcycle (M, M1, M2 in Ontario)
   d. Other licenses please specify ______________________________

14. How often do you drive a motor vehicle?
   a. Almost every day
   b. A few days a week
   c. A few days a month
   d. A few days a year or less

15. Over the last year, how many kilometers have you driven?
   a. Under 5,000 km
   b. Between 5,001 km and 15,000 km
   c. Between 15,001 km and 25,000 km
   d. Between 25,001 km and 35,000 km
   e. Between 35,001 km and 45,000 km
   f. Over 45,000 km
   g. None
   h. I don't know

Simulator sickness screening

Some people tend to experience a type of motion sickness, called simulator sickness, when driving the simulator. The next questions are asked to help us identify if you might be prone to simulator sickness.

16. Have you ever driven in a driving simulator?
   a. No, never
   b. Once or twice
   c. Multiple times
   d. Regularly

17. If you have used a driving simulator before, did you ever experience simulator sickness?
   a. Yes
   b. No

18. Do you frequently experience migraine headaches?
   a. Yes
   b. No

19. Do you experience motion sickness?
   a. Yes
   b. No

20. Are you pregnant?
   a. Yes
   b. No

Multitasking Ability Questionnaire

Please circle the answer to the following questions:

1. Rank your multi-tasking ability relative to that of other people of your same age:

0% 25% 50% 75% 100%

I'm at the bottom	I'm about average	I'm at the very top

2. Rank your multi-tasking abilities relative to other people in the general population:

0% 25% 50% 75% 100%

I'm at the bottom	I'm about average	I'm at the very top

3. How much difficulty do you have performing multiple tasks simultaneously relative to other people of your same age?

1	2	3	4	5
Much more than average	More than than average	About the same than average	Less than than average	Much less than average

4. How much difficulty do you have performing multiple tasks simultaneously relative to other people in the general population?

1	2	3	4	5
Much more than average	More than than average	About the same than average	Less than than average	Much less than average

The Manchester Driving Behaviour Questionnaire (DBQ)

Nobody is perfect. Even the best drivers make mistakes, do foolish things, or bend the rules at some time or another. For each item below you are asked to indicate HOW OFTEN, if at all, this kind of thing has happened to you. Base your judgments on what you remember of your driving. Please indicate your judgments by selecting ONE of the options next to each item. Remember we do not expect exact answers, merely your best guess; so please do not spend too much time on any one item.

How often do you do each of the following (for example, in the past month)?	Never	Hardly ever	Occasionally	Quite often	Frequently	Nearly all the time
Try to pass another car that is signaling a left turn.	0	1	2	3	4	5
Select the wrong turn lane when approaching an intersection.	0	1	2	3	4	5
Fail to 'Stop' or 'Yield'	0	1	2	3	4	5

at a sign, almost hitting a car that has the right of way.						
Misread signs and miss your exit.	0	1	2	3	4	5
Fail to notice pedestrians crossing when turning onto a side street.	0	1	2	3	4	5
Drive very close to a car in front of you as a signal that they should go faster or get out of the way.	0	1	2	3	4	5
Forget where you parked your car in a parking lot.	0	1	2	3	4	5
When preparing to turn from a side road onto a main road, you pay too much attention to the traffic on the main road so that you nearly hit the car in front of you.	0	1	2	3	4	5
When you back up, you hit something that you did not observe before but was there.	0	1	2	3	4	5
Pass through an intersection even though you know that the traffic light has turned yellow and may go red.	0	1	2	3	4	5
When making a turn, you almost hit a cyclist or pedestrian who has come up on your right side.	0	1	2	3	4	5
Ignore speed limits late at night or very early in	0	1	2	3	4	5

the morning.

Forget that your lights are on high beam until another driver flashes his headlights at you.	0	1	2	3	4	5
Fail to check your rear-view mirror before pulling out and changing lanes.	0	1	2	3	4	5
Have a strong dislike of a particular type of driver, and indicate your dislike by any means that you can.	0	1	2	3	4	5
Become impatient with a slow driver in the left lane and pass on the right.	0	1	2	3	4	5
Underestimate the speed of an oncoming vehicle when passing.	0	1	2	3	4	5
Switch on one thing, for example, the headlights, when you meant to switch on something else, for example, the windshield wipers.	0	1	2	3	4	5
Brake too quickly on a slippery road, or turn your steering wheel in the wrong direction while skidding.	0	1	2	3	4	5
You intend to drive to destination A, but you 'wake up' to find yourself on the road to destination B, perhaps because B is your more	0	1	2	3	4	5

usual destination.						
Drive even though you realize that your blood alcohol may be over the legal limit.	0	1	2	3	4	5
Get involved in spontaneous, or spur-of-the moment, races with other drivers.	0	1	2	3	4	5
Realize that you cannot clearly remember the road you were just driving on.	0	1	2	3	4	5
You get angry at the behavior of another driver and you chase that driver so that you can give him/her a piece of your mind.	0	1	2	3	4	5

Eysenck Impulsiveness Questionnaire (I7)

Please answer each question by selecting ‘YES’ or ‘NO’ for the following the questions. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the question.

	Yes	**No**
Would you like to go scuba diving?	( )	( )
Would you enjoy fast driving?	( )	( )
Do you usually work quickly, without bothering to check?	( )	( )
Do you often change your interests?	( )	( )
Before making up your mind, do you consider all the advantages and disadvantages?	( )	( )
Would you like to go pot-holing?	( )	( )
Would you be put off a job involving quite a bit of danger?	( )	( )
Do you prefer to ‘sleep on it’ before making decisions?	( )	( )
When people shout at you, do you shout back?	( )	( )
Do you usually make up your mind quickly?	( )	( )

Arnett Inventory of Sensation Seeking (AISS)

For each item, indicate how well it describes you.

	Very well	Somewhat	Not very well	Not at all
I can see how it would be interesting to marry someone from a foreign country.	( )	( )	( )	( )
When the water is very cold, I prefer not to swim even if it is a hot day.	( )	( )	( )	( )
If I have to wait in a long line, I'm usually patient about it.	( )	( )	( )	( )
When I listen to music, I like it to be	( )	( )	( )	( )
When taking a trip, I think it is best to make as few plans as possible and just take it as it comes.	( )	( )	( )	( )
I stay away from movies that are said to be frightening or highly suspenseful.	( )	( )	( )	( )
I think it's fun and exciting to perform or speak before a group.	( )	( )	( )	( )
If I were to go to an amusement park, I would prefer to ride the rollercoaster or other fast rides.	( )	( )	( )	( )
I would like to travel to places that are strange and far away.	( )	( )	( )	( )

I would never like to gamble with money, even if I could afford it.	( )	( )	( )	( )
I would have enjoyed being one of the first explorers of an unknown land.	( )	( )	( )	( )
I like a movie where there are a lot of explosions and car chases.	( )	( )	( )	( )
I don't like extremely hot and spicy foods.	( )	( )	( )	( )
In general, I work better when I'm under pressure.	( )	( )	( )	( )
I often like to have the radio or TV on while I'm doing something else, such as reading or cleaning up.	( )	( )	( )	( )
It would be interesting to see a car accident happen.	( )	( )	( )	( )
I think it's best to order something familiar when eating in a restaurant.	( )	( )	( )	( )
I like the feeling of standing next to the edge on a high place and looking down.	( )	( )	( )	( )
If it were possible to visit another planet or the moon for free, I would be among the first in line to sign up.	( )	( )	( )	( )
I can see how it must be exciting to be in a battle during a war.	( )	( )	( )	( )

Appendix C: Laboratory Study 2 Experiment Documentation

Participant Consent Form

Title: Designing feedback to help induce safer driving behaviours

Investigators: Liberty Hoekstra-Atwood (519.807.6848; lha@mie.utoronto.ca)

Susana Marulanda (647.376.3536; smarulan@mie.utoronto.ca)

Winnie Chen (416.978.0881; win.chen@mail.utoronto.ca)

Dr. Birsen Donmez (416.978.7399; donmez@mie.utoronto.ca)

You are being asked to take part in a research study. Before agreeing to participate in this study, it is important that you read and understand the following explanation of the proposed study procedures. The following information describes the purpose, procedures, benefits, discomforts, risks and precautions associated with this study. In order to decide whether you wish to participate or withdraw in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is known as the informed consent process. Please ask the investigator to explain any words you don't understand before signing this consent form. Make sure all your questions have been answered to your satisfaction before signing this document.

Purpose

This study aims to understand driver behaviour under the presence of distracting conditions. As a participant you will be asked to:

1. Fill out a series of questionnaires
2. Participate in computer-based cognitive tasks
3. Drive through a simulated traffic environment

Procedure

There are four parts to this study. In the first part you will fill out a questionnaire to provide your demographic information, as well as some information on your driving habits. In the second part you will be directed to complete three interactive cognitive tasks on a computer. In the third part you will drive through experimental scenarios. Before driving, approximately 25 minutes will be used to configure the eye-tracker and introduce you to the simulator; you will be given time to test it and become comfortable driving with it. Next, you will drive through six experimental driving scenarios of approximately 5 minutes each, with small two minute breaks in between. We ask that you attempt to treat the simulation just like you were driving your own car, thinking of all elements of the simulation as if they were encountered in the real world. In the final part, you will be directed through the remaining two interactive cognitive tasks on a computer.

Risks

There are no major risks involved with this experiment, the tasks are not physiologically demanding, psychologically stressing, and there is no manipulation or deception involved. We want to make you aware of the possibility of simulator sickness (a form of motion sickness specific to simulators), however. Especially upon first using a driving simulator, there is a small chance of feeling dizzy, nauseous, or fatigued. If you feel any of these symptoms appear, please immediately stop the experiment and inform the investigator. The investigator will also monitor for any signs of simulator sickness.

Benefits

There are several benefits to conducting this study. The most important benefit is your contribution to research in traffic safety, which will guide the development of methods to encourage long term improvements in driver performance. You will also gain experience with academic research and be able to use and test out a state of the art driving simulator.

Compensation

You will receive $35 for your participation. You can also earn a bonus of up to $5 based on your performance on the cognitive tasks. If you decide to withdraw, you will receive $10 for every hour that you completed.

Confidentiality

All information obtained during the study will be held in strict confidence. You will be identified with a study number only, and this study number will only be identifiable by the primary investigator. No names or identifying information will be used in any publication or presentation. No information identifying you will be transferred outside the investigators in this study.

Please be advised that we video-record the experimental trials with four small web-cameras. One camera will be pointed at you, one will capture the steering wheel, one the pedals, and the final camera the overall scene. We will use four other cameras on and near the dashboard to track and record where you are looking during the experiment. The videos will only be seen by the investigators, the primary investigator's research assistant, and research collaborators. Faces will be blurred in any video used in public presentations. All digital data will also be stored on a UofT networked-attached storage which can only be accessed through the UofT network and has password protected access.

Participation

Your participation in this study is voluntary. You can choose to not participate or withdraw at any time.

Questions

If you have any general questions about this study, please call 416.978.0881 or email lha@mie.utoronto.ca or smarulan@mie.utoronto.ca

Consent

I have had the opportunity to discuss this study and my questions have been answered to my satisfaction. I consent to take part in the study with the understanding I may withdraw at any time. I have received a signed copy of this consent form. I voluntarily consent to participate in this study

________________________	____________________	____________________
Participant's Name (please print)	Signature	Date

I confirm that I have explained the nature and purpose of the study to the participant named above. I have answered all questions.

________________________	____________________	____________________
Investigator's Name	Signature	Date

Demographics and Driving History Questionnaire

What is your first name?
What is your last name?
What is your phone number?
What is your e-mail address?
Choose your preferred method of contact?
E-mail
Phone
Either
If you are interested in participating in future research at the Human Factors and Applied Statistics Lab, please indicate below (if you are not interested, you can skip this question

What is your gender?
Male
Female
Other

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

What country do you currently reside in?

What city do you currently live in?

Do you currently hold a valid government issued driver’s license
Yes
No

What are your current driver’s licenses?
a. Full license (e.g., G license in Ontario)
b. Learner’s license (e.g., G1 and G2 licenses in Ontario)
c. Motorcycle (M, M1, and M2 in Ontario)
d. Other ___________________________

How often do you drive alone?
a. Never
b. Rarely
c. Occasionally/Sometimes
d. Often
e. Very often

Select age groups that reflect your frequent passengers (check all the apply)
a. 0 – 9 years old
b. 10 – 19 years old
c. 20 – 39 years old
d. 40 – 64 years old
e. 64+ years old

What percentage of your driving time is spent driving on highways outside of the city?
a. 0 – 20%
b. 21 – 40%
c. 41 – 60%
d. 61 – 80%
e. 81 – 100%

What percentage of your driving time is spent driving within the city?
f. 0 – 20%
g. 21 – 40%
h. 41 – 60%
i. 61 – 80%
j. 81 – 100%

What is your level of fluency in English?
Elementary proficiency
Limited working proficiency
Professional working proficiency
Full professional proficiency
Native or bilingual proficiency

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., cell phones, automatic teller machines, digital cameras, computers, etc.)?

Very inexperienced	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Very experienced

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?

Avoid technology as long as possible	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Try new technology as soon as possible

Appendix D: Correlations between Executive Function Tasks and Revised SDDQ Measures for Illegal Distractions

Measures	Cognitive Tasks						SDDQ Measures													CFQ
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Flanker	-																			
2. Number-letter	-0.14	-																		
3. 3-back	-0.39**	-0.16	-																	
4. WCST	0.16	0.18	-0.51**	-																
5. Stroop	-0.11	0.22	-0.16	0.10	-															
6. Cell Phone Habits	0.05	0.13	-0.33*	0.27	0.32*	-														
7. Involuntary 1[1]	0.04	0.01	-0.18	0.21	-0.10	0.31*	-													
8. Involuntary 2[2]	-0.08	0.16	-0.10	0.15	0.28*	0.53**	0.55**	-												
9. Involuntary 3[3]	-0.01	-0.02	-0.09	0.28*	0.10	0.49**	0.52**	0.54**	-											
10. Engagement	-0.21	0.08	-0.18	0.11	0.41**	0.25	0.17	0.57**	0.28*	-										
11. Attitudes 1[4]	0.13	-0.09	0.00	0.10	-0.24	-0.13	-0.05	-0.32*	-0.07	-0.65**	-									
12. Attitudes 2[5]	-0.26	0.21	-0.18	-0.04	0.29*	0.23	0.07	0.41**	0.03	0.71**	-0.58**	-								
13. Attitudes 3[6]	0.14	-0.14	-0.05	0.12	-0.26	-0.18	-0.11	-0.41**	-0.01	-0.51**	0.83**	-0.6**	-							
14 .Self-efficacy	-0.17	0.13	-0.08	-0.08	0.23	0.21	-0.03	0.39**	0.03	0.76**	-0.68**	0.78**	-0.64**	-						
15. Controllability 1[7]	0.03	-0.08	0.13	-0.05	0.00	0.08	0.01	0.00	-0.07	0.06	-0.01	0.08	0.02	0.09	-					
16. Controllability 2[8]	-0.15	0.02	0.08	-0.15	0.22	0.24	0.08	0.49**	0.11	0.58**	-0.50**	0.56**	-0.56**	0.72**	0.03	-				
17. Descriptive Norms	0.04	0.02	-0.20	0.18	-0.03	0.31*	0.24	0.37*	0.33*	0.31*	-0.15	0.27*	-0.12	0.27	-0.11	0.16	-			
18. Injunctive Norms 1[9]	-0.06	0.18	0.17	-0.24	0.16	0.04	-0.18	0.14	-0.10	0.21	-0.42**	0.37**	-0.50**	0.39**	0.10	0.30*	0.14	-		
19. Injunctive Norms 2[10]	-0.14	0.04	0.16	-0.27*	0.09	0.03	-0.18	0.17	-0.08	0.26	-0.44**	0.41**	-0.52**	0.42**	0.07	0.29*	0.28*	0.89**	-	
20. CFQ[11]	-0.07	0.00	-0.15	0.40**	0.06	0.42**	0.36*	0.23	0.36*	0.01	0.24	-0.16	0.27	-0.16	0.22	0.07	0.00	-0.20	-0.19	-

*significant correlation (α =.05); ** significant correlation (α =.01); - indicates the correlation between a measure and itself

[1]Involuntary 1: Difficulty ignoring distractions
[2]Involuntary 2: Compulsiveness to respond to cell phone alerts
[3]Involuntary 3: Looking away for longer than intended
[4]Attitudes 1: Semantic Differential Scales
[5]Attitudes 2: 'It is good use of my time to drive and…'
[6]Attitudes 3: 'I lose respect for people who drive and…'
[7]Controllability 1: 'I decide whether I drive and…'
[8]Controllability 2: 'Circumstances determine if I…'
[9]Injunctive norms 1: 'People who are important to me would approve of me driving and…'
[10]Injunctive norms 2: 'People who are important to me would think it is okay for me driving and…'
[11]CFQ: Cognitive Failures Questionnaire

Appendix E: Correlations between Executive Function Tasks and Revised SDDQ Measures for Legal Distractions

Measures	Cognitive Tasks						SDDQ Measures													CFQ
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Flanker	-																			
2. Number-letter	-0.14	-																		
3. 3-back	-0.39**	-0.16	-																	
4. WCST	0.16	0.18	-0.51**	-																
5. Stroop	-0.11	0.22	-0.16	0.10	-															
6. Cell Phone Habits	0.05	0.13	-0.33*	0.27	0.32*	-														
7. Involuntary 1[1]	0.04	0.01	-0.18	0.21	-0.10	0.31*	-													
8. Involuntary 2[2]	-0.08	0.16	-0.10	0.15	0.28*	0.53**	0.55**	-												
9. Involuntary 3[3]	-0.01	-0.02	-0.09	0.28*	0.10	0.49**	0.52**	0.54**	-											
10. Engagement	-0.07	-0.07	0.08	0.08	-0.01	0.24	0.20	0.34**	0.39**	-										
11. Attitudes 1[4]	0.06	-0.09	-0.04	-0.10	-0.26	-0.21	-0.12	-0.35**	-0.28*	-0.46**	-									
12. Attitudes 2[5]	-0.02	0.16	0.00	0.00	0.17	0.27	0.19	0.32*	0.42**	0.36*	-0.54**	-								
13. Attitudes 3[6]	-0.19	0.16	-0.01	-0.08	-0.10	-0.27*	-0.28*	-0.26	-0.3*	-0.34*	0.54**	-0.56**	-							
14 .Self-efficacy	-0.09	-0.04	-0.11	-0.04	0.29*	0.09	-0.15	0.20	0.02	0.37*	-0.56**	0.53**	-0.37*	-						
15. Controllability 1[7]	0.12	0.11	0.02	0.11	0.06	0.12	0.09	0.04	-0.01	0.01	-0.03	-0.04	-0.10	-0.16	-					
16. Controllability 2[8]	-0.04	-0.05	0.10	0.07	0.01	0.05	0.12	0.23	0.20	0.11	-0.35*	0.26	-0.12	0.23	0.13	-				
17. Descriptive Norms	0.09	0.12	-0.27	0.22	0.14	0.05	0.00	0.08	0.10	0.10	0.01	0.03	0.29*	0.04	0.16	0.21	-			
18. Injunctive Norms 1[9]	-0.01	-0.04	-0.03	-0.21	-0.09	0.13	0.19	0.35*	0.26	0.27*	-0.32*	0.33*	-0.31*	0.27*	0.08	0.27	0.21	-		
19. Injunctive Norms 2[10]	-0.01	-0.15	0.39**	-0.33*	-0.05	0.05	0.13	0.26	0.13	0.23	-0.4**	0.36*	-0.42**	0.21	0.09	0.22	0.15	0.62**	-	
20. CFQ[11]	-0.07	0.00	-0.15	0.40**	0.06	0.42**	0.36*	0.23	0.36*	0.16	0.11	-0.07	0.01	-0.18	0.18	0.01	0.09	-0.04	-0.04	-

*significant correlation (α =.05); ** significant correlation (α =.01); - indicates the correlation between a measure and itself

[1]Involuntary 1: Difficulty ignoring distractions

[2]Involuntary 2: Compulsiveness to respond to cell phone alerts

[3]Involuntary 3: Looking away for longer than intended

[4]Attitudes 1: Semantic Differential Scales

[5]Attitudes 2: 'It is good use of my time to drive and…'

[6]Attitudes 3: 'I lose respect for people who drive and…'

[7]Controllability 1: 'I decide whether I drive and...'

[8]Controllability 2: 'Circumstances determine if I...'

[9]Injunctive norms 1: 'People who are important to me would approve of me driving and…'

[10]Injunctive norms 2: 'People who are important to me would think it is okay for me driving and…'

[11]CFQ: Cognitive Failures Questionnaire

Appendix F: Correlations between Executive Function Tasks and Measures of Involuntary and Habitual Distractions

Measures	Cognitive Tasks						SDDQ Measures			CFQ
	1	2	3	4	5	6	7	8	9	10
1. Flanker	-									
2. Number-letter	-0.14	-								
3. 3-back	-0.39**	-0.16	-							
4. WCST	0.16	0.18	-0.51**	-						
5. Stroop	-0.11	0.22	-0.16	0.10	-					
6. Cell Phone Habits	0.05	0.13	-0.33*	0.27*	0.32*	-				
7. Involuntary 1[1]	0.04	0.01	-0.18	0.21	-0.10	0.31*	-			
8. Involuntary 2[2]	-0.08	0.16	-0.10	0.15	0.28*	0.53**	0.55**	-		
9. Involuntary 3[3]	-0.01	-0.02	-0.09	0.28*	0.10	0.49**	0.52**	0.54**	-	
10. CFQ[4]	-0.07	0.00	-0.15	0.40**	0.06	0.42**	0.36*	0.23	0.36*	-

*significant correlation (α =.05); ** significant correlation (α =.01); - indicates the correlation between a measure and itself

[1]Involuntary 1: Difficulty ignoring distractions

[2]Involuntary 2: Compulsiveness to respond to cell phone alerts

[3]Involuntary 3: Looking away for longer than intended

[4]CFQ: Cognitive Failures Questionnaire