Utilizing the Social Norms Theory for Mitigating Teen Driver Distraction

by

Maryam Merrikhpour

A thesis submitted in conformity with the requirements
for the degree of Doctor of Philosophy

Department of Mechanical and Industrial Engineering
University of Toronto

Utilizing the Social Norms Theory for Mitigating Teen Driver Distraction

Maryam Merrikhpour

Doctor of Philosophy

Mechanical and Industrial Engineering
University of Toronto

2017

Abstract

Driver distraction contributes significantly to teens' crash risks. Parents and peers are important social referents for teens, that significantly influence their driving behaviours, including distracted driving. There has been a growing interest in using interventions based on the Social Norms Theory to change negative behaviours. According to this theory, individuals choose to engage in a particular behaviour based on their perceptions of others' behaviour/approval. The overestimation of the prevalence/permissiveness of negative behaviours is common and can lead to increased engagement in those behaviours. Social norms interventions aim to correct these overestimations and thereby reduce negative behaviours by providing accurate normative information. These interventions have been successfully applied in various domains; however, they are yet to be explored for teen driver distraction.

This dissertation addresses this gap by investigating the social norms underlying teen distracted driving and the efficacy of social norms interventions to mitigate teen driver distractions. The role of social norms in teen driver distraction engagement and the existence of normative misperceptions among teens were examined through a survey study. In addition, two driving simulator experiments investigated the effectiveness of social norms interventions incorporating parental and peer norms.

The survey study revealed that teens may hold misperceptions for driver distraction, and that teen perceptions of parent and peer norms are predictive of their self-reported distraction engagement. These findings support the evaluation of social norms interventions to correct misperceived norms to mitigate distractions.

The driving simulator experiments showed that social norms interventions based on parent and peer (both same- and opposite-gender) norms are promising for mitigating teen distractions. Both interventions reduced distraction engagement and improved driving performance, and were well accepted by teens.

Overall, this dissertation contributes to the body of literature on distraction-related norms among teen drivers and the application of social norms interventions for mitigating teen driver distractions.

Acknowledgments

First and foremost, I would like to express my sincere gratitude to my supervisor, Birsen Donmez, for her continuous support throughout my doctoral study and for her patience and immense knowledge. Her guidance helped me to research and write this thesis.

I would like to thank my committee members, Paul Milgram and Greg A. Jamieson for their guidance and for providing many helpful comments and suggestions for the benefit of my research.

I would also like to thank my external examiner Daniel V. McGehee and my internal examiner Mark Chignell for taking an in-depth look at my thesis and providing excellent feedback.

I would like to thank James Foley and Kazu Ebe from Toyota Collaborative Safety Research Centre (CSRC) for their feedback on some of the work included in this thesis as well as providing directions for my research in general.

I am honoured to have had great friends during my graduate studies. I thank all my friends at HFASt for sharing conversations and making my graduate experience more pleasant. Thank you in particular to Wayne Giang for being a great friend and resource, and to Liberty Hoekstra-Atwood for being generous with her knowledge of the driving simulator and data coding.

Last but not least, I would like to thank my family: my parents, brother, and two sisters for their unlimited and continuous support, love, and encouragement. And, of course, my dog, Coco, for bringing joy to my life in the last year.

Table of Contents

Acknowledgments iv

Table of Contents iv

List of Tables vii

List of Figures viii

List of Appendices x

Chapter 1 Introduction 1

1.1 Current Research: Structure and Goals 3

Chapter 2 Background Literature 7

2 7

2.1 Teen Driver Distraction 7

2.2 Feedback to Mitigate Driver Distraction 10

2.3 Social Norms and Teen Drivers 11

2.4 Theory of Planned Behaviour 13

2.5 Social Norms Theory 15

2.6 Social Norms Interventions 16

Chapter 3 Survey Study: Social Norms and Teen Driver Distraction 20

3 20

3.1 Methods 20

3.1.1 Participants 20

3.1.2 Questionnaire 22

3.2 Results 25

3.2.1 Self-reported Distraction Engagement 25

3.2.2 Social Norms 26

3.2.3 Attitudes, Perceived Risk, and Perceived Control 29

3.2.4 Predicting Engagement 31

3.3 Discussion 32

Chapter 4 Apparatus, Secondary Task, and Experimental Drives 36

4 36

4.1 Apparatus 36

4.1.1 Driving Simulator 36

4.1.2 Eye-Tracking System 36

4.1.3 In-vehicle Display 37

4.2 Secondary Task 37

4.3 Experimental Drives 38

Chapter 5 Experiment I: Personalized Normative Feedback for Teen Driver Distraction: Parental Norms 40

5 40

5.1 Methods 40

5.1.1 Participants 40

5.1.2 Experimental Design and Procedure 42
5.1.3 Feedback Design 43
5.1.4 Simulator Measures and Data Analysis 46
5.1.5 Questionnaire Administration and Analysis 47
5.2 Results..**48**
5.2.1 Distraction Engagement Measures...48
5.2.2 Driving Performance Measures...54
5.2.3 Questionnaires..57
5.3 Discussion..**58**

Chapter 6 Experiment II: Personalized Normative Feedback for Teen Driver Distraction: Peer Norms **62**

6.. **62**
6.1 Methods **62**
6.1.1 Participants..62
6.1.2 Experimental Design and Procedure...63
6.1.3 Feedback Design 64
6.1.4 Simulator Measures and Data Analysis 65
6.1.5 Questionnaire Administration and Analysis 66
6.2 Results..**67**
6.2.1 Distraction Engagement Measures...67
6.2.2 Driving Performance Measures...73
6.2.3 Questionnaires..76
6.3 Discussion..**78**

Chapter 7 Conclusion **81**

7.. **81**
7.1 Summary of Key Findings **81**
7.2 Contribution to the Field **82**
7.3 Limitation and Future Work..**83**

References **85**

Appendices.. **93**

Copyright Acknowledgements (if any)..Error! Bookmark not defined.

List of Tables

Table 1: Number (%) of teens and parents by gender, age group, license, and driving frequency 22

Table 2: Distraction tasks included in the questionnaire 23

Table 3: Means and standard deviations (SD) for self-reported engagement in each of the distraction tasks; range 1-5 26

Table 4: Means and standard deviations (SD) for questionnaire responses; range 1-5 28

Table 5: Pearson correlations between teen self-reported distraction engagement frequency and social norms 29

Table 6: Means and standard deviations (SD) for attitude (lower scores represent more positive attitudes), perceived risk, and perceived control 30

Table 7: Pearson correlations between teen self-reported distraction engagement frequency and attitude, perceived risk, and perceived control 31

Table 8: Demographic information of the teens across the four experimental conditions 41

Table 9: Artificial parent data used for comparison in social norms feedback 44

Table 10: Demographic information of the teens across the three feedback conditions 63

Table 11: Artificial peer data used for comparison in same- and opposite-gender peer-norm feedback 65

Table 12: Descriptive statistics on questionnaire responses collected on a scale of 1 to 5 77

Table 13: Pearson correlations between teens' self-reported distraction engagement frequency and perceived norms 77

List of Figures

Figure 1: University of Toronto HFASt Laboratory NADS MiniSim™ driving simulator with (a) eye-tracking system and (b) in-vehicle display ____ 37

Figure 2: Visual-manual secondary task displayed on the Surface Pro 2 display ____ 38

Figure 3: (a) Social norms feedback, (b) post-drive feedback without social norms information ____ 44

Figure 4: Rate of long glances (>2 seconds) per minute across feedback conditions and drives. ____ 49

Figure 5: Average glance duration on the secondary display across feedback conditions and drives ____ 50

Figure 6: 95th percentile glance duration on the secondary display across feedback conditions and drives. ____ 51

Figure 7: Percentage of time looking at the secondary display across feedback conditions and drives. ____ 52

Figure 8: Number of glances on the secondary display across feedback conditions and drives ____ 53

Figure 9: Number of manual interactions with the secondary display across feedback conditions and drives ____ 54

Figure 10: Standard deviation of lane position across feedback conditions and drives ____ 55

Figure 11: Accelerator release time across feedback conditions and drives ____ 56

Figure 12: Maximum deceleration across feedback conditions and drives ____ 57

Figure 13: Acceptance of feedback (estimated means and 95% confidence intervals) ____ 58

Figure 14: (a) Same/opposite-gender peer-norm feedback ____ 65

Figure 15: Rate of long glances (>2 seconds) per minute across feedback conditions ____ 68

Figure 16: Average glance duration on the secondary display across feedback conditions and drives ____ 69

Figure 17: 95th percentile glance duration on the secondary display across feedback conditions and drives. ____ 70

Figure 18: Percentage of time looking at the secondary display across feedback conditions and drives ____ 71

Figure 19: Number of glances on the secondary display across feedback conditions and drives ____ 72

Figure 20: Number of manual interactions with the secondary display across feedback conditions and drives ____ 73

Figure 21: Standard deviation of lane position across feedback conditions and drives ____ 74

Figure 22: Accelerator release time across feedback conditions and drives ____ 74

Figure 23: Brake transition time across feedback conditions and drives ____ 75

Figure 24: Maximum deceleration across feedback conditions and drives _________________________76

Figure 25: Acceptance of feedback (estimated means and 95% confidence intervals) ________________78

List of Appendices

Appendix A- Survey …………………………………………………………………….... 93

Appendix B- Screening Questionnaire …………………………………………….…….107

Appendix C- Consent Form ……………………………………………………….….….114

Appendix D- Advanced Transport Telematics Acceptance Assessment Questionnaire …..….117

Appendix E- Experiment II, Pre-experiment Questionnaire ………………………………….118

Chapter 1
Introduction

Teen drivers have an elevated crash risk relative to adult drivers (Williams, 2003a). In 2014, 15 to 20 year old drivers constituted only 5.5% of all licensed drivers in the U.S., however, they accounted for 9% of drivers involved in fatal crashes and 12% of those involved in police-reported crashes (National Highway Traffic Safety Administration, 2016b). Similarly, in Canada, young drivers play a disproportionate role in crashes. While drivers aged between 16 to 24 years represented about 13% of all licensed drivers in 2010, they accounted for 24% of fatalities and 26% of serious injuries (Road Safety Canada Consulting, 2011).

In line with the findings from police-reported crashes, the findings from the Naturalistic Teenage Driving Study show that, on average, teens have 3.9 times higher crash and near-crash rates than adult drivers (Simons-Morton et al., 2015). Many factors, including risky driving behaviours, contribute to the high crash rate observed among teens (Williams, 2003b). For example, in 2015, 32% of male drivers and 20% of female drivers between 15 to 20 years old who were involved in fatal crashes in the U.S. were speeding at the time of the crash (National Highway Traffic Safety Administration, 2017). In Canada, 27% of fatalities and 19% of serious injuries recorded in 2010 involved speeding, and 40% of speeding drivers who were involved in fatal crashes were 16 to 24 years old (Road Safety Canada Consulting, 2011).

An important risky driving behaviour that is a significant contributing factor to the elevated crash risk among teens is driver distraction (Ferguson, 2003; Shope & Bingham, 2008; Williams, 2003b). In 2014, distraction contributed to 10% of teen driver (15-19 years) fatal crashes in the U.S. (National Highway Traffic Safety Administration, 2016a). Additionally, about 20% of all crashes involving teen drivers (15-18 years) has been attributed to distracted driving (Curry, Hafetz, Kallan, Winston, & Durbin, 2011). Although comparable data for Canada are not available, the contribution of driver distraction to fatal and injury crashes is likely very similar (Road Safety Canada Consulting, 2011). While the teen crash risk associated with driver distraction is already alarming, there is growing concern about the distraction caused by new mobile and interactive technologies. Given the increasing concern, the overall objective of this dissertation was to design effective interventions to mitigate teen driver distraction.

Although in-vehicle technologies can be sources of driver distraction, they can also be utilized to provide drivers with personalized feedback and direct their attention back to the road (Lee, 2007, 2009). Previous studies suggest that providing feedback during (i.e., real-time feedback) and after (i.e., post-drive feedback) driving could be effective countermeasures to mitigate driver distraction and improve driving performance (Carney, McGehee, Lee, Reyes, & Raby, 2010; Donmez, Boyle, & Lee, 2007a, 2008a; Lee, McGehee, Brown, & Reyes, 2002; McGehee, Raby, Carney, Lee, & Reyes, 2007). One important factor governing teens' distracted driving behaviour, which has not yet been studied in the context of personalized feedback to mitigate driver distraction, is social norms (Beck & Watters, 2016; Bingham, Zakrajsek, Almani, Shope, & Sayer, 2015; Carter, Bingham, Zakrajsek, Shope, & Sayer, 2014; 2004). As noted by Lee et al. (2004, p. 586),"(T)he most powerful factors governing distraction may be the most difficult to quantify and shape. In particular, social norms governing acceptable risks – specifically, whether it is socially acceptable to use a cell phone while driving – may have the largest effect on driving safety". Therefore, despite the challenge, this dissertation aimed to understand the social norms underlying teen driver distraction, and to investigate the effectiveness of social norms feedback in mitigating teen driver distraction.

In recent years, there has been a growing interest in using social norms interventions to change individuals' behaviours. According to the Social Norms Theory (Perkins & Berkowitz, 1986), individuals choose to engage in a particular behaviour based on their perceptions of others' behaviour (i.e., descriptive norms) or approval (i.e., injunctive norms). The overestimation of the prevalence/permissiveness of negative behaviours is common and can lead to increased engagement in those behaviours. Social norms interventions aim to correct these overestimations and reduce negative behaviours by providing accurate social norms information.

Over the past two decades, social norms interventions have been used to target behavioural changes in various domains, such as energy consumption (e.g., Allcott, 2011), alcohol use (e.g., Haines, Barker, & Rice, 2003), smoking (e.g., Linkenbach & Perkins, 2003), and drunk driving (e.g., Linkenbach & Perkins, 2005). However, to the best of my knowledge, this approach has not yet been systematically evaluated in the teen driver distraction domain, and there has been only one previous study which has incorporated social norms information in the design of a post-drive feedback system to mitigate driver distraction (Roberts, Ghazizadeh, & Lee, 2012). Roberts et al. (2012) conducted a simulator experiment with 36 participants between the ages of 25 and

50 years to evaluate two different driver feedback systems: post-drive feedback incorporating social norms information and real-time feedback. Post-drive feedback included a post-drive report with feedback on participants' driving performance and distraction level, as well as a comparison between participants' and their peers' distracted driving behaviour. Real-time feedback included visual and auditory warnings based on glance behaviours to alert drivers to distracted driving. Post-drive feedback increased eyes-on-road time and decreased unsafe off-road glances compared to a no feedback condition, whereas real-time feedback was not found to generate such benefits (Lee et al., 2013; Roberts et al., 2012). Although these results provide evidence that post-drive feedback incorporating social norms information can be effective to reduce driver distraction, it is unclear which aspect of the intervention, i.e., summary of driving performance or comparison to peers, was effective. Therefore, this dissertation systematically evaluated the social norms approach in the teen driver distraction domain by decomposing and evaluating the unique contributions of each component in a social norms intervention. As for social referents, we focused on both parents and peers, as they are the primary reference groups for teens, and a substantial body of literature provides evidence that parental and peer norms influence teens' risky driving behaviours (Carter et al., 2014; H. Y. W. Chen & Donmez, 2016; Hill et al., 2015; Simons-Morton et al., 2011, 2014; Taubman - Ben-Ari & Katz - Ben-Ami, 2012).

1.1 Current Research: Structure and Goals

As mentioned earlier, this dissertation aimed to understand the social norms underlying teen driver distraction and to investigate the effectiveness of social norms feedback for mitigating distracted driving among teens. The background literature motivating these objectives in detail is presented in Chapter 2. To achieve these objectives, a survey study was conducted along with two driving simulator studies, one focusing on parental norms and the other one focusing on peer norms. The survey results are partly reported in a conference proceeding paper which received an Honourable Mention in the Student Paper Competition: *Merrikhpour, M. & Donmez, B. (2016), Social norms and distractions among teenage drivers, In the Proceedings of the 2016 Canadian Association of Road Safety Professionals Conference, Halifax, NS*. The simulator experiment on parental norms is reported in a journal article: *Merrikhpour, M. & Donmez, B. (2017), Designing feedback to mitigate teen distracted driving: A social norms approach,* *Accident Analysis and Prevention, 104, pp. 185-194.* A journal paper based on the other simulator study is currently in preparation.

The survey, presented in Chapter 3, investigated the existence of social norms misperceptions among teens, and studied the role of parental and peer norms in teen driver distraction. It was hypothesized that teens might overestimate parental and peer norms, and that teen perceptions of parental and peer norms are predictive of their self-reported engagement in driver distractions. The survey was completed by 101 teen-parent dyads. However, 30 teens, who reported to drive infrequently, and their parents were excluded from analyses. Consistent with our hypotheses, the results showed that teens may overestimate driver distraction norms. It also showed that teen perceptions of parental and peer norms were predictive of teen self-reported frequency of engagement in driver distractions. Overall, the findings supported the second component of this dissertation, which was the evaluation of social norms feedback to mitigate driver distraction among teens.

The two driving simulator experiments aimed to investigate the effectiveness of social norms feedback based on (1) parental norms and (2) peer norms. We hypothesized that providing teens with social norms feedback can correct the potential misperceptions that may exist among teens and mitigate their distracted driving behaviours.

Forty teen-parent dyads participated in the first experiment, which had four between-subject conditions: (1) post-drive feedback incorporating parent norms (social norms feedback), (2) post-drive feedback without social norms information in order to tease out the effect of parent norms, (3) real-time feedback as it has also been shown to be effective in distraction mitigation, and (4) no feedback as control. Pre- and post-experiment questionnaires were also administered to collect data on teens' and their parents' self-reported engagement in driver distractions and the associated social norms. The pre-experiment questionnaire was part of the survey study (Chapter 3) that overlapped in data collection with the first driving simulator experiment. Teens' acceptance of the feedback types was also investigated. Overall, the results showed that social norms feedback based on parent norms is promising for mitigating teen driver distraction. Our findings indicated that both social norms feedback and real-time feedback reduced distraction engagement and improved driving performance, with social norms feedback outperforming real-time feedback as implemented in this study. However, no major benefit was observed with post-drive feedback without social norms information. Analysis of acceptance data revealed that teens found social norms and post-drive feedback to be useful and satisfactory. However, teens did not find real-time feedback satisfying. In addition, despite the promising results for social norms feedback based on parent norms, teens' perceptions of parent norms did not change after receiving feedback. The lack of significance may be due to small sample size in this experiment. Also we were not able to consider gender as a factor again due to sample size issues. As explained below, gender may play a role in the efficacy of social norms feedback. In the second simulator experiment, which focused on peer norms, we increased the sample size and investigated the effects of tailoring social norms feedback to teen gender.

Based on the Social Comparison Theory (Festinger, 1954), which states that socially proximal comparison referents (e.g., same age, same gender) have a greater influence than more distal comparison referents, we hypothesized that social norms feedback based on peer norms will also be effective in mitigating teen driver distraction and that social norms feedback based on same-gender peer norms will have a larger positive effect than social norms feedback based on opposite-gender peer norms. Three between-subject feedback conditions were evaluated in the second experiment: (1) post-drive feedback incorporating same-gender peer norms, (2) post-drive feedback incorporating opposite-gender peer norms, and (3) no feedback as control. Given that the first experiment did not find any effects for the post-drive feedback only condition compared to no feedback, the post-drive feedback only condition was eliminated in the second experiment. 46 participants were recruited for the second experiment. Data from the 11 participants who completed the no feedback condition in the first experiment were added to the no feedback condition of the second experiment (leading to 17 participants in no feedback and 57 participants total) as the experimental design and procedures for the no feedback conditions across the two experiments were exactly the same. To further justify this merge, the data for two groups were compared and no significant differences were observed. Similar to Experiment 1, questionnaires were administered to all Experiment 2 participants to collect data on teen self-reported engagement in distractions, the associated social norms, and their acceptance of the interventions. Overall, the results showed that social norms feedback based on peer norms is effective in reducing distraction engagement and improving driving performance among teens. Analyses of acceptance data revealed that all feedback types were found to be useful and satisfactory, and were well accepted by teens. Contrary to our hypothesis, no significant difference was observed between feedback based on same-gender peer norms and feedback based on opposite-gender peer norms. Further, no significant change was observed in teen perceptions of peer norms after receiving social norms feedback.

Chapter 4 presents the experimental apparatus used in the two experiments. Chapters 5 and 6 present the experimental design, methods, and results for the first and second experiments, respectively. Chapter 7 summarizes the main findings and contributions of this dissertation, and identifies limitations and opportunities for future research.

Chapter 2
Background Literature

2

2.1 Teen Driver Distraction

Distraction, the diversion of attention from the driving task towards some other activity (National Highway Traffic Safety Administration, 2016b), is a growing problem among teen drivers. In fact, 15- to 19-year-old drivers compose the largest proportion of drivers involved in distraction-affected crashes (National Highway Traffic Safety Administration, 2016a). For fatal crashes in 2014, 15 to 19 year old drivers made up 7% of all drivers (2,898 of the 44,583) but 10% of distracted drivers (285 of the 3,000). In addition, Carney et al. (2015) reviewed 1,691 crashes that occurred between August 2007 and July 2013 involving teen drivers (16-19 years) and indicated that in up to 58% of the crashes, teen drivers were engaged in some type of potentially distracting behaviour.

While distractions have always been present in the driving environment, rapid advancement of mobile technologies in our lives and interactive technologies built into vehicles in recent years have made the issue ever more pronounced. Wilson et al. (2010) estimated that increases in texting while driving resulted in 16,141 additional fatalities from 2001 to 2007. In a survey study of high school students in 2012, Olsen at al. (2013) found that 45% reported to texting and driving; a 2009 study found 26% of 16 and 17 year olds to report the same behaviour (Madden & Lenhart, 2009). In addition, in a recent survey study of 4964 college students, Hill et al. (2015) found that 91% of respondents reported talking on a phone or texting while driving, and 25% reported using hands-free devices "most of the time". Compared to older and experienced drivers, younger drivers are more likely to engage in distraction while driving. Through a national survey of 1219 drivers, Farmer et al. (2010) estimated drivers younger than 30 years old to be distracted by their cell phone 16% of the time they spend driving. The estimates for drivers 30-59 and 60+ were 7.1% and 2.5%, respectively.

Driver distraction poses a threat to the safety of teen drivers in particular given their lack of skill and poor judgment (Horberry, Anderson, Regan, Triggs, & Brown, 2006) as well as their tendency towards risk-taking behaviours (Steinberg, 2008; Williams, 2003b). Teens also may have less attentional resources available for secondary tasks, as operating a vehicle takes an extensive amount of experience to become an automatic process, and therefore places significant demands on teens' attentional capacity (Lee, 2007; Shinar, Meir, & Ben-Shoham, 1998).

Besides age, gender is another factor that is prominent in traffic safety research. Previous research shows that young males have an overall higher crash risk than same-aged females (Bingham & Ehsani, 2012; H. Chen, Cao, & Logan, 2012; Williams, 2003b). However, regarding teen driver distractions, literature is not conclusive about gender differences. For example, in a survey study of 756 high school students, Barr et al. (2015) found that males reported a higher level of engagement in driver distractions compared to females. In a naturalistic driving study of 52 teen drivers, Foss et al. (2014) showed that females were twice as likely as males to be using an electronic device and more than three times as likely to be observed using a hand-held cell phone. In addition, females were slightly more likely to engage in other distractions including adjusting controls and reaching for an object in vehicle. It is important to note that participants were mainly females (69%) in this study, and there might exist some sample bias. In contrary to these findings, several studies reported no association between gender and teen driver distraction engagement (Beck & Watters, 2016; Bernstein & Bernstein, 2015; Bingham et al., 2015; Carter et al., 2014; Hill et al., 2015).

Despite the conflicting findings regarding gender differences in distraction engagement, the detrimental effects of distractions on driving performance of young novice drivers are well documented. Donmez et al. (2007b) conducted a simulator study and showed that engagement in a visual-manual secondary task degraded driving performance of young drivers (18-21), and resulted in increased steering entropy (i.e., more steering instability), degraded braking performance, and shorter minimum time to collision. Beede et al. (2006) also investigated the effects of distractions on driving performance of college students through a simulator study. Their results showed that talking on a hands-free cell phone significantly increased traffic violations (e.g., speeding, running stop signs and lights) and attention lapses (e.g., stopping at green lights, failure to visually scan for intersection traffic). With regard to crash risk, Klauer et al. (2015) conducted a systematic review of crash databases, simulator, instrumented vehicle, and naturalistic driving studies to examine the effects of secondary task engagement on teen crash risk. Overall, 15 studies were reviewed. Findings indicated that secondary tasks which required drivers to look away from the forward roadway (e.g., texting) increased crash risk; however, secondary tasks where eyes were not required to be off the forward roadway (e.g., talking on a cell phone) did not significantly increase crash risk. A noteworthy study included in Klauer et al.'s review is the Naturalistic Teenage Driving Study (Simons-Morton et al., 2015), which was conducted between June 2006 and September 2008 and involved 42 newly-licensed teen drivers during the first 18 months of their licensure. Results of this study showed that engagement in dialing or reaching for a cell phone, reaching for an object other than a cell phone, texting, looking at a roadside object such as a vehicle in a previous crash, and eating were all associated with a significantly increased risk of a crash or a near-crash. Given the performance decrements and associated crash risks reported in the distraction literature across a wide variety of study types, driver distraction among younger drivers needs to be mitigated.

Different countermeasures have been proposed and implemented to mitigate driver distraction. One common approach that targets all drivers is law and enforcement. However, previous evaluations of this approach have shown mixed results. McCartt et al. (2004) reported that handheld cellphone use in New York declined from 2.3% to 1.1% shortly after the cell phone ban came into effect. However, the immediate post-law benefit did not sustain after one year, and no significant effect was observed when compared to Connecticut, an adjacent state without such a law. In addition, several studies have shown that laws banning texting and talking on the cell phone while driving were not effective in reducing crash risk, particularly for teen and young drivers (Burger, Kaffine, & Yu, 2014; Ehsani, Bingham, Lonides, & Childers, 2014; Goodwin, O'Brien, & Foss, 2012). On the other hand, Carpenter et al. (2014), who evaluated the effectiveness of the cellphone ban on overall, handheld, and hands-free cellphone use while driving in Ontario, Canada, showed that the cellphone ban significantly reduced self-reported overall and handheld cellphone use. However, their results also showed that self-reported hands-free cellphone use increased. In addition, some studies suggest these laws are effective in reducing crashes (Abouk & Adams, 2013; Kwoon, Yoon, & Jang, 2014).

Graduated driver licensing (GDL) and driver education are approaches that are applied to teens in particular. GDL is a three-phase approach including a learner's permit, a provisional license, and a full license. GDL helps novice drivers acquire experience gradually by extending the period of supervised driving and imposing a set of driving restrictions, including limiting driving at night and carrying teen passengers. This approach has consistently been shown to be effective in reducing teen crash risk (Vanlaar et al., 2009). With regard to driver education, however, several studies have shown that this approach may not increase roadway safety (Fisher, Pollatsek, & Pradhan, 2006; Katila, Keskinen, Hatakka, & Laapotti, 2004).

One promising approach, which is the focus of this dissertation, is to utilize in-vehicle technologies to provide drivers with feedback and direct their attention back to the road (Lee, 2007, 2009). In the following section, previous efforts that evaluated this approach to mitigate driver distraction are presented.

2.2 Feedback to Mitigate Driver Distraction

Feedback in the context of driving can be defined as the information available to the driver regarding the state of the driver-vehicle system (Donmez et al., 2008a). Such feedback can be provided both during driving (real-time feedback) and after a road trip (post-drive feedback). Real-time feedback warns the driver of an improper action or potential hazard as it is occurring and aims to enhance immediate driving performance (Donmez et al., 2008a). Real-time feedback has to be concise and has to communicate a salient message to the driver as any information provided in real-time would compete for resources needed for the driving task. In contrast, post-drive feedback can present detailed information on driving behaviour and performance on past trips, and it can include a summary of specific incidents where unsafe driving behaviours were executed (Donmez et al., 2008a). Post-drive feedback aims to induce long-term positive changes in driving behaviour rather than improving immediate driving performance.

A number of simulator studies have been conducted to examine the effects of real-time and post-drive feedback on distracted driving. With young (18-21) and middle aged (35-55) drivers, Donmez et al. (2007a) evaluated the safety implications of providing visual real-time feedback to distracted drivers. Their results indicated that both age groups benefitted from real-time feedback, as indicated by less frequent off-road glances and longer on-road glances. Lee et al. (2002) showed that real-time auditory collision avoidance warnings reduced reaction times of distracted drivers (25-55 years) to lead vehicle braking events. In another study, Donmez et al. (2008b) evaluated the effects of post-drive feedback that provided participants (18-21 years) with information on their critical incidents (e.g., speeding, too close to lead vehicle, and lane deviation), the severity level of the incident (low, medium, or high), as well as their distraction level during the incident (low/none, medium, or high). Their results showed that post-drive feedback resulted in faster reactions to lead vehicle braking events compared to no feedback.

Through a naturalistic study conducted in a rural environment, McGehee et al. (2007) showed that a combination of real-time and post-drive feedback decreased the rate of safety-relevant events (e.g., crash/near crash, improper turns, and abrupt braking) observed among 16 and 17 year olds. In this study, teens received real-time visual feedback that informed them about their risky manoeuvres. In addition, weekly feedback including video clips of the safety-relevant events and a report on teen's performance relative to their peers were mailed to both teens and their parents. In addition, in a follow-up study, Carney et al. (2010) showed that the combination of real-time and post-drive feedback was also effective in decreasing safety-relevant events among 16-year-old teens with less than 6 months of driving experience who drive in an urban environment. Overall, these previous studies suggest that providing feedback during and after driving could be effective countermeasures to mitigate driver distraction and improve driving performance. As described in the following section, one important factor governing teen driving behaviour, including distracted driving behaviour, is social norms. Therefore, when considering distraction mitigation interventions for teen drivers, consideration of social norms influences is critical.

2.3 Social Norms and Teen Drivers

Two main types of social norms that have been distinguished in the literature are descriptive norms and injunctive norms (Cialdini, Kallgren, & Reno, 1991; 1990). Descriptive norms describe what other people commonly do and induce the perception that a common behaviour should be the effective thing to do, whereas injunctive norms refer to what other people commonly approve or disapprove of and therefore motivate behaviour through the promise of social sanctions. The changes that occur during adolescents' development can leave them especially vulnerable to basing their decisions on the perceived behaviour/approval of others to justify their own behaviour or gain acceptance (Christie & Viner, 2005).

A substantial body of literature provides evidence of social norms influences on teen driving behaviours (Carter et al., 2014; Chen & Donmez, 2016; Hill et al., 2015; Simons-Morton et al., 2011, 2014; Taubman - Ben-Ari & Katz - Ben-Ami, 2012). Two important sources of social influences on teens are parents and peers. Parents can serve as primary role models for driving behaviours. They can affect their children's driving behaviours through their own driving behaviours and the way they interpret social norms and riskiness of different driving behaviours.

They can also be involved in teaching teens to drive, monitoring them, and setting rules and restrictions on teen driving. Taubman-Ben-Ari et al. (2012) found that teen drivers, who perceived their parents to be more committed to safety and to provide more encouraging feedback for safe driving, reported driving more carefully and taking risks less frequently. In addition, Taubman-Ben-Ari et al. (2005) indicated significant positive associations between self-reported parent and teen driving styles. In a naturalistic study, McGehee et al. (2007) showed that extending parental monitoring through an event-triggered video device resulted in decreased risky driving behaviours among teens. In this study, teens received real-time visual feedback that informed them about their risky manoeuvres. In addition, weekly feedback including video clips of the safety-relevant events and a report on teen's performance relative to their peers were mailed to both teens and their parents. Overall, results showed that the combination of real-time feedback, weekly feedback, and parental monitoring/mentoring resulted in decreased number of safety-relevant events. Hartos et al. (2002) also showed that parental monitoring and restrictions on teen driving are inversely associated with risky driving among teens. Their results indicated that teens who exhibited higher levels of risky driving were three times more likely to report low parental monitoring and two times more likely to report low parental restrictions on their driving. With regard to driver distraction specifically, Carter et al. (2014) found that teens who perceived their parents to engage in driver distraction more frequently reported higher engagement in driver distraction themselves. Also, parents' self-reported driver distraction engagement was positively associated with that of their teens.

Peers also play an important role on teen driving behaviours. During adolescence, teens turn increased attention to peer social cues and desire to please their peers (Allen & Brown, 2008; Blos, 1966; Gifford-Smith, Dodge, Dishion, & McCord, 2005). In the Naturalistic Teenage Driving Study, Simons-Morton et al. (2011) showed that teens who reported to have more risk-taking friends had significantly higher rates of crashes/near crashes and risky driving. Carney et al. (2015) also reviewed 1,691 moderate-to-severe crashes involving teen drivers aged 16 to 19 years. Their results indicated that in 36% of these crashes, passengers were present, and the majority of passengers (84%) were estimated to be 16-19 years old. In a driving simulator study, Simons-Morton et al. (2014) found that male teens who were exposed to a risk-accepting confederate peer exhibited more high-risk driving behaviours compared to those who were exposed to a risk-averse confederate peer. Also, Allen et al. (2008) argued that in the presence of peer passengers, teens are concerned with maintaining and strengthening their relationships with their peers rather than solely trying to drive safely. Particular to driver distractions, Carter et al. (2014) found that teen perceptions of their peer engagement in driver distraction were predictive of teen self-reported driver distraction. In addition, in a recent survey study of 861 college students, Beck et al. (2016) showed that teen perceptions of their friend and their significant other engagement in texting while driving were predictors of their own texting and driving behaviour.

Overall, these previous studies indicate that social norms influence teen risky driving behaviours, including distracted driving. These findings underscore the need to pay closer attention to social norms influences in designing effective interventions aimed at mitigating teen driver distraction. Social norms interventions have been widely used in other domains. However, as mentioned earlier, this approach has not yet been studied in the teen driver distraction domain, and this dissertation aimed to address this gap. The following two sections describe two commonly used theories from the social sciences, which served as the primary guiding framework for this dissertation: the Theory of Planned Behaviour and the Social Norms Theory. Then, interventions based on the Social Norms Theory are described.

2.4 Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB) (Ajzen, 1991) is one of the most commonly used frameworks from the social sciences for understanding people’s intentions and behaviours (Armitage & Conner, 2001). TPB states that behaviour extends from intention, which in turn is a product of attitudes, perceived behavioural control, and subjective norms. Attitude refers to a person’s positive or negative evaluations of the behaviour; perceived behavioural control reflects a person’s belief of how well he/she is able to carry out the particular behaviour; and subjective norms refer to what is commonly approved or disapproved by those who are deemed important to the individuals. Subjective norms are analogous to the concept of injunctive norms described above.

Extensive research in the literature has shown that TPB can successfully predict risky driving behaviours such as speeding and aggressive driving (Elliott, Armitage, & Baughan, 2003; Forward, 2009; Paris & Den Broucke, 2008; Parker & Manstead, 1992). Compared to these risky driving behaviours, the use of TPB is relatively new for driver distraction. In addition, the majority of work in the driver distraction domain focuses on cell phone use. For example, Zhou et al. (2009) studied the utility of TPB in predicting young drivers' (17-34 years) intentions to use a hands-free or hand held cell phone while driving. The results indicated that subjective norms, attitude, and perceived behavioural control were all significant predictors of behavioural intention in relation to using either a hands-free or hand held cell phone. White et al. (2010) also investigated the efficacy of TPB in predicting drivers' hands-free and hand held cell phone use. Their results indicated that both the frequent users of hands-free cell phones and the frequent users of hand held cell phones reported more positive attitude, more approval from others, and fewer barriers that would prevent them from using either a hands-free or a hand held cell phone while driving than infrequent users. In a recent study, Chen et al. (2016) sampled 578 drivers with ages ranging from 18 to 77 years old to investigate the utility of TPB in predicting driver intentions to engage in six distraction tasks: (1) conversations on a phone, (2) manual interaction with a phone, (3) manual interaction with in-vehicle technology, (4) reading of roadside advertisements, (5) visual dwelling on roadside accident scenes, and (6) conversation with passengers. In addition to the TPB constructs, the authors included descriptive norms (i.e., perception of what other people do) in their study. The study found that descriptive norms, attitudes, and perceived behavioural control were significant predictors of self-reported engagement after controlling for age and gender.

Overall, these previous studies using the TPB framework provide valuable insights into drivers' motivations for engaging in distractions. However, these studies do not address the role of parental and peer norms on teen driver distractions, which is the focus of the current dissertation. Therefore, questionnaires evaluated within this dissertation were built with TPB as the framework to examine the effects of parental and peer norms, attitudes, and perceived behavioural control on a range of distractions engaged in by teen drivers. Similar to Chen et al. (2016), we included descriptive norms in addition to the TPB construct of subjective norms. This allowed us to differentiate the potential influences of descriptive (i.e., perception of what others do) and subjective (i.e., perception of what others approve) norms on teen driver distraction.

Another theory that emphasizes the role of social norms on behaviour is the Social Norms Theory (Perkins & Berkowitz, 1986). This theory, which is outlined in the following section, has been applied as a framework for developing social norms feedback evaluated within this dissertation.

2.5 Social Norms Theory

The Social Norms Theory contends that perceptions of others' behaviours/approval of behaviours affect an individual's decision to engage in a particular behaviour (Perkins & Berkowitz, 1986). This theory describes the phenomenon of "pluralistic ignorance", the common misconception that attitudes and/or behaviours of peers and other social group members vary from their own when in fact they do not (Katz & Allport, 1928; Miller & McFarland, 1991; Prentice & Miller, 1993; Schroeder & Prentice, 1998). This theory predicts that people usually overestimate the prevalence and permissiveness of unhealthy or harmful behaviours, and they underestimate the extent to which others engage in and approve of healthy or protective behaviours. These misperceptions cause individuals to change their own behaviours and adopt unhealthy behaviours in order to align with their perceived norms (Berkowitz, 2004, 2005; Prentice & Miller, 1993). The Social Norms Theory also predicts that manipulation of perceived social norms can subsequently result in behavioural change (Perkins & Berkowitz, 1986). It hypothesizes that correcting misperceptions can reduce the occurrence of unhealthy behaviours or encourage protective and healthy behaviours (Berkowitz, 2004, 2005). Interventions based on the Social Norms Theory apply these assumptions to correct the misperceptions or overestimations of unhealthy behaviours and thereby reduce these behaviours by providing accurate social norms information to individuals.

Overestimation of social norms has been addressed extensively in the literature for negative behaviours such as alcohol consumption, impaired driving, and gambling behaviours. For example, in a statewide phone survey, Linkenbach et al. (2003a) sampled 500 18-to-24-year olds in order to investigate the potential misperceptions of peer alcohol norms among young adults. Participants were asked about their own drinking behaviours and their perceptions of alcohol consumption of their peers. Their results indicated that while male and female participants reported to consume three and two drinks during a typical night out on average, respectively, they perceived that their male and female peers were typically consuming seven and five drinks on average, respectively. Further, although, only 15% of respondents reported that they had driven within one hour of consuming two or more drinks in the previous month, 96% of respondents perceived that the majority of their peers had done so. In addition, Perkins et al. (1986; 1999) showed that college students overestimated the prevalence (descriptive norms) and permissiveness (injunctive norms) of alcohol consumption among their peers. Similar results were found for gambling behaviours, where students overestimated the frequency and amount of gambling among their peers (Celio & Lisman, 2014).

As for teen driver distractions, research on teen perceptions of parental and peer norms is very limited. In a recent study (Bingham et al., 2015; Carter et al., 2014), 403 teen-parent dyads were interviewed. Results of this study showed that teens may overestimate their parents' and peers' frequency of engagement in driver distractions. However, this survey did not investigate teens' potential overestimation of approval of distraction (injunctive norms). Therefore, this dissertation aimed to investigate the existence of misperceptions around both descriptive and injunctive norms. In addition, in (Bingham et al., 2015; Carter et al., 2014) referent's gender was not taken into account. As mentioned earlier, one of the objectives of this dissertation was to investigate the effects of tailoring social norms feedback based on teen's gender (we evaluated social norms feedback based on same-gender vs. opposite-gender peer norms). According to the Social Comparison Theory (Festinger, 1954), we hypothesized that social norms feedback based on same-gender referent norms has a greater influence than social norms feedback based on opposite-gender referent norms. Therefore, this dissertation investigated the existence of misperceptions with the consideration of referent's gender.

2.6 Social Norms Interventions

Social norms interventions aim to correct the misperceptions of unhealthy behaviours and manipulate the perceived norms in a way that results in individuals reducing their negative behaviours. In order to adjust misperceptions, social norms interventions present accurate normative information. Social norms interventions are typically in one of two forms: social norms marketing campaigns or personalized normative feedback.

Social norms marketing campaigns are the most widely employed form of social norms intervention, and rely on mass communication methods, including newspaper ads, posters, flyers, billboards, and electronic media for disseminating normative information (Haines, Barker, & Rice, 2003; Perkins et al., 2010). The social norms marketing campaign conducted at the Northern Illinois University was the first intervention that applied the Social Norms Theory (Haines, 1996; Haines & Spear, 1996). This media campaign was a 5-year intervention, from 1988 to 1992, that aimed to adjust college students' perceptions of drinking norms and reduce binge drinking behaviour. Results indicated an 18.5% reduction in the number of students who perceived binge drinking as the norm and 8.8% reduction in self-reported binge drinking behaviour. As for the driving domain, Montana's *Most of Us Don't Drink and Drive* statewide campaign aimed to emphasize accurate normative information (i.e., 4 out of 5 don't drink and drive) to correct 21-to-34-year-old drivers' perception of the prevalence of drunk driving in Montana (Linkenbach & Perkins, 2005; Perkins et al., 2010). The researchers concluded that the campaign was successful; it decreased the target population's misperceptions of the frequency of impaired driving among their peers, as well as self-reported drinking and driving behaviour among young adults.

Although many studies have provided evidence for the efficacy of the social norms marketing campaigns (Haines, 1996; Haines & Spear, 1996; Linkenbach & Perkins, 2005; Perkins & Craig, 2006; Perkins et al., 2010), there exist methodological limitations/challenges to this form of intervention, and a number of researchers suggest that this approach needs further evaluation and may not be effective (Clapp, Lange, Russell, Shillington, & Voas, 2003; Dejong, 2002). One of the challenges is message saturation, as normative information needs to be salient and adequately presented to individuals in order to be viewed and remembered (Clapp et al., 2003). Placing a few posters within a small community may be adequate to capture target audiences' attention and reinforce the message; however, it may lack proper message saturation within a large community. Therefore, conducting effective campaigns within large social communities can be costly. Further, social norms marketing campaigns do not directly highlight the discrepancies between individuals' behaviour/perceived norms and the actual norms. Such interventions also can be difficult to evaluate in terms of effectiveness due to the lack of control of extraneous variables. Due to these limitations/challenges, the other form of social norms interventions, personalized normative feedback, was evaluated in this dissertation.

Personalized Normative Feedback (PNF) involves providing comparative feedback of one's own behaviours/perceived norms with the others' behaviour/approval (Lewis & Neighbors, 2006). PNF is designed to highlight discrepancy and develop motivation for behavioural change. This form of social norms intervention can be given to an individual or a group in person or via email, website, or letter.

PNF has been applied successfully in many domains. For example, Walters et al. (2000) showed that PNF mailed to college students who were heavy drinkers comparing their self-reported alcohol use and consumption rates with the university population successfully reduced individuals' self-reported drinking behaviour. Neighbors et al. (2015) investigated the efficacy of computer-based PNF for gambling of college students. Their results indicated that PNF significantly decreased the perceived norms for quantities lost and won, and actual quantity lost as well as gambling behaviour at the 3-month follow-up. Brannan (2011) conducted a randomized controlled trial investigating the effects of an email-based PNF on college students' fuel-efficient driving behaviours. Feedback included a historic comparison, a comparison of the participants' fuel economy to the average and maximum fuel economy of other students, and tips on fuel-efficient driving practices. The study lasted for three weeks, and feedback was provided in the middle of the second and third weeks. Overall, results suggested that feedback can be effective in changing fuel-efficient driving behaviours. However, it is important to note that in this study, social norms feedback was provided in combination with historic comparisons and fuel-efficient driving tips.

In the driver distraction domain, as mentioned in Chapter 1, Roberts et al. (2012) evaluated the effectiveness of post-drive feedback incorporating social norms information on distracted driving behaviours provided to 25 to 50 year-olds. Feedback included a report on participants' driving performance and distraction level, as well as a comparison between participants' and their peers' distracted driving behaviours. Results showed that feedback increased eyes-on-road time and decreased unsafe off-road glances compared to a no feedback condition (Lee et al., 2013; Roberts et al., 2012). These findings provide evidence that personalized normative feedback can be effective in reducing driver distraction; however, it is unclear which aspect of feedback, i.e., summary of driving performance or comparison to peers, was effective. In addition, effects of feedback on teen drivers remain unexamined, despite the fact that this group is arguably the one that is influenced most by social norms. Therefore, this dissertation aimed to systematically investigate the ability of personalized normative feedback to mitigate teen driver distraction.

Overall, social norms interventions can be based on descriptive norms and/or injunctive norms. In this dissertation, we focused on descriptive norms, based on the extensive research supporting the effectiveness of social norms interventions based on descriptive norms (Lewis & Neighbors, 2006; Linkenbach & Perkins, 2005; Neighbors et al., 2015; Perkins et al., 2010). This approach is also supported by the findings directly related to teen driver distractions, that is, those of

Carter et al. (2014) and Beck et al. (2016) who showed that descriptive norms have a larger effect on self-reported teen driver distraction engagement than injunctive norms.

Chapter 3
Survey Study: Social Norms and Teen Driver Distraction

3

A survey study aiming to understand the role of parental and peer norms in teen driver distraction and to investigate the existence of social norms misperceptions among teens was conducted. It was hypothesized that teen perceptions of driver distraction norms are predictive of their self-reported engagement in distractions while driving, and teens might overestimate the norms. Theory of Planned Behaviour (TPB) was used as the framework for developing the survey as TPB has proven to successfully predict individual's risky driving behaviours, including distracted driving (Chen, Donmez, Hoekstra-Atwood, & Marulanda, 2016; Elliott, Armitage, & Baughan, 2003; Parker & Manstead, 1992; White, Hyde, Walsh, & Watson, 2010; Zhou, Wu, Rau, & Zhang, 2009). As mentioned in Chapter 2, in addition to the TPB constructs of attitude, perceived behavioural control, and subjective norms (i.e., perception of what others approve), we included descriptive norms (i.e., perception of what others do) in our survey. This allowed us to differentiate the potential influences of descriptive and subjective norms on teen driver distraction.

3.1 Method

3.1.1 Participants

101 teen-parent dyads completed our survey over a period of 12 months, from Summer 2015 to Summer 2016. Participants were recruited via online advertisements, emails sent to pools of potential participants (e.g., within universities, high schools, and driving schools), and flyers posted at local universities, coffee shops, and gas stations. The stopping criterion for recruitment was time based; that is, we stopped recruiting at the end of one year. It was not possible to keep track of response rate as the survey was an online internet survey open to anyone who had access to the link.

To be eligible for the experiment, teens (17-19 years) and their parent who was going to participate in the study needed to be Canadian residents, and have at least a Class G2 license or equivalent in Ontario, Canada. Under the Ontario Graduated Licensing Program, drivers with a Class G2 can drive alone, at any Ontario road, and at any time, day or night. However, G2 drivers must follow these rules: (a) the driver must have a 0 blood alcohol level, (b) there cannot be more passengers than seatbelts, (c) drivers under 19 years may not carry more than one passenger during the hours of midnight to 5 am, unless the passengers are family members or a fully licensed driver is in the passenger seat; this restriction is lifted after 6 months with the G2 license. Drivers with a G license can drive without these restrictions. However, if they are 21 years or younger, they must have a 0 blood-alcohol level.

Of the 101 teens, 30 teens reported to drive either “a few times a year” or “a few times a month”. These teens and their parents were excluded from analyses in order to avoid a potential confound between the amount of driving and the frequency of self-reported distraction engagement. Of the remaining 71 dyads, 32 were recruited and participated in the first driving simulator experiment (Chapter 5) that coincided with survey data collection. These teens and 10 of the parents completed the survey online but before they drove the simulator in our laboratory; the remaining 22 parents were not invited to the laboratory but were asked to fill out the survey online. The additional 39 dyads (adding up to 71 total) participated solely in the survey study and were invited to fill out the survey online. Monetary compensation was provided to the simulator participants, others had a chance of winning an item from a selection of gifts. The study was approved by the University of Toronto Research Ethics Board.

As shown in Table 1, 56.3% of teen participants were female, and 54.9% reported to drive “a few times a week”. Further, teens were mostly 18- and 19-years old; and held a G2 driver’s license. About half of the parents were female (52.1%), they were mostly between the ages of 35 and 59 years, all had a G driver’s license, and 91.5 % reported to drive “almost every day”.

Table 1: Number (%) of teens and parents by gender, age group, license, and driving frequency

Teens, n (%)		Parents, n (%)	
Gender			
Male	31 (43.7)	*Male*	34 (47.9)
Female	40 (56.3)	*Female*	37 (52.1)
Age			
17	8 (11.3)	*35-49*	33 (46.5)
18	30 (42.2)	*50-59*	34 (47.9)
19	33 (46.5)	*60+*	4 (5.6)
License			
G2	51 (71.8)	*G2*	0 (0.0)
G	20 (28.2)	*G*	71 (100)
Driving Frequency			
Almost Every Day	32 (45.1)	*Almost Every Day*	65 (91.5)
A Few Times a Week	39 (54.9)	*A Few Times a Week*	6 (8.4)

3.1.2 Questionnaire

Self-reported distraction engagement (see Appendix A)

Sixteen distractions were selected to provide a wide range of tasks that drivers may engage in while driving (Table 2). These distractions were mainly adopted from the survey developed by Carter et al. (2014). A few distractions such as "updating or checking social media" and "playing digital games" were added as they are relevant to more recent technology. For analyses, these distraction tasks were narrowed to 10 tasks, excluding the tasks that more than 90% of the teens reported to never or rarely engaging in (i.e., the last five items in Table 2). Further, one task (i.e., talking to passengers if any) was excluded as its wording was not consistent with other items (asking about "talking to passengers if any" rather than "talking to passengers").

For the distraction engagement measure and all other measures presented below, an environmental context (i.e., a two-lane road with low traffic and good weather conditions) was included in order to help participants answer questions more accurately. Previous research shows that driver decisions to engage in distraction depend on context. For example, drivers report being less willing to answer a phone call when approaching a turning manoeuvre than when stopped at a traffic signal (Lerner & Boyd, 2005). A written description of the environmental context and an image representing the context were included in the questionnaire. Participants were asked to answer all questions with this environmental context in mind.

Teens and parents were asked on average how often they have engaged in each of the distractions over the last year (1= never, 2= rarely, 3= sometimes, 4= often, and 5= very often). The 5-point Likert scale was adopted from the Susceptibility to Driver Distraction Questionnaire (SDDQ) developed by Feng et al. (2014). Similar to the SDDQ, in addition to the 5-point Likert scale, an option of 'I don't use this technology' was also provided if applicable. This option helped differentiate respondents who own the technology but do not use it while driving from those who do not own it. If a participant indicated that they do not use a particular technology, then items related to that technology were excluded from later sections of the survey. For the purpose of scoring, responses were averaged across the distractions for each teen and parent. Parents' self-reported distraction engagement served as actual descriptive norms. Other measures collected are presented below. The same approach of averaging was used for these measures.

Table 2: Distraction tasks included in the questionnaire

Distraction Tasks
1- Talking on a hand-held cell phone while driving
2- Talking on the phone using a hands-free device (e.g., Bluetooth headset)
3- Reading a text message on a hand-held device (e.g., cell phone) while driving
4- Responding to a text message on a hand-held device (e.g., cell phone) while driving
5- Manually entering an address into a navigation app on a smartphone that is NOT mounted inside the vehicle while driving
6- Manually entering an address on a built-in or mounted navigational system while driving
7- Updating or checking social media such as Facebook, Twitter, or Instagram while driving
8- Chatting with passengers if there are any while driving
9- Eating something messy like a taco while driving
10- Drinking a hot beverage while driving
11- Having a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)
12- Grooming (e.g., combing hair, applying makeup, flossing teeth) while driving
13- Playing digital games such as Angry Birds, Farmville, or Words with Friends
14- Watching online videos
15- Reading emails on a hand-held device (e.g., cell phone)
16- Reading extended text such as book, magazine, and e-book, or the web

Perceived engagement in distraction (perceived descriptive norms)

Teens were asked, on average, how often they thought their mother, father, and friends their age engaged in each of the distractions over the last year (1= never to 5= very often). Parents responded to the question: 'On average, how often do you think your teen engaged in each of the distractions over the last year?' (1= never to 5= very often).

Perceived approval of distraction (perceived injunctive norms): Teens were asked how strongly they thought their mother, father, and friends their age disapprove/approve their engagement in each of the distractions while driving (1= strongly disapprove, 2= disapprove, 3= neutral, 4= approve, and 5= strongly approve).

Parents' approval of distraction engagement (actual injunctive norms): Parents were asked how strongly they disapprove/approve their teen's engagement in each of the distractions while driving (1= strongly disapprove; 5= strongly approve).

Attitude

Teens were asked to choose their position on a scale of 1 to 5 between the paired bipolar adjectives: 'bad' versus 'good', 'pleasant' versus 'unpleasant', and 'wise' versus 'unwise'. This scale was adopted from SDDQ (Feng et al., 2014). One of the adjectives was worded from negative to positive (i.e., bad=1 vs. good=5 rather than good=1 vs. bad=5) as a way of checking, post-response, whether the participants were reading the scales. For the purpose of scoring, first, the order of this adjective was reversed. Then attitude toward each distraction was calculated by averaging the scores across the three adjectives. These scores then were averaged across the distractions for each teen.

Perceived Risk

Teens were asked how risky they found each distraction. Responses were collected using a 10-point scale anchored as follows: 1= no additional risk beyond my normal driving, 5= an average driving situation, 10= very likely I would be involved in an accident. The responses were averaged across the distractions for each teen.

Perceived Control

Control over driving performance while engaging in distraction was measured by asking teens to indicate the extent to which they agreed or disagreed with the statement: “While driving, I have no difficulty to engage in [distraction]”. Responses were collected using a 5-point Likert scale (1= strongly disagree, 5= strongly agree) and were averaged across the distractions for each teen. The Likert scale was adopted from SDDQ (Feng et al., 2014).

Internal Consistency

The internal consistency within each measure above (e.g., self-reported distraction engagement, perceived descriptive norms) was assessed using Cronbach’s alpha. For all measures, alpha met the well-established threshold of 0.7 (Nunnally, 1978).

3.2 Results

3.2.1 Self-reported Distraction Engagement

The group means and standard deviations of teens’ and parents’ self-reported engagement in each of the 10 distraction tasks are presented in Table 3. Overall, the three most commonly reported distractions among teens were drinking a hot beverage (M=2.79, SD=1.33), reading text messages (M=2.28, SD=1.30), and entering an address into a device not mounted inside the vehicle (M=2.27, SD=1.17). The three most commonly reported distractions among parents were drinking a hot beverage (M=2.70, SD=1.31), talking on a hands-free cell phone (M=2.64, SD=1.25), and talking on a hand-held cell phone (M=1.72, SD=0.89). Overall, teens reported to engage in distractions more frequently than parents (paired t-test: $t(70)=3.64$ $p=.0005$). Independent sample t-tests were conducted to compare the engagement in each of the distractions for male and female participants. No significant gender difference was observed for teens and parents ($p>.05$).

Table 3: Means and standard deviations (SD) for self-reported engagement in each of the distraction tasks; range 1-5

		Mean (SD)		
Distraction		**All**	**Males**	**Females**
Talking on hand-held cell phone	Teen	1.84 (1.02)	1.97 (0.98)	1.75 (1.06)
	Parent	1.72 (0.89)	1.73 (0.96)	1.71 (0.82)
Talking on hands-free cell phone	Teen	2.23 (1.46)	2.60 (1.54)	1.94 (1.33)
	Parent	2.64 (1.25)	2.65 (1.17)	2.61 (1.33)
Reading text message	Teen	2.28 (1.30)	2.58 (1.34)	2.05 (1.24)
	Parent	1.65 (0.94)	1.65 (1.01)	1.66 (0.87)
Responding to text message	Teen	1.96 (1.16)	2.26 (1.15)	1.72 (1.13)
	Parent	1.36 (0.77)	1.29 (0.80)	1.43 (0.74)
Having text message conversation	Teen	1.49 (0.92)	1.58 (1.02)	1.42 (0.84)
	Parent	1.21 (0.64)	1.23 (0.74)	1.18 (0.52)
Entering address into a device not mounted inside the vehicle	Teen	2.27 (1.17)	2.58 (1.18)	2.03 (1.11)
	Parent	1.30 (0.69)	1.32 (0.70)	1.28 (0.68)
Entering address on a built-in/mounted navigational system	Teen	2.15 (1.09)	2.35 (1.09)	2.03 (1.09)
	Parent	1.70 (1.00)	1.72 (1.05)	1.68 (0.96)
Updating social media	Teen	1.51 (1.08)	1.45 (1.06)	1.55 (1.12)
	Parent	1.07 (0.41)	1.11 (0.57)	1.03 (0.18)
Eating something messy	Teen	1.99 (1.22)	2.10 (1.22)	1.90 (1.24)
	Parent	1.62 (0.95)	1.65 (0.95)	1.59 (0.96)
Drinking a hot beverage	Teen	2.79 (1.33)	2.71 (1.24)	2.85 (1.41)
	Parent	2.70 (1.31)	2.68 (1.34)	2.73 (1.30)

3.2.2 Social Norms

Table 4 presents the overall scores (averaged over 10 distractions) for items analyzed. Paired t-tests were conducted to compare: (1) teen perceptions of their parent distraction engagement frequency and approval with their parent self-reports, (2) teen perceptions of their parent and peer distraction engagement frequency and their own distraction engagement, and (3) parent perception of their teen distraction engagement frequency with their teen self-reports. Further, independent sample t-tests were conducted to compare male and female teen perceived norms. Correlation analyses were also conducted to examine the associations between teen self-reported distraction engagement frequency and their perceived norms (Table 5). When possible based on sample size, a distinction was made between male and female responses; otherwise the analyses were conducted without a gender consideration.

The comparison of teen perceptions of their parent engagement (perceived descriptive norms) with their parent self-reported engagement (actual descriptive norms) provided evidence that teens may be overestimating their mother (perceived mother engagement: $M=1.84$, $SD=0.76$; mother self-reported engagement: $M=1.72$, $SD=0.53$, $t(36)=2.76$, $p=.009$) and father (perceived father engagement: $M=2.03$, $SD=0.81$; father self-reported engagement: $M=1.70$, $SD=0.61$, $t(32)=2.11$, $p=.04$) distraction engagement. The comparison of teen perceptions of their parent approval (perceived injunctive norms) with parent self-reported approval (actual injunctive norms) indicated that teens also may be overestimating their mother (perceived mother approval: $M=1.98$, $SD=0.58$; mother self-reported approval: $M=1.61$, $SD=0.47$, $t(35)=5.04$, $p< .001$) and father (perceived father approval: $M=2.09$, $SD=0.63$; father self-reported approval: $M=1.66$, $SD=0.65$, $t(33)= 2.94$, $p=.006$) approval of distraction. Both male (self-reported distraction engagement: $M=2.21$, $SD=0.78$; perceived peer engagement: $M=2.69$, $SD=0.72$, $t(30)=4.68$, $p< .0001$) and female (self-reported distraction engagement: $M=1.92$, $SD=0.88$; perceived peer engagement: $M=2.58$, $SD=0.98$, $t(39)=7.19$, $p< .0001$) teens perceived that their peers engaged in distractions more often than they do.

Teen self-reported distraction engagement was also compared with parent perception of teen distraction engagement. The results showed that parents may underestimate their male (perceived teen engagement: $M=1.88$, $SD=0.84$; teen self-reported engagement: $M=2.21$, $SD=0.78$, $t(30)=-2.10$, $p=.04$) and female (perceived teen engagement: $M=1.57$, $SD=0.63$; teen self-reported engagement: $M=1.92$, $SD=0.88$, $t(38)=-3.60$, $p= .0009$) teen distraction engagement. The underestimation was more apparent for female teen distraction engagement.

Male and female teen perceptions of parent and peer norms were compared. No significant gender differences were found ($p>.05$).

Table 4: Means and standard deviations (SD) for questionnaire responses; range 1-5

	Mean (SD)		
	All participants	Males	Females
Self-reported distraction engagement			
Teens	2.05 (.84)	2.21 (.78)	1.92 (.88)
Parents	1.71 (.57)	1.70 (.61)	1.72 (.53)
Teen perceived descriptive norms			
Mother distraction engagement	1.84 (.76)	1.77 (.59)	1.89 (.87)
Father distraction engagement	2.03 (.81)	1.99 (.54)	2.07 (.99)
Peer distraction engagement	2.63 (.87)	2.69 (.72)	2.58 (.98)
Teen perceived injunctive norms			
Mother approval	1.98 (.58)	2.00 (.45)	1.97 (.67)
Father approval	2.09 (.63)	2.14 (.47)	2.05 (.73)
Peer approval	2.54 (.66)	2.62 (.60)	2.48 (.71)
Parent approval of teen distraction engagement	1.63 (.56)	1.66 (.65)	1.61 (.47)

Correlation analyses (Table 5) revealed that male teen self-reported distraction engagement was positively correlated with their perceptions of father distraction engagement (r=.62, p=.0003) and approval of distraction (r=.35, p=.04). However, no correlation was found between male distraction engagement and their perceived mother engagement in or approval of distractions (p>.05). Female teen distraction engagement was found to be highly positively correlated with their perceptions of father and mother engagement in (fathers: r=.63, p<.0001; mothers: r=.52, p=.001) and approval of (fathers: r=.75, p<.0001; mothers: r=.78, p<.0001) distractions. Further, both male and female teen distraction engagements were highly positively correlated with their perceived peer engagement in (males: r=.71, p<0001; females: r=.81, p<.0001) and approval of (males: r=.45, p=.01; females: r=.73, p<.0001) distractions.

Female teens' distraction engagement was positively correlated with their parent's self-reported distraction engagement (or actual descriptive norms: r=.54, p=.0004) and approval of distraction (or actual injunctive norms: r=.58, p=.0001). These correlations were not significant for male teen drivers.

Overall, these findings indicate that, as we hypothesized, teens may overestimate driver distraction norms. Teen self-reported distraction engagement frequencies were positively correlated with their perceptions of parent and peer norms; stronger correlations were observed with peer norms compared to parent norms. Some gender differences were observed, which are discussed in section 3.3.

Table 5: Pearson correlations between teen self-reported distraction engagement frequency and social norms

	Teen Distraction Engagement (r)		
Perceived Norms	All (n=71)	Males (n=31)	Females (n=40)
Descriptive norms			
Perceived mother engagement	**.44*** **	.31	**.52** **
Perceived father engagement	**.60*** **	**.62** **	**.63*** **
Perceived peer engagement	**.77*** **	**.71*** **	**.81*** **
Parent self-reported engagement	**.44** **	.28	**.54*** **
Injunctive norms			
Perceived mother approval	**.60*** **	.23	**.78*** **
Perceived father approval	**.61*** **	**.35* **	**.75*** **
Perceived peer approval	**.63*** **	**.45* **	**.73*** **
Parent self-reported approval	**.38** **	.08	**.58** **

*p<.05, **p<.01, ***p<.0001

3.2.3 Attitudes, Perceived Risk, and Perceived Control

Table 6 presents the overall scores (averaged over 10 distractions) for attitude, perceived risk, and perceived control among teens and parents. Paired t-tests were conducted to compare teen and parent self-reported attitude, perceived risk, and perceived control. Further, independent t-tests were conducted to examine gender effects for teen and parent responses. Correlation analyses were also conducted to investigate the associations between teen self-reported distraction engagement frequency and their attitude, perceived risk, and perceived control.

The comparison of teens' and their parents' responses showed that teens reported more positive attitude ($t(66)= -2.04$, $p=.04$), lower perceived risk ($t(67)= -4.79$, $p<.0001$), and higher perceived control ($t(66)= 4.18$, $p<.0001$) for distractions. Note that lower scores in the semantic differential scales represent more positive attitudes.

Female teens reported higher perceived risk for distractions than male teens. This difference approached significance ($t(67)=1.95$, $p=.055$). No significant difference was observed between male and female teen attitude and perceived control (p>.05). Further, no significant gender effect was observed for parent attitude, perceived risk, and perceived control (p>.05).

Table 6: Means and standard deviations (SD) for attitude (lower scores represent more positive attitudes), perceived risk, and perceived control

	Mean (SD)		
	All participants	Males	Females
Attitude (range 1-7)			
Teens	5.17 (.86)	5.06 (.84)	5.25 (.88)
Parents	5.55 (1.10)	5.48 (1.22)	5.61 (.96)
Perceived risk (range 1-10)			
Teens	6.37 (1.65)	5.92 (1.80)	6.69 (1.47)
Parents	7.67 (1.47)	7.63 (1.44)	7.70 (1.51)
Perceived control (range 1-5)			
Teens	2.67 (.82)	2.80 (.73)	2.57 (.87)
Parents	2.09 (.78)	2.09 (.80)	2.08 (.78)

Correlation analyses results were as expected within the TPB framework for both male and female teens (Table 7). Teens who reported engaging more in distractions reported more positive attitude towards distractions (r=-.57, p<.0001), lower perceived level of risk for distractions (r=-.48, p<.0001), and higher perceived control (r=.55, p<.0001). Higher scores on the distraction engagement represent more frequent engagement, while lower scores on the semantic differential scales represent more positive attitudes towards distractions. Therefore the correlations between these two measures were negative. In addition, lower scores on perceived control represent higher perceived difficulty to engage in distractions while driving (less agreement with "while driving, I have no difficulty to engage in distractions"). Therefore, the correlation coefficients between distraction engagement frequency and perceived control measure were positive.

Male and female teens differed with respect to perceived risk, which was more strongly associated with distraction engagement of females (r=-.53, p=.0004) than males (r=-.38, p=.04).

Overall, teen self-reported distraction engagement was positively correlated with the TPB constructs. Teens had more positive attitude, lower perceived risk, and higher perceived control for driver distraction than parents. This can partly explain teens' higher self-reported frequency of engagement in distractions compared to parents.

Table 7: Pearson correlations between teen self-reported distraction engagement frequency and attitude, perceived risk, and perceived control

	Teens' Distraction Engagement (r)		
	All (n=71)	Males (n=31)	Females (n=40)
Attitude	**-.57*** **	**-.49** **	**-.60*** **
Perceived risk	**-.48*** **	**.38* **	**-.53*** **
Perceived control	**.55*** **	**.56** **	**.53*** **

*p<.05, **p<.01, ***p<.0001

3.2.4 Predicting Engagement

A linear model was constructed in SAS using distraction engagement score (averaged over 10 distractions) as the response variable. Explanatory variables were age, gender, attitude, perceived control, perceived peer norms (both descriptive and injunctive), and perceived parent norms (both descriptive and injunctive). Perceived parent descriptive and injunctive norms were calculated by averaging perceived mother and father descriptive and injunctive norms in order to avoid multicollinearity. In order to assess the potential impact of age and gender on the relationships between distraction engagement frequency and the other variables, all two-way interaction terms between age group, gender, and each of the six other variables were also included in the model initially. As none of the interactions were significant at the level of .05, they were removed from the model.

Results indicated that attitude (F(1,59)=14.88, p=.0003), perceived parent distraction engagement (F(1,59)=9.68, p=.003), and perceived peer distraction engagement ((F(1,59)=16.02, p=.0002) were all significant predictors of teen self-reported distraction engagement. However, no significant effect was observed for age, gender, perceived control, and perceived peer/parent approval of distraction (perceived injunctive norms) (p>.05).

The model fitted explained a considerable amount of variability (R-square = 76.8%). And regression diagnostics found that the model met all necessary assumptions, and the variance inflation factors (VIFs) were checked to protect against multicollinearity.

A model without perceived parent and peer norms was also fitted, and was found to explain lower level of variability (R-square = 45.6%). In this model, attitude (F(1,62)=14.57, p=.0003) and perceived control (F(1,62)=8.61, p=.005) were significant predictors. Hence, perceived parent and peer norms (particularly descriptive norms) appeared to be useful in predicting engagement.

3.3 Discussion

In a survey study with 71 teen-parent dyads, we investigated the existence of social norms misperceptions among teens, and studied the role of parental and peer norms in teen distracted driving.

Our results suggested that teens may overestimate their mother's and father's distraction engagement (descriptive norms). The observed overestimations of parents' distraction engagement are consistent with results of the recent phone survey study of 403 teen-parent dyads (Bingham, Zakrajsek, Almani, Shope, & Sayer, 2015; Carter, Bingham, Zakrajsek, Shope, & Sayer, 2014). As mentioned in Chapter 2, in Bingham et al. (2015) misperceptions around parent's approval of distraction (injunctive norms) were not studied. Our results extended these previous findings to perceived injunctive norms, and showed that teens may also overestimate their mother and father's approval of distraction.

Our results also showed that parents may underestimate the extent to which their teens engage in driver distractions. This finding may be related to our other finding, which suggests that teens overestimate their parents' approval. Parents who do not have an accurate knowledge of their teen's distraction engagement may underestimate the importance of talking with their teens and expressing their disapproval about distracted driving. Our finding is consistent with a previous study conducted by Beck et al. (2001). In that study, 424 teen-parent dyads were interviewed. Results showed that parents were unaware of the extent to which their teens had engaged in risky driving behaviours, including being distracted by friends. Our findings on the other hand conflict with the findings of Bingham et al. (2015), with parents overestimating their teen's engagement in distractions, possibly due to the methods (e.g., phone vs. online survey) and sample (e.g., from the U.S. vs. Ontario, Canada) used in that earlier study being different than ours. Further research is warranted to clarify this conflicting result. Overall, given these parental misperceptions and the corresponding teen overestimations, it appears that teens can be targeted along with their parents to correct these misperceptions.

In accordance with Carter et al. (2014), significant positive correlations were observed between teen self-reported distraction engagement and their perceptions of peer engagement in and approval of distractions. Regarding parental norms, we found that female teen distraction engagement was positively associated with their perception of both mother and father distraction engagement and approval. However, male teen distraction engagement was positively associated with their perception only of same-gender parent (i.e., father) distraction engagement and approval. These findings suggest that the same-gender parent might be a better referent for developing PNF targeting male teens than opposite-gender parent. Carter et al. (2014) also showed that teen distraction engagement was positively correlated with their parent's engagement in and approval of distraction. However, they did not consider parent's gender in their analyses.

Similar to Carter et al. (2014), we did not find any significant gender differences for perceived parental and peer norms. These results could be expected, given that we did not find any gender difference for teen and parent self-reported distraction engagement as well. This lack of gender difference for engagement in distraction is consistent with several previous studies in the literature (Beck & Watters, 2016; Bernstein & Bernstein, 2015; Bingham et al., 2015; Carter et al., 2014; Hill et al., 2015). Overall, our findings that males and females reported to engage in driver distraction at similar levels, and both males and females overestimated norms, suggest that social norms interventions can address driver distraction among teens of both genders.

Our results also showed that teens had lower perceived risk, higher perceived control, and more positive attitude for driver distraction than parents. This is consistent with previous studies which have shown that compared to experienced adult drivers, young novice drivers underestimate the risk of an accident in hazardous situations and overestimate their own driving skills (Deery, 1999; Harre, Foster, & O'Neil, 2005). In addition, Chen et al. (2016) showed that young drivers have more positive attitudes towards distractions compared to senior drivers.

Our correlation analyses results were as expected within the TPB framework. Teens who reported engaging more in distractions reported more positive attitude towards distractions, lower perceived level of risk for distractions, and lower perceived control. Further, our linear regression model including TPB constructs, age, and gender explained a considerable amount of variability. Results indicated that attitude, perceived parent distraction engagement, and perceived peer distraction engagement were all significant predictors of the self-reported distraction engagement. However, perceived peer/parent approval of distraction (perceived injunctive norms) were not significant predictors of self-reported teen driver distraction. This lack of significance is consistent with findings of Carter et al. (2014) and Chen et al. (2016). In addition, similar to White et al. (2010), we did not find a significant effect for perceived control.

There were a number of limitations of this study. Although parental norms were analyzed with a consideration of their gender whenever sample size permitted, we did not conduct similar analysis regarding peer influences, as relevant data was not collected. This limitation is addressed in our second driving simulator experiment (Chapter 6), in which we collected data on teen perceptions of their female and male peer norms separately. The reliability of self-reported data is also a limitation as participants may have under- or over-reported their distracted driving behaviours. In order to improve the reliability of data, teens were informed that all information obtained during the study would be held in strict confidence. In addition, participants were asked to respond based on what they do rather than what they think they should do.

Another limitation is the use of differing rating scales in the questionnaire. However, it is important to note that these scales were mostly adopted from previous studies in the literature (Feng et al., 2014; Carter et al., 2014), and hence the scales were not always consistent with each other. In addition, the 10-point scale (i.e., 1= no additional risk beyond my normal driving, 5= an average driving situation, 10= very likely I would be involved in an accident) used for collecting responses on risk perception might have been vague; for example, points 1 and 5 appear to be very similar. Therefore, the results related to perceived risk must be interpreted with caution. Further, as mentioned before, composite scores were calculated for each construct by averaging responses over 10 distractions surveyed. Overall, Cronbach's α values were generally high for the different constructs analyzed, and met the well-established threshold of 0.70 (Nunnally, 1978). However, it is possible that there might be groupings among these 10 distractions that may have different inter-grouping effects on normative influences. In addition, it should be noted that non-parametric statistics could also be used for analyses of Likert items, as there exist contention in the literature about weather Likert data should be analyzed with parametric or nonparametric statistics (Winter & Dodou, 2010; Carifio & Perla, 2008; Jamieson, 2004).

Further, although this study has several strengths in its use of matched teen-parent dyads, the sample was limited to teens and parents who were willing to participate in the study and thus our findings are subject to this bias.

Overall, our results suggest that teens may hold misperceptions about driver distraction norms, and that teen perceptions of parental and peer descriptive norms are predictive of their self-reported engagement frequency in driver distractions. These results provided support for the second component of this dissertation, which was the evaluation of PNF to correct such misperceptions and mitigate driver distractions among teens. We conducted two driving simulator experiments to systematically investigate the effectiveness of PNF based on parent (Chapter 5) and peer (Chapter 6) descriptive norms.

Chapter 4
Apparatus, Secondary Task, and Experimental Drives

4

In this chapter, apparatus including the driving simulator and the eye-tracking system used in the two experiments are described. In addition, details are provided about the experimental drives and the secondary task completed by the participants in both experiments.

4.1 Apparatus

4.1.1 Driving Simulator

Data collection for both driving simulator experiments was conducted using a NADS MiniSim™ Driving Simulator (Figure 1). The NADS MiniSim™ is a PC-based quarter-cab driving simulator developed by the University of Iowa's National Advanced Driving Simulator (NADS). The simulator includes a driver seat, a steering wheel, brake and gas pedals, a gearshift, and three 42-inch monitors. In addition, a 20-inch digital dashboard is used to display speedometer and revolution meter. The simulator also features stereo sound produced by two satellite speakers at the front left and front right. The simulator collects a large number of measures, including driver inputs (e.g., pedal position and pedal force), vehicle information (e.g., speed and lane deviation), and scenario variables (e.g., lead vehicle information) at 60 Hz. Further, a four-channel video capture system is integrated into the MiniSim to capture video of the participant's drive. Four video files were created every time the simulator was run. Three of the videos captured participant's pedal position, a front view of participant driving, and a rear view capturing the participant and the simulator monitors. The fourth video captured simulator outputs such as frame number, simulation time/date, and participant ID.

4.1.2 Eye-Tracking System

A FaceLAB™ 5.1 eye-tracking system developed by Seeing Machines was utilized to collect gaze data. FaceLAB uses a pair of cameras to track the participant's face in 3D as they move relative to cameras. The cameras were placed on the dashboard of the driving simulator (Figure 1a). The eye-tracking system collects data on eye movements, head position and rotation, eyelid aperture, and pupil size, at a frequency of 60 Hz. The accuracy of gaze direction measurements is between 0.5° and 1°. The system was integrated with the driving simulator and EyeTracking

Inc.'s EyeWorks™ software. The EyeWorks™ software overlaid the participant's gaze data over the driving simulator's centre monitor.

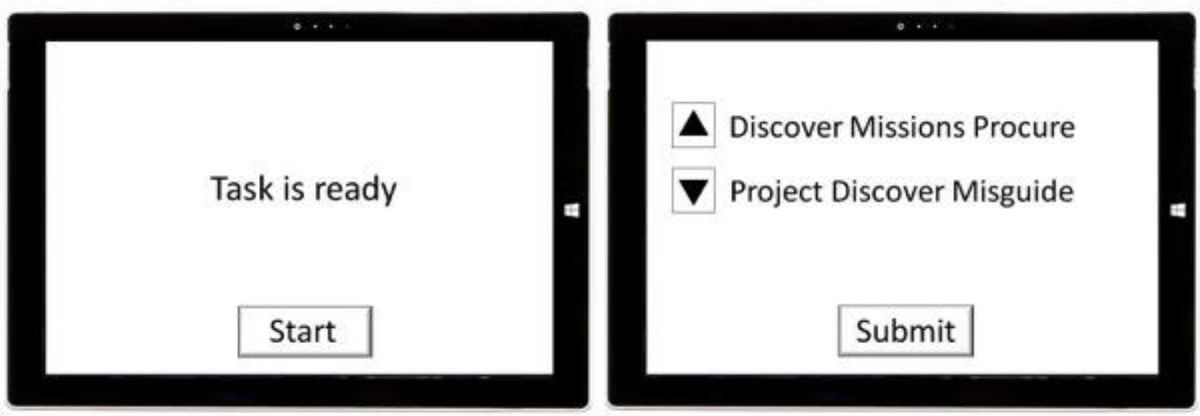
4.1.3 In-vehicle Display

A 10.6-inch touchscreen Microsoft Surface™ Pro 2 was used for the presentation of a self-paced secondary task (described in section 4.2) as well as post-drive feedback used in the experiments (described in Chapters 5 and 6). The display was mounted to the right of the steering wheel where it would not visually obstruct the driving simulator's monitors (Figure 1b). A custom program developed in Python synchronized the Surface with the driving simulator, and ensured that the secondary task was displayed throughout the driving scenario and that the post-drive feedback was displayed at the end of the driving scenario for participants in the post-drive feedback conditions.

Figure 1: University of Toronto HFASt Laboratory NADS MiniSim™ driving simulator with (a) eye-tracking system and (b) in-vehicle display

4.2 Secondary Task

A self-paced visual-manual secondary task was used to simulate distractions that are typical to many in-vehicle device interactions, such as adjusting the radio, interacting with GPS, and scanning an MP3 playlist. Since in-vehicle devices and interactive mobile technologies advance rapidly, a generic secondary task was chosen so that the findings of this dissertation can be generalizable to future in-vehicle devices. We adopted the secondary task developed by Donmez et al. (2007a). In this task, participants were asked to select a match with the phrase “Discover Project Missions” from a list of 10 phrases presented on the Microsoft Surface display. The task was available throughout an entire drive. The participants initiated the task by touching the start button (Figure 2a). Participants then scrolled through a list of closely related phrases, for a phrase that had either “Discover” first, “Project” second, or “Missions” as the third word (Figure 2b). For example, “Discover Missions Procure” is a match because “Discover” is in the correct position, whereas “Project Discover Misguide” is not. The phrases were presented two at a time, and participants could view the entire list of 10 phrases by scrolling using the up and down arrows. Each phrase submission was followed by another set of phrases. This task has been shown to have a detrimental effect on driving performance by deteriorating driver’s response to lead vehicle braking events (Donmez et al., 2007a).



(a) **(b)**

Figure 2: Visual-manual secondary task displayed on the Surface Pro 2 display

4.3 Experimental Drives

Identical drives were used in the two driving simulator experiments. The road network was created using the Tile Mosaic Tool (TMT) and the driving scenario was created using the

Interactive Scenario Authoring Tool (ISAT). Each drive was on a 2-lane rural road with some oncoming traffic (five oncoming cars per drive). Each lane was modeled to be 12.0 feet (3.7 m) wide, with a gravel shoulder on each side of the roadway. The posted speed limit was 50 mph (80.47 km/h). Participants were instructed to follow a lead vehicle and to maintain the posted speed limit unless the lead vehicle was braking. They were informed that the lead vehicle may occasionally brake; however, they were not informed about when and how frequently these braking events would occur. Within each drive, there were a total of eight lead vehicle braking events, each at a deceleration rate of 0.4 g (3.9 m/s^2). The lead vehicle speed was programmed to adjust to obtain a gap time of 2.2 s (experiment 1: M =1.88 s, SD =0.19 s; experiment 2: M =1.91 s, SD =0.22 s) at the onset of lead vehicle braking. These particular deceleration rate and gap time values were chosen during pilot testing to induce a response right away without imposing an emergency. Each drive was about 6 minutes (experiment 1: 6.1 minutes, SD= 0.46; experiment 2: 6.2 minutes, SD= 0.35).

Chapter 5
Experiment I: Personalized Normative Feedback for Teen Driver Distraction: Parental Norms

5

As mentioned earlier, the first driving simulator experiment aimed to systematically investigate the effectiveness of PNF based on parents' descriptive norms. We hypothesized that providing teens with parent norms can correct the potential misperceptions and mitigate teen distracted driving behaviour.

Four between-subjects conditions were implemented: (1) post-drive PNF based on parent norms (or social norms feedback), (2) post-drive feedback without social norms information in order to tease out the effect of parent norms, (3) real-time feedback as it has also been shown to be effective in distraction mitigation, and (4) no feedback as control. Pre- and post-experiment questionnaires were also administered to collect data on teen and their parent's self-reported engagement in driver distractions and the associated social norms. As mentioned earlier, the pre-experiment questionnaire was part of the survey study (discussed in Chapter 3), which overlapped in data collection with this first driving simulator experiment. Teens' acceptance of different feedback types was also investigated. The work presented in this chapter has been published in the Journal of Accident Analysis and Prevention (Merrikhpour, M. & Donmez, B. (2017), Designing feedback to mitigate teen distracted driving: A social norms approach, Accident Analysis and Prevention, 104, 185–194).

5.1 Method

5.1.1 Participants

Forty teen-parent dyads completed this study. They were recruited via online advertisements, flyers posted at local universities, coffee shops, and gas stations, as well as through emails sent to pools of potential participants (e.g., within universities, high schools, and driving schools). To be eligible for the experiment, teens (17-19 years) and their parent who was going to participate in the study needed to have at least a Class G2 license (allowing independent driving with restrictions) or equivalent in Ontario, Canada.

The sample consisted of seven 17-year-olds, seventeen 18-year-olds, and sixteen 19-year-olds (Table 8). The gender breakdown of the teens across the four experimental conditions was fairly balanced: social norms (6 females, 4 males), post-drive (4 females, 5 males), real-time (4 females, 6 males), and no feedback (6 females, 5 males).

For recruitment, we first reached out to teens and found out through them whether they had a parent who could also participate. The teens were required to come to the laboratory to drive the simulator, whereas only the parents in the social norms feedback condition were required to do so, as their teens were told that the feedback they receive would reflect their parent's behaviour doing the same task (as will be described later, we actually used artificial data rather than actual parental data to control for variability). The other parents were asked only to fill out an online survey. All teens were asked to come to the laboratory only after their parent completed the study (whether online or in the laboratory), and within one month after their parent's participation. Parents were not present during the teen sessions and vice versa.

Table 8: Demographic information of the teens across the four experimental conditions

			% age group			% years of G2 licensure		
Condition	**N**	**% male**	17	18	19	≤1	>1, ≤2	>2
Social norms	10	40	20	50	30	10	70	20
Post-drive	9	55.6	22.3	22.3	55.6	22.3	55.6	22.3
Real-time	10	60	10	60	30	10	40	50
No feedback	11	45.5	18.2	36.4	45.4	9.1	63.6	27.3
Overall	40	50	17.5	42.5	40	12.5	57.5	30

It was harder to find parents who were willing to come to the laboratory than those who were willing to fill out an online survey. Thus, the first 10 teen-parent dyads who agreed to come to the laboratory were assigned to the social norms feedback condition. In other words, for this experimental condition, participant assignment was not random but was on a rolling basis based on interest and eligibility, whereas the 30 teen-parent dyads that completed the other three experimental conditions were randomly assigned to their condition. Further, those participants who agreed to drive the simulator were screened via a simulator sickness questionnaire and were also required to be able to drive without the use of corrective lenses to ensure good eye tracking data (Appendix B). Out of all participants, only one parent experienced simulator sickness and did not complete the simulator portion of the experiment; as a result, this teen-parent dyad was removed from the social norms feedback condition and was randomly assigned to another experimental condition.

The parents and teens who came to the laboratory were compensated C$45 and C$25, respectively, upon completion of the study, which took approximately 2 hours. Parents were compensated more than teens in order to encourage participation, as parents consider higher compensation rates to be fair (Scherer et al., 2005). The parents who completed only the online questionnaire, which took approximately 20 minutes, were compensated C$20. Participants also had a chance to win an iPad mini. The study was approved by the University of Toronto Research Ethics Board.

5.1.2 Experimental Design and Procedure

The experiment was a mixed factorial design, with feedback type as a between-subjects variable (social norms, post-drive, real-time, and no feedback) and drive number as a within-subject variable (drives 1 to 5). Each participant completed six consecutive drives while performing the secondary task (see section 4.2 for the description of the secondary task): a practice drive followed by 5 experimental drives, drive 1 to 5. Drive 1 did not involve any feedback and was identical across all conditions. This drive established baseline driving performance under a state of self-paced distraction without feedback. Drives 2, 3, 4, and 5 differed across the feedback conditions.

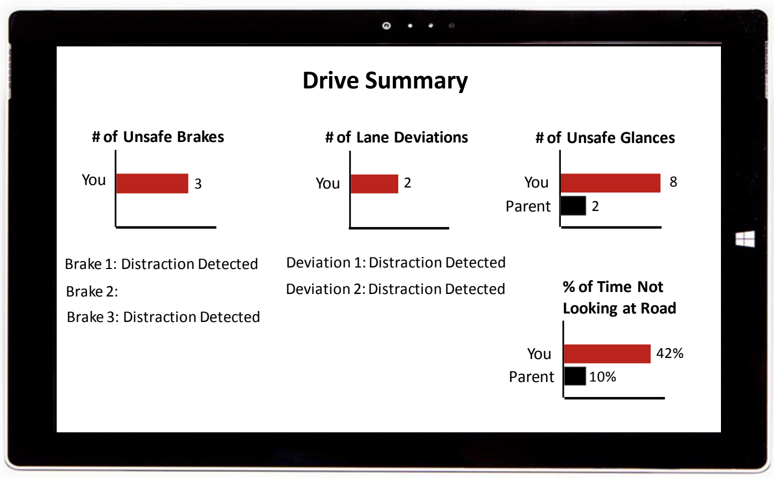
Prior to driving the simulator, participants signed a consent form outlining the details of the study, confidentiality, potential risks, and the voluntary nature of participation (Appendix C). Participants then filled out the survey (described in Chapter 3). In the simulator portion, participants were introduced to the secondary task and performed the task until they indicated comfort with performing it. To provide motivation for secondary task engagement, participants were told that they could receive up to C$5 compensation based on their secondary task performance, although everyone received the full amount regardless of performance. Participants were instructed that the task would be available at all times and they could choose to engage in the task at their own pace that they felt comfortable with. They were also instructed to prioritize safety and to drive as they would in their own vehicle. These instructions were repeated prior to each drive.

Participants performed one practice drive and five experimental drives. As mentioned earlier in Chapter 4, participants were instructed to follow a lead vehicle, and they were informed that the lead vehicle may occasionally brake.

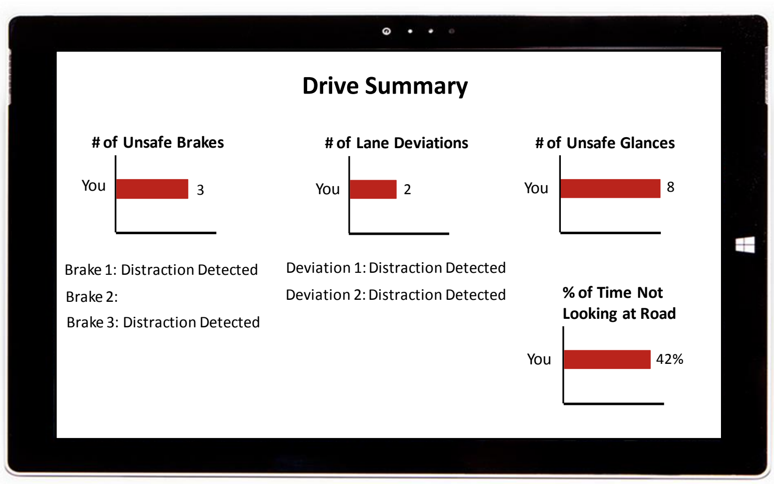
At the end of the last experimental drive, participants completed a post-experiment questionnaire similar to the survey to assess whether social norms feedback changed their perceived norms about their parents. Further, participants who experienced feedback completed the Advanced Transport Telematics Acceptance Assessment Questionnaire, to assess their attitudes toward the feedback systems (Appendix D) (Van Der Laan, Heino, & De Waard, 1997).

5.1.3 Feedback Design

Social norms feedback consisted of a post-drive report presented to the teens, which provided a comparison of their distracted driving behaviour to that of their parents (Figure 3a). As mentioned earlier, the parents assigned to this condition were invited to the laboratory to perform the simulator experiment before their teens and completed the five experimental drives while engaging in the secondary task presented above. The teens were then invited to the laboratory and also conducted the five experimental drives as described above but were also presented with social norms feedback at the end of each of these five experimental drives. Although the teens were told that the information presented to them was based on their parent's behaviour, artificial data (Table 9) was used instead to control for potential variances among the parents. To ensure that the teens were not aware of this deception, parents were asked not to disclose any information about the experiment to their teenagers, in particular their own performance. The teens were debriefed at the end about this deception and none of them indicated any suspicion.



(a)



(b)

Figure 3: (a) Social norms feedback, (b) post-drive feedback without social norms information

Table 9: Artificial parent data used for comparison in social norms feedback

Drive Number	# of Unsafe Glances	% Time Not Looking at the Road
1	2	10
2	1	7
3	0	6
4	0	6
5	0	5

As shown in Figure 3a, social norms feedback presented detailed performance and attention measures using bar graphs. Driving performance graphs presented information on teens' "unsafe braking" and "lane deviations". The criteria for unsafe braking and lane deviations were empirically determined by the researcher for the particular experiment design and simulator used in this experiment. "Unsafe braking" was defined as a maximum deceleration equal to or greater than 0.6 g (5.9 m/s^2) or a minimum Time to Collision (TTC_{min}) equal to or shorter than 1.5 s; while "lane deviation" was defined as straying from the intended lane either into the adjacent lane (i.e., the tire coming into contact with the lane marker) or off the road (i.e., the tire coming into contact with the shoulder). The teens were not provided with the thresholds but were informed about the criteria. For example, they were told that a braking event would be considered unsafe if they brake too hard or if they get too close to the lead vehicle. Attention to driving graphs provided a comparison between teens' and parents' unsafe glances (glances over 2 seconds on the secondary display) and percentage of the time not looking at the roadway. Moreover, information about teen's distraction status prior to each driving error (i.e., unsafe braking and lane deviation) was provided. The phrase "distraction detected" was presented when either a single long glance (>2 seconds) on the secondary display was detected within 5 seconds prior to the driving error or when the driver's eyes were on the secondary display for a total of 3 seconds in a 5-second moving window. The 2-second threshold was chosen as Klauer et al. (2006) showed that glances away from the road of over 2 seconds can double the risk of a crash. Other thresholds utilized in this experiment were selected based on the particular secondary task and the simulator used in the study.

Post-drive feedback used in this study also consisted of a report provided at the end of each drive on teens' driving performance (i.e., unsafe braking and lane deviation) and attention to driving (i.e., unsafe glance and percentage of the time not looking at the roadway) (Figure 3b). However, no information on parents was provided.

Real-time feedback was provided as an auditory alert, given that the visual channel is highly occupied during driving (Sivak, 1996). When glance duration on the secondary display exceeded 2 seconds, a real-time auditory alert was provided in the form of a 2050 Hz tone for 0.5 seconds. The alert was repeated if the driver kept looking at the secondary display an additional second after receiving the first alert.

5.1.4 Simulator Measures and Data Analysis

Distraction engagement measures of interest were rate of long glances (>2 seconds) per minute on the secondary display, average glance duration on the secondary display, 95th percentile glance duration, percentage of time looking at the secondary display, number of glances on the secondary display, and number of manual interactions with the secondary task. The rate of long glances per minute measured the number of glances longer than 2 seconds to the secondary display divided by the drive length. The percentage of time looking at the secondary display measured the total time with eyes on the secondary display during a drive divided by the drive length and multiplied by 100. The average glance duration measured the total time with eyes on the secondary display during a drive divided by the number of individual glances in that drive. The 95th percentile glance duration captured the longest 5 percent of glances to the secondary display during a drive. Number of glances on the secondary display measured the total number of glances on the secondary display. For the glance-related measures, only glances over 100ms were used in the analysis as shorter glances may be transition data that do not represent proper fixations (Horrey & Wickens, 2007). Finally, number of manual interaction included the total number of times the participant tapped on the secondary display to engage in the secondary task.

Driving performance measures included Standard Deviation of Lane Position (SDLP), Accelerator Release Time (ART), Brake Transition Time (BTT), Brake Response Time (BRT), maximum deceleration, and minimum Time to Collision (TTC_{min}). These measures followed the SAE J2944 Operational Definitions of Driving Performance Measures and Statistics (2015). SDLP measured the variability of the participant vehicle's lateral position relative to the lane centre. ART was defined as the time from brake event onset (the point when the brake lights of the lead vehicle turn on and the lead vehicle begins to decelerate) until the foot (initially on the accelerator pedal) is no longer in contact with the accelerator pedal. BTT was the time from accelerator pedal release until the foot contacts the brake pedal. BRT referred to the time from brake event onset to the foot contacting the brake pedal (ART + BTT), and excluded cases where the participant's foot was not on the accelerator pedal at the onset of lead vehicle braking. Maximum deceleration was the maximum deceleration (or minimum acceleration) value reached by the driver during the braking event. Finally, minimum TTC was defined as the shortest time to hypothetically colliding with the lead vehicle during a braking event, assuming both vehicles continue at their present speed and on the same path (Hayward, 1972).

To analyze the number of long glances on the secondary display, a Poisson model was built using PROC GENMOD in SAS, with the specifications of log link function and Poisson distribution. Repeated measures were accounted for by using Generalized Estimating Equations and the logarithm of drive duration was used as an offset variable. Feedback type, gender, age, drive number, and their two-way interactions were used as predictor variables. All other variables (i.e., %time looking at, average glance duration on, and 95th percentile glance duration on the secondary display, number of glances on the secondary display, number of manual interactions with the secondary task, SDLP, ART, BTT, BRT, maximum deceleration, and TTC_{min}) were analyzed using mixed linear models, with repeated measures accounted through a compound-symmetry variance-covariance structure. This modelling framework is equivalent to a repeated measures ANOVA. Feedback type, gender, age, drive number, drive duration, and their two-way interactions were considered in the model as predictor variables. For lead vehicle braking event response, gap time between the lead vehicle and the participant's vehicle at brake event onset was used as a covariate, and all lead vehicle braking events were considered individually rather than in an aggregate manner. For all models, non-significant terms were removed from the models in a stepwise fashion using backward elimination. Follow-up contrasts that were set apriori were then tested using t-tests.

Glance behaviour of one participant in the no-feedback condition was not analyzed due to a failure in the eye tracking system. Driving performance data of two participants (one in no feedback, other in real-time feedback) were not analyzed due to driving simulator failures in recording the data properly.

5.1.5 Questionnaire Administration and Analysis

As mentioned earlier, the pre-experiment questionnaire was part of the survey study that overlapped in data collection with the first driving simulator experiment (Appendix A). The teens in all experimental conditions and the parents in the social norms feedback condition were administered the survey in the laboratory before driving the simulator. The remaining parents filled them out online, remotely. Results of the survey are provided in Chapter 3. The teens were also administered a post-experiment questionnaire similar to the survey, after completing their simulator session, to assess whether social norms feedback resulted in changes in their perceived descriptive norms (i.e., what their parents do). Teens who experienced feedback also completed the Advanced Transport Telematics Acceptance Assessment Questionnaire (Appendix D) (Van Der Laan et al., 1997) which consists of nine items along a five-point scale: 1) useful/useless, 2) pleasant/unpleasant, 3) bad/good, 4) nice/annoying, 5) effective/superfluous, 6) irritating/likeable, 7) assisting/worthless, 8) undesirable/desirable, and 9) raising alertness/sleep-inducing. Three of the items (i.e., items 3, 6, and 8) were mirrored. For the purpose of scoring, individual items were coded from +2 to -2 from left to right, while scores on items 3, 6, and 8 (which were mirrored) were coded from -2 to +2 from left to right. Usefulness scale was measured by averaging the scores across items 1, 3, 5, 7, and 9. And, satisfying scale was measured by averaging the scores across items 2, 4, 6, and 8.

5.2 Results

5.2.1 Distraction Engagement Measures

Overall, the statistical findings described in detail below indicate that both social norms and real-time feedback mitigated teens' distraction engagement, with the effects of social norms feedback being stronger and emerging sooner than the effects of real-time feedback. It also appears that real-time feedback was mitigating distraction through mainly limiting glance durations, whereas social norms feedback decreased engagement in the secondary task in addition to limiting glance durations. No benefits of post-drive feedback was observed over no feedback.

There were no significant differences across feedback conditions for the baseline drive (drive 1) for all distraction engagement measures, as expected.

Rate of long glances (>2 seconds) per minute

Feedback type ($\chi^2(3)=11.15$, $p=.01$) and drive number ($\chi^2(4)=9.53$, $p=.049$) were both significant for the rate of long glances on the secondary display. Further, the interaction between feedback type and drive number was marginally significant ($\chi^2(12)=20.50$, $p=.06$). Compared to no feedback, social norms feedback resulted in a significantly lower rate of long glances on the secondary display for all feedback drives (drive 2: $\chi^2(1)=13.52$, $p=.0002$; drive 3: $\chi^2(1)=23.25$, $p<.0001$; drive 4: $\chi^2(1)=15.03$, $p=.0001$; drive 5: $\chi^2(1)=19.61$, $p<.0001$) (Figure 4). Real-time feedback also resulted in a decreased rate of long glances compared to no feedback. However, this positive effect was significant for drives 2 to 4 (drive 2: $\chi^2(1)=6.49$, $p=.01$; drive 3: $\chi^2(1)=5.57$, $p=.02$; drive 4: $\chi^2(1)=9.12$, $p=.003$).

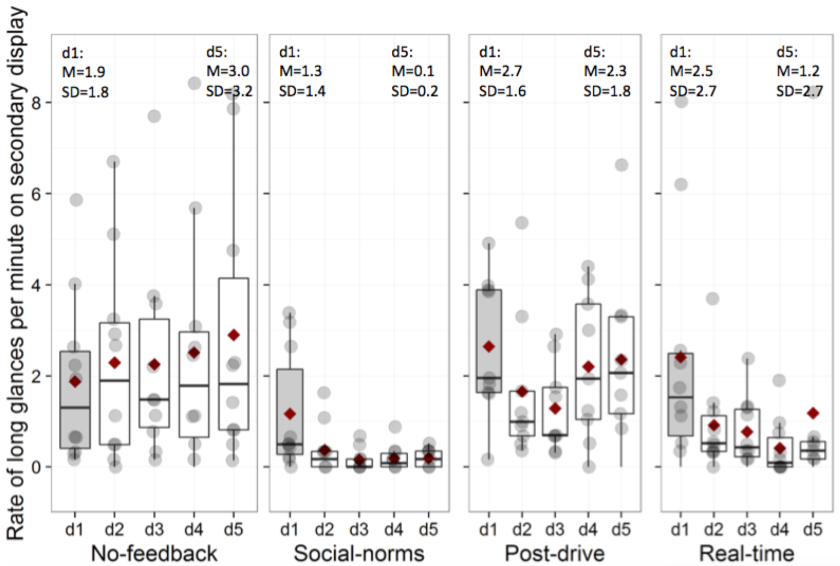


Figure 4: Rate of long glances (>2 seconds) per minute across feedback conditions and drives. The boxplots here and in the following figures present the data points (gray circles), the first and the third quartiles, the median, the mean (red diamond), and potential outliers; d1 (drive 1) with the shaded background is the baseline drive; d2 (drive 2) to d5 (drive 5) are feedback drives.

Average glance duration on the secondary display

Feedback type (F(3,31)=8.21, p=.0004), drive number (F(4,137)=15.88, p<.0001), and their interaction (F(12,137)=4.54, p<.0001) were significant. Compared to no feedback, social norms feedback resulted in significantly smaller average glance durations for all drives (drive 2: t(137)=-3.02, p=.003; drive 3: t(137)=-4.20, p<.0001; drive 4: t(137)=-4.72, p<.0001; drive 5: t(137)= -5.31, p<.0001) (Figure 5). Real-time feedback also resulted in a reduction compared to no feedback but only for drives 4 (t(137)=-3.51, p=.0006) and 5 (t(137)=-2.90, p=.004).

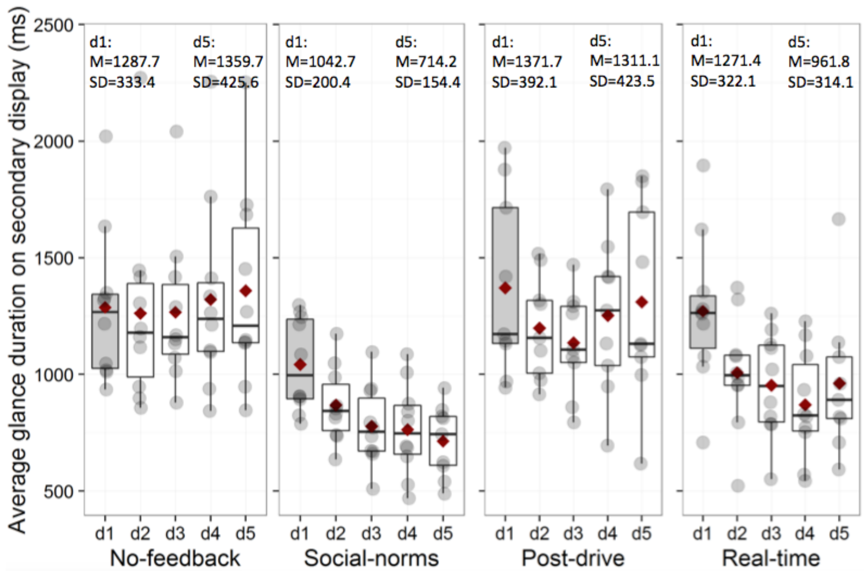


Figure 5: Average glance duration on the secondary display across feedback conditions and drives

95th percentile glance duration on the secondary display

Feedback type (F(3,32)=8.67, p=.0002), drive number (F(4,135)=5.71, p=.0003), and their interaction (F(12,135)=2.74, p=.002) were significant. Compared to no feedback, social norms feedback resulted in significantly smaller 95th percentile glance duration for all drives (drive 2: t(135)=-3.79, p=.0002; drive 3: t(135)=-4.46, p<.0001; drive 4: t(135)=-4.33, p<.0001; drive 5: t(135)= -4.49, p<.0001) (Figure 6). Similarly, real-time feedback reduced the 95th percentile glance duration compared to no feedback during all drives (drive 2: t(135)=-3.29, p=.001; drive 3: t(135)=-3.82, p=.0002; drive 4: t(135)=-3.91, p=.0001; drive 5: t(135)= -3.69, p=.0003).

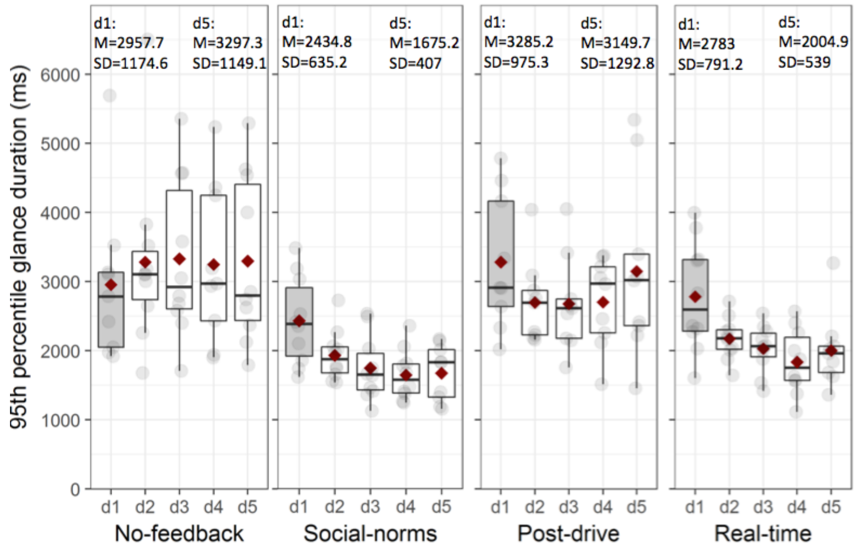


Figure 6: 95th percentile glance duration on the secondary display across feedback conditions and drives.

Percentage of time looking at the secondary display

Drive number (F(4,137)=4.79, p=.001), its interaction with feedback type (F(12,137)=4.38, p<.0001), and age (F(2,32)=5.16, p=.01) were significant for %time looking at the secondary display. Compared to no feedback, social norms feedback resulted in less time looking at the secondary display for drives 3 to 5 (drive 3: t(137)=-2.57, p=.01; drive 4: t(137)=-2.42, p=.02; drive 5: t(137)= -3.50, p<.0001) (Figure 7). No effect was observed for real-time feedback. Further, the 18-year-old teens spent less time looking at the secondary display compared to 17- (t(31)=-3.25, p=.003) and 19-year-olds (t(31)=-2.58, p=.01).

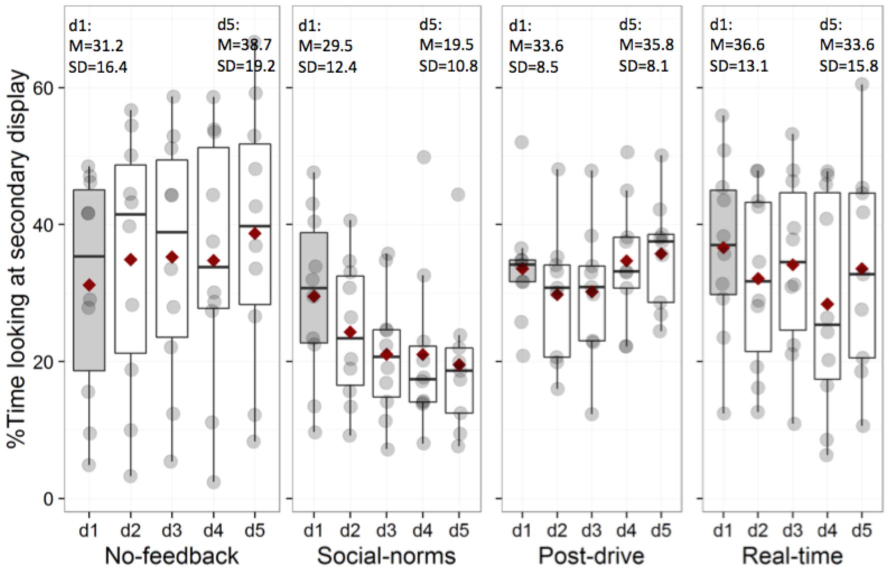


Figure 7: Percentage of time looking at the secondary display across feedback conditions and drives.

Number of glances on the secondary display

Effects of age (F(3,31)=6.71, p=.001), gender (F(1,31)=5.37, p=.03), and drive number (F(4,137)=2.49, p=.046) were significant. 17-year-olds had larger number of glances compared to 18- (t(31)=3.78, p=.0007) and 19-year-olds (t(31)=2.59, p=.01). In addition, male teens had larger number of glances than female teens (t(31)=2.32, p=.03). Teens had larger number of glances in drive 5 than they did in drives 1, 2, and 4 (drive 1: t(137)=2.86, p=.004; drive 2: t(137)=2.31, p=.02; drive 4: t(137)=1.99, p=.048) (Figure 8). No significant effect was observed for feedback types (p>.05).

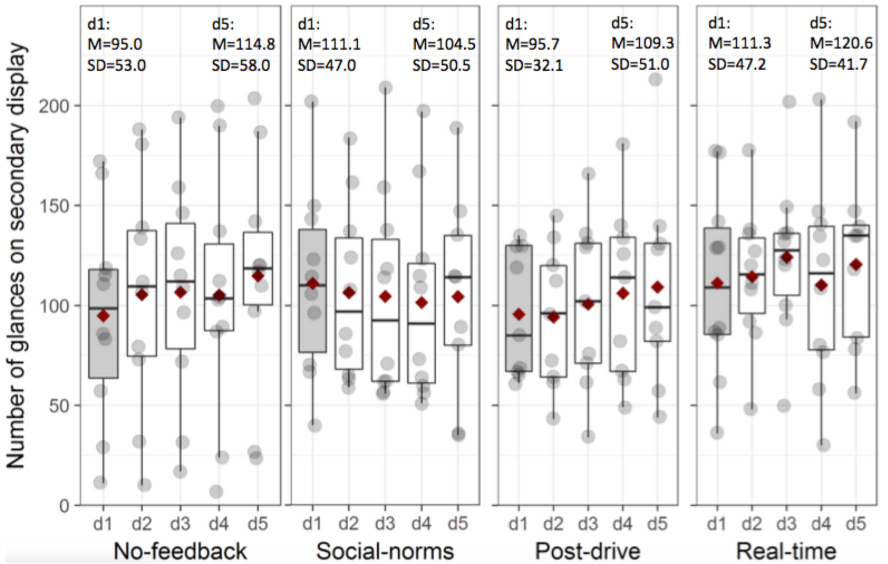


Figure 8: Number of glances on the secondary display across feedback conditions and drives

Number of manual interactions with the secondary display

Number of times the participants manually interacted with the secondary display to perform the secondary task was found to be affected by drive number (F(4, 142)=4.51, p=.002), its interaction with feedback type (F(12, 142)=2.70, p=.003), and age (F(2,33)=4.09, p=.02). Number of interactions increased from drive 1 (baseline) to drive 5 in no feedback, real-time feedback, and post-drive feedback conditions (Figure 9), indicating that the participants potentially became more comfortable with performing the task over time. No such effect was observed for the social norms feedback condition (t(146)=1.08, p=.28), suggesting that the social norms information may have counteracted this increasing comfort effect. Further, the increase in the no feedback condition was higher than that observed in the real-time feedback condition (t(142)=4.28, p<.0001), suggesting that the real-time feedback may have also counteracted this comfort effect to some extent. 17-year-old teens had larger number of interactions than 18- (t(33)=2.76, p=.009) and 19-year-olds (t(33)=2.47, p=.01).

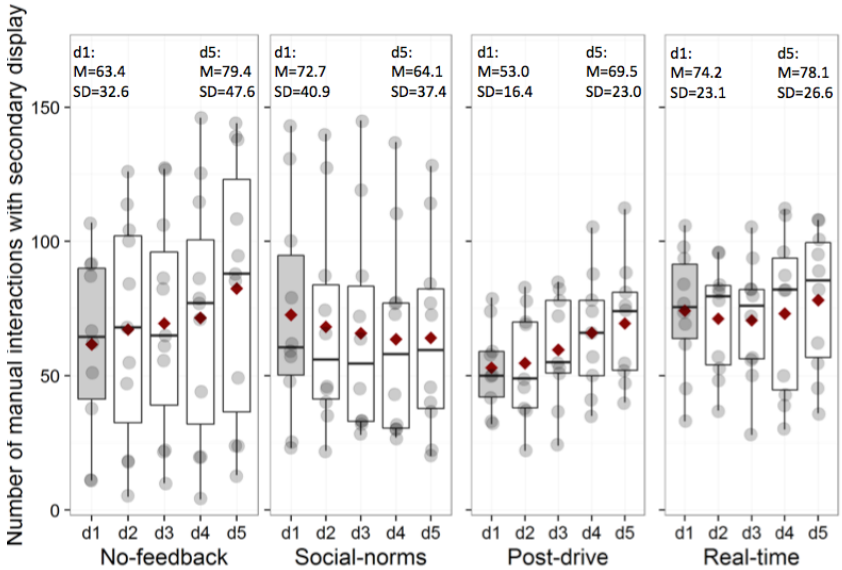


Figure 9: Number of manual interactions with the secondary display across feedback conditions and drives

5.2.2 Driving Performance Measures

Overall, the statistical findings described in detail below indicate that both social norms and real-time feedback improved driving performance, with the effects of social norms feedback being stronger particularly for lead vehicle braking event response. Similar to the distraction engagement measures reported earlier, post-drive feedback was not different than no feedback.

There were no significant differences across feedback conditions for the baseline drive (drive 1) for all driving performance measures but ART. Hence, as will be explained later, to control for potential differences among the between-subject groups, the baseline drive was taken into account during the analysis of lead vehicle braking event responses.

Standard Deviation of Lane Position (SDLP)

SDLP analysis revealed a significant interaction between feedback type and drive number ($F(12,130)=2.41$, $p=.007$) (Figure 10). Compared to no feedback, SDLP decreased for all drives with both the social norms (drive 2: $t(130)=-2.54$, $p=.01$; drive 3: $t(130)=-2.04$, $p=.04$; drive 4: $t(130)=-3.14$, $p=.002$; drive 5: $t(130)=-2.75$, $p=.006$) and the real-time feedback conditions (drive2: $t(130)=-2.70$, $p=.007$; drive 3: $t(130)=-2.47$, $p=.01$; drive 4: $t(130)=-2.84$, $p=.005$; drive

5: t(130)=-2.03, p=.04). A similar positive effect was observed for post-drive feedback on drive 4 (t(130)=-2.02, p=.04).

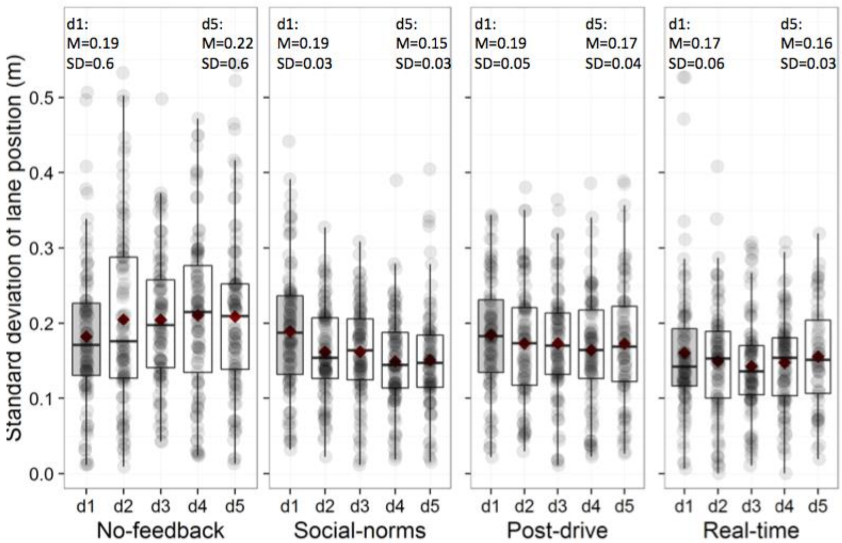


Figure 10: Standard deviation of lane position across feedback conditions and drives

Accelerator release time

Although no other measures revealed differences for the baseline drive (drive 1), a significant difference was found for ART. In the baseline drive, participants in the no-feedback condition were significantly faster to release the accelerator pedal than those in the real-time (t(131)=-2.53, p=.01) and post-drive (t(131)=-3.00, p=.003) feedback conditions (Figure 11). To minimize the influence of this baseline difference among participants, rather than directly comparing feedback conditions for a given drive, the changes in ART from drive 1 to drive 5 were compared across the feedback conditions. Overall no significant changes from drive 1 to drive 5 were observed for no-feedback, real-time feedback, and post-drive feedback conditions. However, social norms feedback significantly decreased ART from drive 1 to drive 5 (t(131)=2.52, p=.01). Results also showed that a 1 ms increase in gap time at the brake event onset contributed to a 0.17 ms increase in ART (t(1394)=3.35, p=.0008).

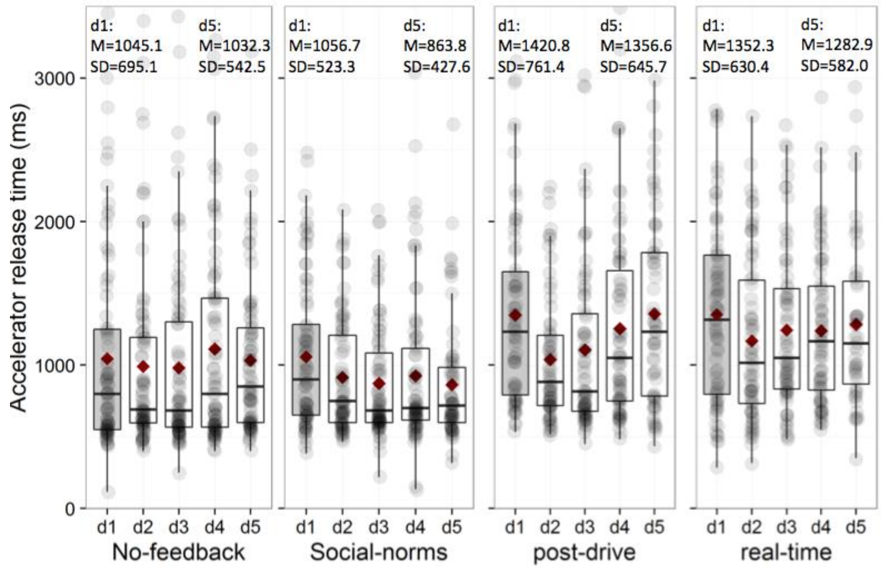


Figure 11: Accelerator release time across feedback conditions and drives

Brake transition time

No feedback effects were found for BTT; only drive number (F(4,131)=6.51, p<.0001) and gap time (F(1,1394)=19.17, p<.0001) were significant. Participants had significantly shorter BTTs during drive 1 compared to other drives (drive 2: t(131)=-2.65, p=.009; drive 3: t(131)=-3.84, p=.0002; drive 4: t(131)=-3.37, p=.0003; drive 5: t(131)=-4.56, p<.0001). Further, a 1 ms increase in gap time at the event onset contributed to a 0.14 ms increase in BTT (t(1394)=4.38, p<.0001).

Brake response time

As expected from the results of ART and BTT, a positive effect of social norms feedback was observed for BRT (ART + BTT). Overall, social norms feedback significantly decreased BRT from drive 1 to drive 5 (t(131)=2.10, p=.04), but no such effect was observed for the other conditions.

Maximum deceleration

Drive number (F(4,131)=8.73, p<.0001) and its interaction with feedback type (F(12,131)=2.68, p=.003) were significant for maximum deceleration. Compared to no feedback, social norms feedback resulted in smaller maximum decelerations during drives 2 (t(131)=-1.96, p=.052) and

3 (t(131)=-2.16, p=.03) (Figure 12). Further, both social norms (t(131)=-3.83, p=.0002) and real-time (t(131)=-2.04, p=.04) feedback significantly decreased maximum deceleration from drive 1 to drive 5. This effect was not observed in the no feedback condition (t(131)=0.05, p=.96).

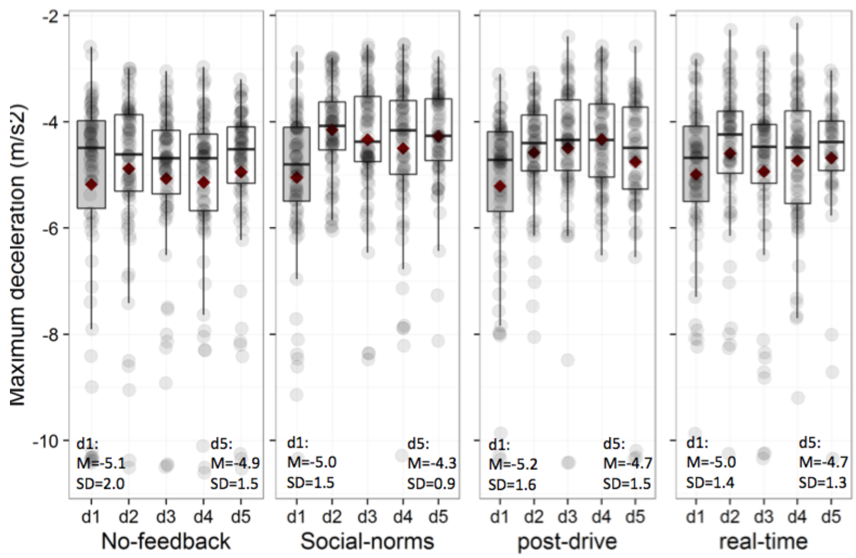


Figure 12: Maximum deceleration across feedback conditions and drives

Minimum time to collision

Only gap time was significant, with a 1 ms increase in gap time at the event onset contributing to a 0.23 ms decrease in TTC_{min} (t(1394)=-4.11, p<.0001).

5.2.3 Questionnaires

A paired t-test revealed that teen perceptions of their parent's distraction engagement did not change from pre- to post-experiment for any of the feedback conditions (p>.05). Analysis of the Advanced Transport Telematics Acceptance Assessment Questionnaire (Van Der Laan et al., 1997) showed that teens had positive attitudes towards social norms and post-drive feedback, as indicated by the 95% confidence intervals of mean usefulness and satisfaction scores excluding zero (Figure 13). Social norms and post-drive feedback received mean usefulness scores of 1.18 (SD=0.30) and 1.16 (SD=0.36) and mean satisfaction scores of 0.95 (SD=0.45) and 0.64 (SD=0.66), respectively. Teens found real-time feedback useful but not satisfying (95% confidence interval included zero). Real-time feedback received a mean usefulness score of 1.12

(SD=0.83) and a mean satisfaction score of 0.28 (SD=0.90). Analysis of variance showed no significant difference between feedback types in either usefulness or satisfaction (p>.05).

Figure 13: Acceptance of feedback (estimated means and 95% confidence intervals)

5.3 Discussion

In the first driving simulator experiment, we investigated the effectiveness of PNF based on parents' descriptive norms in mitigating teen driver distractions. The effectiveness of three feedback types (social norms, post-drive, and real-time) was compared to no feedback.

Overall, our results suggest that PNF based on parent's norms are promising for mitigating distraction among teens. The analysis of driving simulator data showed that both social norms and real-time feedback decreased distraction engagement compared to no feedback, with the effects of social norms feedback being stronger and emerging sooner than the effects of real-time feedback. It also appeared that real-time feedback was mitigating distraction through mainly limiting glance durations, as it was triggered solely based on glance duration information, whereas social norms feedback also decreased manual engagement in the secondary task in addition to limiting glance durations. Specifically, compared to no-feedback, social norms feedback resulted in significantly smaller average glance duration, average 95th percentile glance duration, %time looking, and rate of long glances (>2 seconds) on the secondary display. Further, manual interactions with the display increased with all experimental conditions but social norms feedback. Real-time feedback also resulted in smaller rate of long glances, average glance duration, and average 95th percentile glance duration on the secondary display compared to no feedback. These glance duration/manual interaction results are important as several studies have shown that visual-manual distractions are the riskiest type of distraction (Dingus et al., 2016; Klauer et al., 2014b, 2006; Victor et al., 2015), and glances away from the road over 2 seconds can double the risk of a crash (Klauer et al., 2006).

The increase in manual interactions with the secondary display from the first to the last drive observed in the real-time, post-drive, and no feedback conditions may have been due to teens' increased familiarity with the driving scenario and secondary task. Drivers tend to be less cautious when they become familiar with a certain type of road or situation (Martens, 2007). Another potential explanation is the bonus promised to the participants based on their secondary task performance. Participants may have increased their interactions towards the end, in order to increase their chance to receive the bonus. However, no such increase was observed for the social norms feedback condition, suggesting that the social norms information had counteracted this effect. Further, the increase observed in the real-time feedback condition was smaller than that in no-feedback, suggesting that real-time feedback may have also been effective to some extent.

Social norms and real-time feedback also improved driving performance, with the effects of social norms feedback being stronger. In particular, both social norms and real-time feedback resulted in better lane keeping compared to no-feedback. In terms of lead vehicle braking response, social norms feedback resulted in smaller maximum deceleration compared to no-feedback. Further, social norms feedback led to a significant decrease in ART and BRT from the baseline drive (drive 1) to the last feedback drive (drive 5). This effect was not observed for real-time feedback. The additional information provided on lead vehicle braking response in social norms feedback appeared to directly affect the teens' relevant performance in the successive drives, whereas the benefits observed in glance duration with real-time feedback did not directly translate to faster reactions to lead vehicle braking, but only to better lane keeping. The lack of significance with real-time feedback in brake response may also be due to lack of statistical power or generally low driving demands placed on the drivers in this study.

Although Donmez et al. (2008b) showed that post-drive feedback can help drivers better modulate their distraction engagement, no major benefit was observed with post-drive feedback in our study. This conflicting result may in part be due to different post-drive feedback designs employed. In Donmez et al. (2008b), participants received information on their critical incidents (e.g., speeding, too close to lead vehicle, and lane deviation), the severity level of the incidents (low, medium, or high), and their distraction level during the incidents (low/none, medium, or high). Further, participants could receive positive feedback based on their driving performance. Thus, the design used in that previous study provided more information compared to ours. More research is needed to address which post-drive feedback characteristics are important in their effectiveness.

Analysis of acceptance data revealed that social norms and post-drive feedback types were found to be useful and satisfactory, and were well accepted by teens. Our results also showed that teens found the real-time feedback useful but not satisfying. These findings are important as feedback effectiveness depends on drivers' acceptance (Donmez, Boyle, Lee, & McGehee, 2006). Finally, contrary to our hypothesis, we did not find any changes in teens' perceived norms after receiving social norms feedback in the simulator. The lack of significance may be due to small sample size or the use of artificial data for parental norms that we introduced to increase experimental control given our limited sample size.

This study has some limitations. The generalization of the study findings could be limited by the sample of teens and parents who were willing to participate in the study jointly, in addition to the potential selection bias associated with the social norms group. In addition, although the use of artificial data to provide a comparison between teens' distracted driving behaviour and their parent allowed experimental control and none of the teens indicated any suspicion about this deception, it may still have provided teens with a somewhat artificial experience. The effectiveness of social norms feedback with actual parental data needs to be investigated, with a particular consideration of the degree of similarity/dissimilarity between the teens' behaviour and that of their parents. The small sample size is also a limitation that may have obscured weak effects such as the main effect of feedback type on teens' perceived norms. In addition, we did not use a multiple-comparison correction method, such as Bonferroni, which control for the overall Type I error, but decrease power. To avoid inflating Type I error unnecessarily, we set apriori contrasts based on our hypothesis instead of conducting all pairwise comparisons. In addition, it is important to note that the consistency of our results provide more confidence that spurious findings may not be present. Finally, Hawthorne effect (Jones, 1992) is another potential limitation in this study despite the fact that the experimenter attempted not to bias participant responses by providing the same instructions to all participants to the extent possible.

Overall, our results suggested that PNF based on parent descriptive norms are promising for mitigating distraction among teens. During adolescence, there is a shift from family to group life, and teens turn increased attention to peer social cues (Blos, 1966; Gifford-Smith et al., 2005). Therefore, in the second driving simulator experiment (discussed in the next chapter), we investigated the effectiveness of PNF based on peer descriptive norms. We hypothesized that providing teens with peer descriptive norms can also mitigate teen driver distraction. In addition, we investigated the effects of tailoring PNF based on teen's gender. Based on the Social Comparison Theory (Festinger, 1954), which states that socially proximal comparison referents (e.g., same age, same gender) have a greater influence than more distal comparison referents, we hypothesized that PNF based on same-gender peer norms will have a larger effect on teen distraction than PNF based on opposite-gender peer norms.

Chapter 6
Experiment II: Personalized Normative Feedback for Teen Driver Distraction: Peer Norms

6

As mentioned earlier, the second driving simulator experiment aimed to investigate the effectiveness of PNF based on same- and opposite-gender peer descriptive norms. Three between-subject feedback conditions were evaluated: (1) post-drive feedback incorporating same-gender peer norms, (2) post-drive feedback incorporating opposite-gender peer norms, and (3) no feedback as control. Given that the first experiment did not find any effects for the post-drive feedback only condition compared to no feedback, the post-drive feedback only condition was eliminated in the second experiment. Questionnaires were also administered to collect data on teens' self-reported engagement in distractions, the associated peer norms with consideration of gender, and teen acceptance of the different feedback interventions.

6.1 Method

6.1.1 Participants

Participants were recruited via advertisements on social media, flyers posted at local universities, as well as through emails sent to pools of potential participants (e.g., within universities, high schools, and driving schools). All participants held at least a Class G2 license, were able to drive without the use of corrective lenses, and were screened for simulator sickness.

46 participants were recruited: 19 for same-gender peer norm, 21 for opposite-gender peer norm, and 6 for no feedback. Data from the 11 participants who completed the no feedback condition in the first experiment were added to the no feedback condition of the second experiment as the experimental design and procedures for the no feedback conditions across the two experiments were exactly the same. To further justify this merge, the experimental data for the two groups were compared and no significant differences were observed. Thus, there were a total of 57 participants in the Experiment 2 dataset (Table 10): 19 for same-gender peer norm, 21 for opposite-gender peer norm, and 17 for no feedback. All teens were compensated C$25 for their participation.

Table 10: Demographic information of the teens across the three feedback conditions

Condition	**N**	**% male**	**% age group** 17	18	19	**% years of G2 licensure** ≤1	>1, ≤2	>2
Same-gender peer norm	19	47.4	0	52.6	47.4	10.5	52.6	36.8
Opposite-gender peer norm	21	47.6	4.8	61.9	33.4	19	47.6	33.4
No feedback	17	58.8	11.8	29.4	58.8	11.8	64.7	23.5
Overall	57	50.9	5.3	49.1	45.6	14	54.4	33.4

6.1.2 Experimental Design and Procedure

A 2x3x5 mixed factorial design was used, with driver gender (male, female) and feedback type (same-gender peer norm, opposite-gender peer norm, and no feedback) as between-subjects factors, and experimental drive (drive 1-5) as a within-subjects factor. During all drives, participants performed the self-paced secondary task described in section 4.2. Drive 1 did not involve any feedback and was identical across all feedback types. Drives 2 to 5 differed across the feedback conditions. Participants, except those who were added from the first experiment, were randomly assigned to one of the feedback conditions.

The experimental drives (d1 to d5) (see section 4.3) as well as the practice drive completed by all participants were identical. Participants were instructed to follow a lead vehicle and to maintain the speed limit of 50 mph (~80 kph). They were informed that the lead vehicle may occasionally brake. The secondary task was available throughout an entire drive. Participants were instructed that the task would be available at all times and they could choose to engage in the task at their own pace that they felt comfortable with. Participants were told that they could receive up to C$5 compensation based on their secondary task performance, although everyone received the full amount regardless of performance. They were also instructed to prioritize safety and to drive as they would in their own vehicle.

Prior to driving the simulator, teens completed a pre-experiment questionnaire (Appendix E). At the end of the last experimental drive, the teens were administered the same questionnaire once more to assess whether PNF resulted in changes in their perceived descriptive norms (i.e., what their peers do). Teens who experienced feedback also completed the Advanced Transport Telematics Acceptance Assessment Questionnaire (Appendix D) (Van Der Laan et al., 1997).

6.1.3 Feedback Design

Same-gender and opposite-gender peer norm feedback consisted of a post-drive report presented to the teens, which provided a comparison of their distracted driving behaviour to that of their same-gender and opposite-gender peers, respectively (Figure 14). The teens were told that the information presented to them was based on the average driving behaviour of 30 of same/opposite-gender students 17 to 19 years old who participated in the same study. However, in order to control for the potential variances among male and female teens, the data used for the comparison was created artificially (Table 11). Initially, in a pilot study, we tested the same artificial data used for parent behaviour in the first experiment in order to be able to compare the results of the two experiments. However, teens did not find the data credible, as the level of distraction used for parents was deemed to be too low for other teens. Therefore, in order to ensure credibility, the artificial data for peer comparison was adjusted based on teen behaviour observed in the first experiment (around 25^{th} percentile). The teens were debriefed at the end about this deception and none of them indicated any suspicion.

Same- and opposite-gender peer norm feedback presented detailed performance and attention measures using bar graphs (Figure 14). Driving performance graphs presented information on teen unsafe braking and lane deviation. Attention to driving graphs provided a comparison between teen and peer unsafe glances (glances over 2 seconds on the secondary display) and percentage of the time not looking at the roadway. The criteria for unsafe braking, lane deviations, and unsafe glances were similar to those used in the first experiment (see section 5.1.3). Information about teen distraction status prior to each driving error (i.e., unsafe braking and lane deviation) was also provided. The phrase "distraction detected" was presented when either a single long glance (>2 seconds) on the secondary display was detected within 5 seconds prior to the driving error or when the driver's eyes were on the secondary display for a total of 3 seconds in a 5-second moving window.

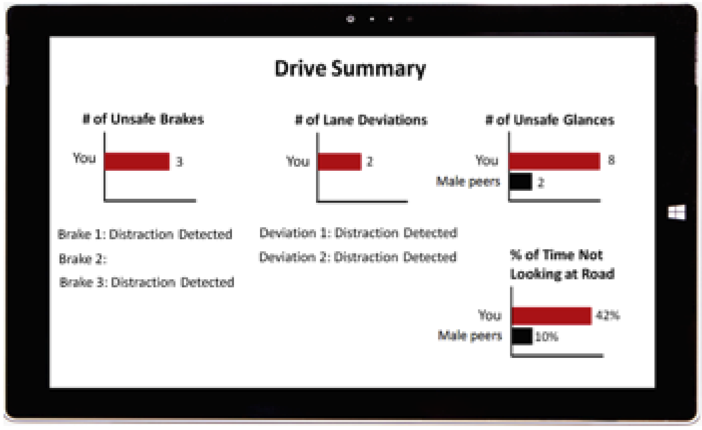


Figure 14: (a) Same/opposite-gender peer-norm feedback

Table 11: Artificial peer data used for comparison in same- and opposite-gender peer-norm feedback

Drive Number	# of Unsafe Glances	% Time Not Looking at the Road
1	5	21
2	3	18
3	2	10
4	0	6
5	0	5

6.1.4 Simulator Measures and Data Analysis

Measures and analysis methods were the same as those used in the first experiment. Six measures involving the secondary display were assessed for distraction engagement: rate of long glances (>2 seconds) per minute, average glance duration, 95th percentile glance duration, percentage of time looking at the secondary display, number of glances on the secondary display, and number of manual interactions. Further, to assess the effect of feedback on driving performance, including response to lead vehicle braking, five measures were examined: Standard Deviation of Lane Position (SDLP), Accelerator Release Time (ART), Brake Transition Time (BTT), Brake Response Time (BRT), and maximum deceleration (see section 5.1.4 for description of variables).

To analyze rate of long glances on the secondary display, a negative binomial model was built using PROC GENMOD in SAS, with the specifications of log link function. Repeated measures were accounted for using Generalized Estimating Equations and the logarithm of drive duration was used as an offset variable. Feedback type, driver gender, age, drive number, and their two-way interactions were used as predictor variables. All other variables were analyzed using mixed linear models, with repeated measures accounted through a compound-symmetry variance-covariance structure. This modeling framework is equivalent to a repeated measures ANOVA. For lead vehicle braking event response, gap time between the lead vehicle and the participant's vehicle at brake event onset was used as a covariate. For all analyses, non-significant terms were removed from the models using backward elimination method.

6.1.5 Questionnaire Administration and Analysis

Questionnaires were developed and administered to assess driver distraction engagement and related social norms (Appendix E). 17 distraction tasks were selected to provide a wide range of tasks that drivers may engage in while driving. 16 tasks were the same as those used in the survey study (see Table 2), and an additional task of "adjusting the audio system using controls on the console" was added, as previous research has shown that this task also is associated with an increase in the risk of a crash among novice drivers (Klauer et al., 2014a). For analysis, these tasks were narrowed to 12 tasks, excluding those that around 90 percent of the teens reported to never or rarely engage in (i.e., updating or checking social media; playing digital games; watching online videos; reading emails; reading extended text).

The following measures on engagement frequency and social norms were collected for each distraction using 5-point Likert scales and an additional option of "I/s(he) do/does not use this technology' when relevant. The same environmental context as the one used in our survey study (i.e., a two-lane road with low traffic and good weather conditions) was included in the questionnaire, and participants were asked to answer all questions with this environmental context in mind.

Self-reported distraction engagement was assessed by asking teens how often they have engaged in each of the distractions over the last year (1= never, 2= rarely, 3= sometimes, 4= often, and 5= very often). *Perceived peers' engagement in distraction (perceived descriptive norms)* was assessed by asking teens how often they thought their female and male peers engaged in each of the distractions while driving over the last year (1= never, 5= very often). *Perceived peers' approval of distraction (perceived injunctive norms)* was measured by asking teens how strongly they thought their female and male peers disapprove/approve their engagement in each of the distractions while driving (1= strongly disapprove, 5= strongly approve). The internal consistency of each measure was checked using Cronbach's alpha and met the well-established threshold of 0.7 (Nunnally, 1978). For the purpose of scoring, responses were averaged across the different distractions for each teen. Teens who experienced feedback also completed the Advanced Transport Telematics Acceptance Assessment Questionnaire (Appendix D) (Van Der Laan et al., 1997).

Paired t-tests were conducted to compare teen pre- and post-experiment responses on their perceived peer descriptive norms to assess whether PNF changed perceived descriptive norms. In addition, teen self-reported engagement and their perceptions of peer engagement in distractions were compared using paired t-tests. The relationship between teen distraction engagement and their perceived peer norms was evaluated using Pearson correlation analysis. Finally, analysis of variance using PROC GLM in SAS was conducted for perceived usefulness and satisfaction to assess teens' acceptance of the two feedback types.

The analyzed sample for questionnaire data consisted of 46 participants who completed the second experiment. Those 11 participants, who were added from the first experiment, were excluded as they were asked about their perceptions of peer norms without the consideration of peer gender (i.e., "your peers" rather than "your male/female peers").

6.2 Results

6.2.1 Distraction Engagement Measures

Overall, the statistical findings described in detail below indicate that both same- and opposite-gender peer norm feedback mitigated teen driver distraction. Contrary to our hypothesis, no major difference was observed between same-gender and opposite-gender peer norm feedback.

Rate of long glances (>2 seconds) per minute

Feedback type ($\chi^2(2)=10.00$, $p=.007$), drive number ($\chi^2(4)=19.00$, $p=.0008$), and their interaction ($\chi^2(8)=67.67$, $p<.0001$) were significant (Figure 14). No effect for gender was observed ($p>.05$).

As expected, there were no significant differences across feedback conditions during the baseline drive (drive 1) for rate of long glances per minute and all the other distraction engagement measures.

Overall, compared to no feedback, same-gender peer norm feedback resulted in a significantly lower rate of long glances on the secondary display during drives 3 to 5 (drive 3: $\chi^2(1)=8.11$, p=.004; drive 4: $\chi^2(1)=9.07$, p=.003; drive 5: $\chi^2(1)=10.80$, p=.001). Opposite-gender peer norm feedback also resulted in a decreased rate of long glances compared to no feedback during drives 2 to 5 (drive 2: $\chi^2(1)=8.43$, p=.004; drive 3: $\chi^2(1)=5.50$, p=.02; drive 4: $\chi^2(1)=5.76$, p=.02; drive 5: $\chi^2(1)=10.79$, p=.001). No significant difference was observed between same- and opposite-gender peer norm feedback (p>.05).

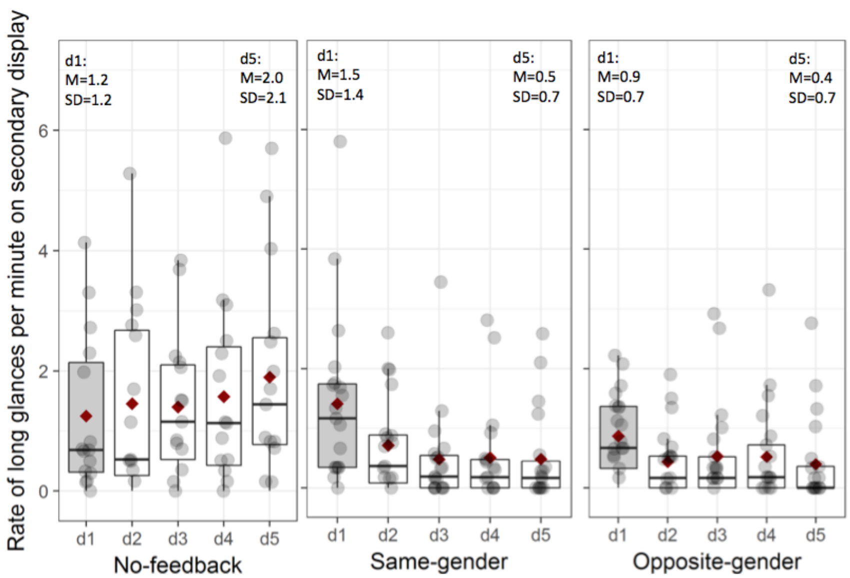


Figure 15: Rate of long glances (>2 seconds) per minute across feedback conditions

Average glance duration on the secondary display

Feedback type (F(2,50)=4.51, p=.02), drive number (F(4,212)=7.66, p<.0001), and their interaction (F(8,212)=4.98, p<.0001) were significant (Figure 15). No gender effect was observed (p>.05). Compared to no feedback, same-gender peer norm feedback resulted in significantly smaller average glance durations for drives 3 (t(212)=-1.92, p=.054), 4 (t(212)=-2.81, p=.005), and 5 (t(212)=-3.21, p=.001). Opposite-gender peer norm feedback decreased average glance durations for drives 2 to 5 compared to no feedback (drive 2: t(212)=-2.87, p=.004; drive 3: t(212)=-2.51, p=.01; drive 4: t(212)= -3.08, p=.002; drive 5: t(212)= -3.96, p=.0001). No significant difference was observed between same- and opposite-gender peer norm feedback in any of the drives (p>.05).

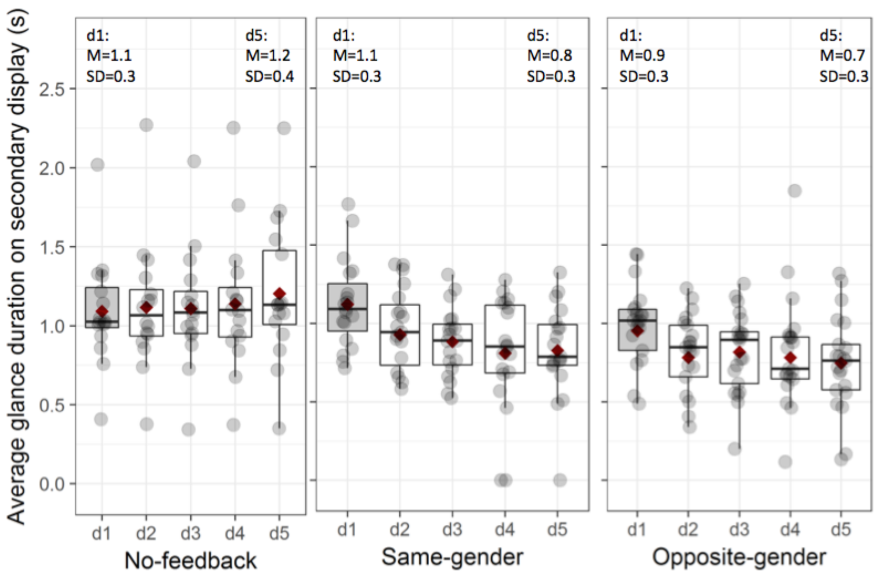


Figure 16: Average glance duration on the secondary display across feedback conditions and drives

95th percentile glance duration on the secondary display

Feedback type (F(2,50)=5.09, p=.009), drive number (F(4,205)=4.00, p=.004), and their interaction (F(8,205)=2.47, p=.01) were significant (Figure 16). No gender effect was observed (p>.05). Compared to no feedback, same-gender peer norm feedback resulted in significantly smaller 95th percentile glance duration for drives 2 to 5 (drive 2: t(205)=-2.05, p=.04; drive 3: t(205)=-2.92, p=.0039; drive 4: t(205)=-2.44, p=.02, drive 5: t(205)=-3.19, p=.002). Opposite-gender peer norm feedback also decreased 95th percentile glance duration for drives 2 to 5 compared to no feedback (drive 2: t(205)=-2.93, p=.004; drive 3: t(205)=-2.98, p=.003; drive 4: t(205)= -2.16, p=.03; drive 5: t(205)= -3.72, p=.0003). No significant difference was observed between same- and opposite-gender peer norm feedback in any of the drives (p>.05).

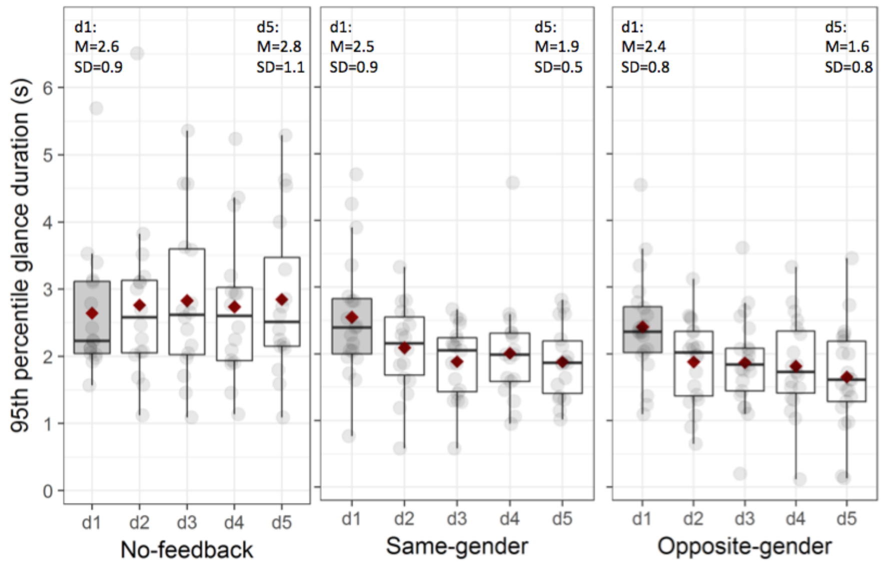


Figure 17: 95th percentile glance duration on the secondary display across feedback conditions and drives.

Percentage of time looking at the secondary display

Feedback type (F(2,50)=3.18, p=.050), its interaction with drive number (F(8,212)=7.29, p<.0001), and gender (F(1,50)=7.12, p=.01) were significant. Compared to no feedback, same-gender peer norm feedback resulted in less time looking at the secondary display for drives 2 to 5 (drive 2: t(212)=-2.06, p=.040; drive 3: t(212)=-2.48, p=.01; drive 4: t(212)=-2.56, p=.01; drive 5: t(212)= -2.98, p=.003) (Figure 17). Opposite-gender peer norm feedback also resulted in a decreased %time looking at the secondary display compared to no feedback during drives 2, 4, and 5 (drive 2: t(212)=-2.33, p=.02; drive 4: t(212)=-2.35, p=.02; drive 5: t(212)= -3.96, p=.0001). Females spent less time looking at the secondary display compared to males (t(50)=-2.67, p=.01). No significant difference was observed between same- and opposite-gender peer norm feedback in any of the drives (p>.05).

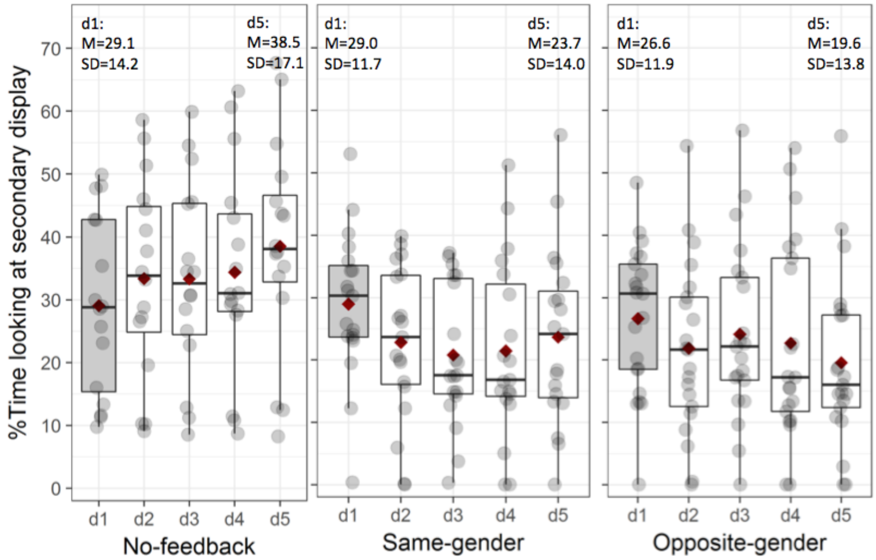


Figure 18: Percentage of time looking at the secondary display across feedback conditions and drives

Number of glances on the secondary display

Effects of gender (F(1,48)=5.22, p=.03) and drive duration (F(1,211)=4.84, p=.03) were significant. Male teens had a larger number of glances than female teens (t(48)=2.29, p=.03). In addition, a 1 minute increase in drive duration contributed to a 14.8 increase in the number of glances on the secondary display (t(211)=2.20, p=.03). The interaction between feedback type and drive number was also significant (Figure 19). In the no-feedback condition, number of glances increased significantly from drive 1 to 5 (t(211)=3.10, p=.002), whereas no significant change was observed for same- and opposite-gender peer norm feedback (p>.05).

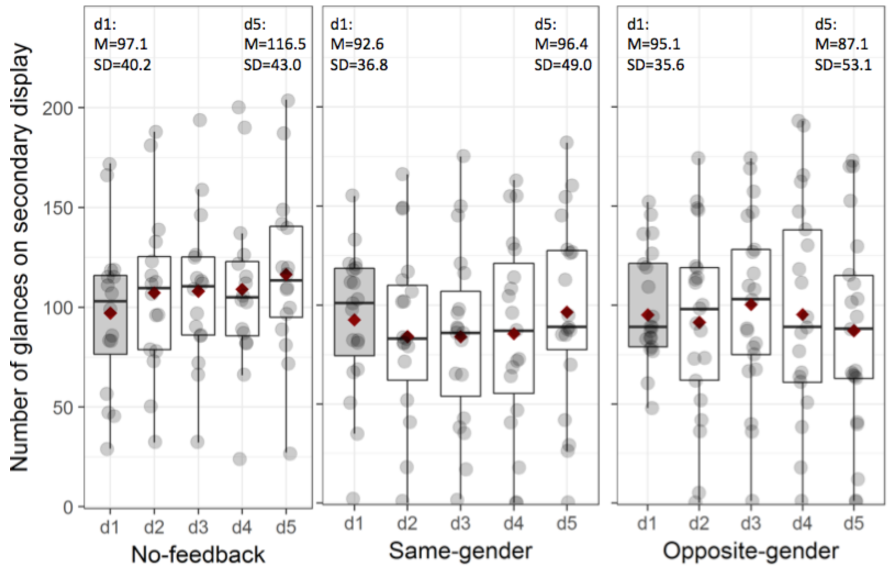


Figure 19: Number of glances on the secondary display across feedback conditions and drives

Number of manual interactions with the secondary display

Number of times the participants manually interacted with the secondary display to perform the secondary task was found to be affected by drive number (F(4,215)=4.03, p=.004), its interaction with feedback type (F(8,215)=4.06, p=.0002), and gender (F(1,51)=6.12, p=.02). Compared to no feedback, same-gender peer norm feedback resulted in a smaller number of interactions during drives 2 to 5 (Figure 20) (drive 2: t(215)=-2.07, p=.04; drive 3: t(215)=-2.41, p=.02; drive 4: t(215)=-2.59, p=.01; drive 5: t(215)= -2.69, p=.008). This positive effect was observed during drive 5 (t(215)=-2.86, p=.005) for opposite-gender peer norm feedback. Number of interactions increased significantly from drive 1 to drive 5 in no feedback condition (t(215)=5.27, p<.0001), indicating that the participants possibly became more comfortable with performing the task over time. Overall, male teens had a larger number of interactions than female teens (t(51)=2.47, p=.02).

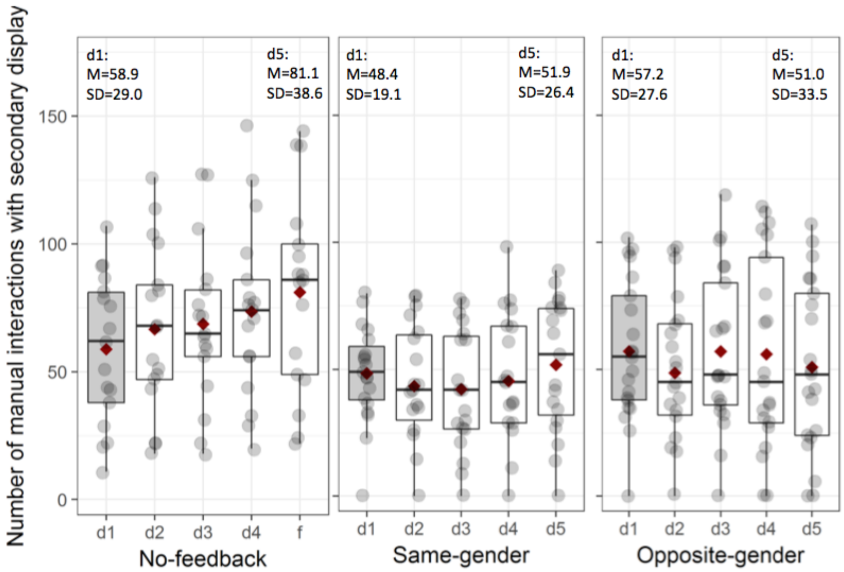


Figure 20: Number of manual interactions with the secondary display across feedback conditions and drives

6.2.2 Driving Performance Measures

Overall, the statistical findings described in detail below indicate that both same-gender and opposite-gender peer norm feedback conditions improved driving performance compared to no feedback.

Standard deviation of lane position

Drive number (F(4,203)=6.12, p=.0001) and its interaction with feedback type (F(8,203)=4.19, p=.0001) were significant for SDLP (Figure 21). As expected, there were no significant differences across feedback conditions during the baseline drive (drive 1) for SDLP and all the other driving performance measures. Compared to no feedback, SDLP decreased for drives 3 to 5 with same-gender peer norm feedback (drive 3: t(203)=-2.19, p=.03; drive 4: t(203)=-2.32, p=.02; drive 5: t(203)=-2.45, p=.01). Opposite-gender peer norm also decreased SDLP on drives 3 and 5 (drive 3: t(203)=-2.02, p=.04; drive 5: t(203)=-2.70, p=.007). No significant difference was observed between same- and opposite-gender peer norm feedback in any of the drives (p>.05).

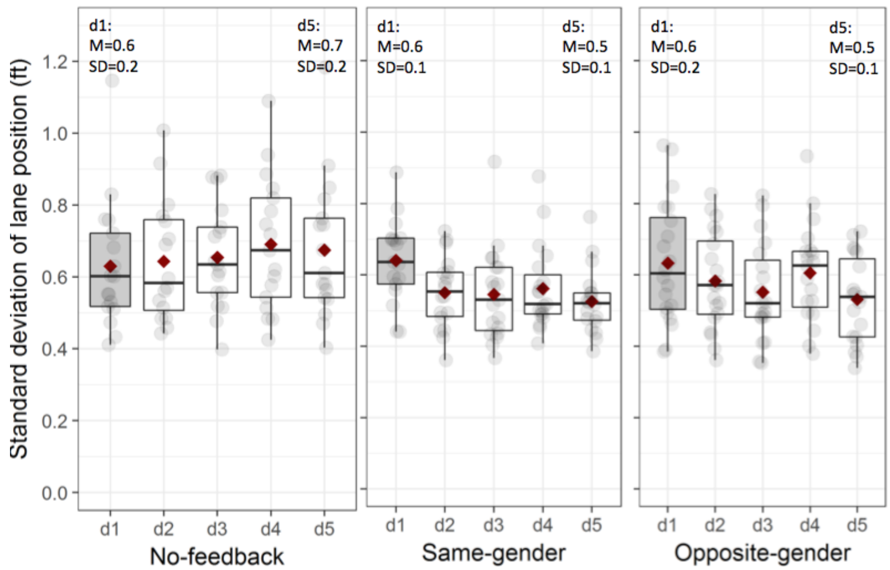


Figure 21: Standard deviation of lane position across feedback conditions and drives

Accelerator release time

Main effect of drive number (F(4,204)=4.38, p=.002) was significant. In the drive 1 (baseline drive), participants were significantly slower to release the accelerator pedal than other drives (drive2: t(204)=2.48, p=.01; drive3: t(204)=3.56, p=.0005; drive4: t(204)=3.01, p=.003; drive5: t(204)=3.58, p=.0004) (Figure 22). No significant effect was observed for either feedback type or gender (p>.05).

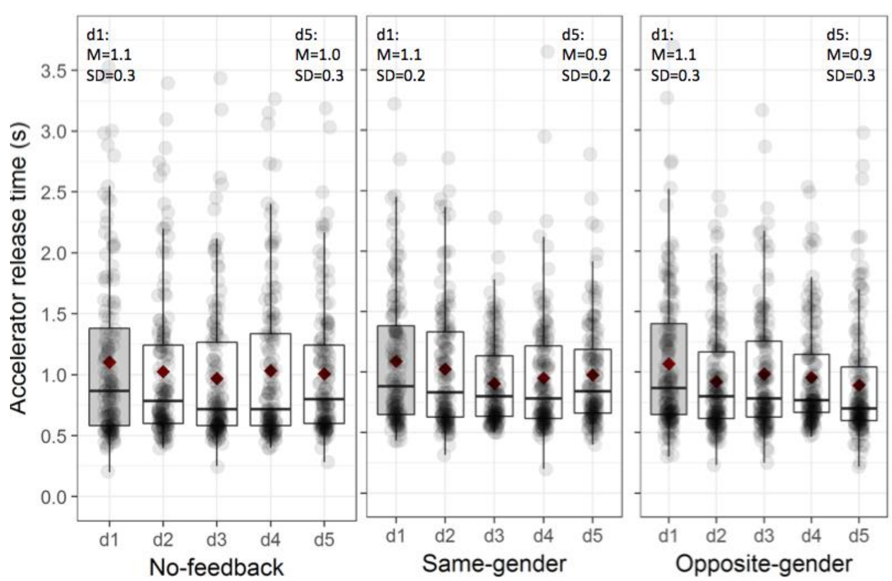


Figure 22: Accelerator release time across feedback conditions and drives

Brake transition time

Main effect of drive number was significant (F(4,202)=6.56, p<.0001). During the baseline drive, participants had significantly shorter BTTs compared to drives 3 to 5 (drive3: t(202)=-2.64, p=.008; drive4: t(202)=-3.15, p=.002; drive5: t(202)=-4.81, p<.0001) (Figure 23). No significant effect was observed for feedback type or gender (p>.05).

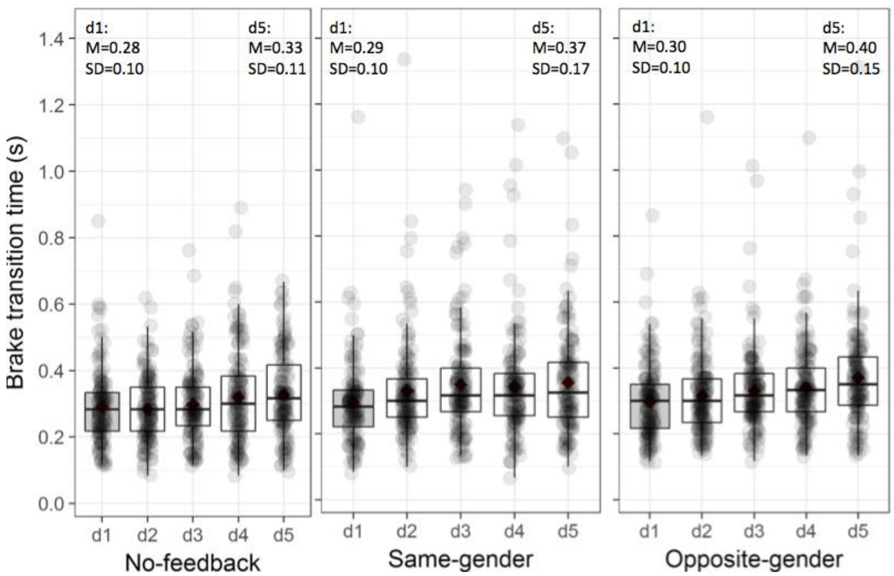


Figure 23: Brake transition time across feedback conditions and drives

Brake response time

No significant effect for drive number, feedback type, or gender was observed (p>.05). The gap time at lead vehicle braking onset was a significant covariate (F(1,203)=4.17, p=.04). A 1 ms increase in gap time at the brake event onset contributed to a 19% increase in BRT.

Maximum deceleration

Drive number (F(4,207)=17.16, p<.0001) and its interaction with feedback type (F(8,207)=2.82, p=.005) were significant for maximum deceleration (Figure 24). Compared to no feedback, same-gender peer norm feedback resulted in smaller maximum decelerations during drives 4 (t(207)=-2.38, p=.02) and 5 (t(207)=-2.03, p=.04). Opposite-gender peer norm feedback also decreased maximum deceleration during drives 2, 4, and 5 (drive 2: t(207)=-2.29, p=.02; drive 4:

t(207)=-2.98, p=.003; drive 5: t(207)= -2.76, p=.006). No significant difference was observed between same- and opposite-gender peer norm feedback (p>.05).

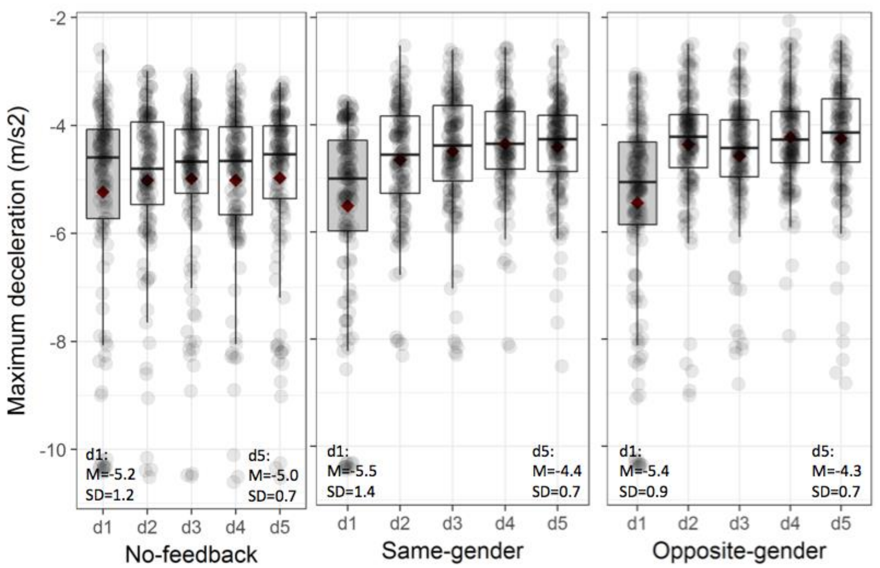


Figure 24: Maximum deceleration across feedback conditions and drives

6.2.3 Questionnaires

The paired t-test revealed that teens' perceptions of their peer engagement in distraction did not change from pre- to post-experiment for any of the feedback conditions (p>.05).

Table 12 presents the overall scores (averaged over 12 distractions) for the pre-experiment questionnaire. No significant effects for teen driver gender, peer gender, and their interaction were observed for either the perceived descriptive or the perceived injunctive norms (p>.05). Paired t-tests were conducted to compare teen self-reported distraction engagement and their perceived peer engagement in distractions. Results showed that both female and male teen participants reported that both their female peers (female participants: t(22)=8.56, p<.0001; male participants: t(24)=6.40, p<.0001) and male peers (female participants: t(22)=7.83, p<.0001; male participants: t(24)=6.57, p<.0001) engaged in distractions more often compared to themselves.

Table 12: Descriptive statistics on questionnaire responses collected on a scale of 1 to 5

	Mean (SD)		
	All participants (n=48)	Females (n=23)	Males (n=25)
Self-reported engagement			
Teens	2.41 (0.67)	2.29 (0.68)	2.51 (0.65)
Teen perceived descriptive norms			
Female peer distraction engagement	3.37 (0.64)	3.35 (0.73)	3.37 (0.56)
Male peer distraction engagement	3.29 (0.59)	3.26 (0.66)	3.32 (0.53)
Teen perceived injunctive norms			
Female peer approval	3.19 (0.54)	3.26 (0.57)	3.12 (0.51)
Male peer approval	3.20 (0.53)	3.30 (0.55)	3.11 (0.50)

Consistent with the findings of the survey study, no significant difference was observed between female and male teen self-reported distraction engagement ($t(46)=1.12$, $p=.27$). Correlation analyses (Table 13) were also in agreement with our survey study. As mentioned before, in this questionnaire we considered peer gender as a factor while collecting data on teen perceived peer norms. Teen self-reported distraction was positively correlated with their perceptions of female and male peer distraction engagement and approval of distraction. Although, the observed correlations tended to be stronger between teen (particularly male teen) distractions and their same-gender peer norms than their opposite-gender peer norms, the difference was not significant.

Table 13: Pearson correlations between teens' self-reported distraction engagement frequency and perceived norms

	Teens' Distraction Engagement (r)		
Perceived Norms	All participants (n=48)	Females (n=23)	Males (n=25)
Descriptive norms			
Perceived female peer engagement	**.52***	**.66***	**.39**
Perceived male peer engagement	**.54**	**.61**	**.47**
Injunctive norms			
Perceived female peer approval	**.44**	**.46**	**.48**
Perceived male peer approval	**.47***	**.49**	**.53**

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

Analysis of the Advanced Transport Telematics Acceptance Assessment Questionnaire responses (Van Der Laan et al., 1997) showed that overall teens had positive attitudes towards both feedback types as indicated by the 95% confidence intervals, excluding zero for the estimated mean usefulness and satisfaction (Figure 25). Same-gender peer norm feedback and opposite-gender peer norm feedback received mean usefulness scores of 1.36 (SD=0.39) and 1.29 (SD=0.57) and mean satisfaction scores of 0.70 (SD=0.71) and 0.76 (SD=0.66), respectively. No significant difference was observed between the feedback types in either usefulness or satisfaction (p>.05).

Figure 25: Acceptance of feedback (estimated means and 95% confidence intervals)

6.3 Discussion

In the second driving simulator experiment, we investigated whether PNF based on peer descriptive norms can mitigate teen driver distractions. We also tested whether tailoring PNF to teen drivers' gender provides additional benefits. The effectiveness of two feedback types was compared to no feedback: post-drive feedback incorporating same-gender peer norms and post-drive feedback incorporating opposite-gender peer norms. Questionnaires were also conducted to assess teens' self-reported engagement in distraction and their perceptions of female and male peer engagement in and approval of distraction. Further, teen acceptance of the two feedback types was evaluated. Overall, our results suggest that, similar to the PNF based on parent norms (Chapter 5), PNF based on peer norms is effective in reducing distraction engagement and improving driving performance among teens. However, the presentation of same-gender peer norms did not significantly benefit the teen behaviour more than the presentation of opposite-gender peer norms.

Both same- and opposite-gender peer norm feedback resulted in significantly smaller average glance duration, 95^{th} percentile glance duration, % time looking, rate of long glances (>2 seconds) on the secondary display compared to no feedback. Further, number of manual interactions with the secondary display was decreased by same- and opposite-gender peer norm feedback compared to no feedback. Same- and opposite-gender peer norm feedback also improved driving performance. In particular, they resulted in better lane keeping and smaller maximum deceleration compared to no feedback. Analysis of acceptance data revealed that both feedback types were found to be useful and satisfactory, and were well accepted by teens.

Contrary to our hypothesis that same-gender peer norm feedback may have a greater influence on teen distracted driving than opposite-gender peer norm feedback, no major difference was observed between the two feedback types. As mentioned in Chapter 2, PNF aims to develop motivation for behavioural change by highlighting the discrepancy between one's own behaviour and perceived or actual norms. The results of our survey study (Chapter 3) and the pre-experiment questionnaire used in the second experiment suggested that there were no significant gender differences in either the teens' self-reported driver distraction or their perceived norms. In addition, the same artificial data was provided to male and female teens as the actual male and female peer norms. Therefore, male and female teens might have experienced similar discrepancies by the two feedback types, and have changed their behaviour based mainly on the discrepancy. It is also possible that same-gender peers are not perceived to be a more proximal reference group by teens compared to their opposite-gender peers. Results from the correlation analyses conducted on the questionnaire data from the second experiment support this explanation: teens' self-reported distraction engagement did not show significantly higher correlations with their same-gender peer norms compared to their opposite-gender peer norms. Future research should evaluate the effectiveness of PNF based on more proximal reference groups such as same-gender close friends. A difference might be expected here given other research. For example, Korcuska and Thombs (2003) showed that college students' alcohol use was better explained by same-gender best friends' drinking norms compared to same-gender typical students' drinking norms.

Although both PNF types were effective in mitigating teen driver distraction, no significant changes were observed in teen perceptions of descriptive norms after receiving feedback. The lack of significance may be due to the artificial data used for peer norms, which may not have been representative of what the participants considered their peers to do. Also, it is possible that teens may not have considered the engagement behaviour demonstrated in the simulator by their peers to be representative of their real-world behaviour or more exposure to feedback is needed to change teens' perceptions. In the future, the effectiveness of PNF needs to be investigated in the real-world for a longer period.

In Experiment 2 questionnaires, both female and male teens reported that both their female and male peers engage in distractions more often compared to themselves. This finding is consistent with the findings of our survey study, which showed that both male and female teens perceived that their peers engage in distractions more often than they do. However, in the survey, peer gender was not taken into account. Experiment 2 data also revealed that teen perceptions of their female and male peers' engagement in and approval of distraction was positively correlated with their own self-reported distraction engagement. Although the observed correlation of teens' (particularly male) self-reported distraction engagement with their same-gender peer norms appeared to be larger than with their opposite-gender peer norms, the difference was not significant. Overall, the observed positive correlations are consistent with the results of our survey study as well as the study conducted by Carter et al. (2014). However, in our survey study and Carter et al. (2014), peer norms were not investigated with a consideration of the peer's gender.

Limitations of the study should be noted. Similar to the first experiment, although the use of artificial data to provide a comparison between teen distracted driving and their peers allowed experimental control and none of the teens indicated any suspicion about this deception, it may still have provided teens with a somewhat artificial experience. The effectiveness of PNF with actual normative information needs to be investigated. Further, only short-term effects of feedback types were investigated in the current study. In addition, the reliability of self-reported data is a limitation as participants may have under- or over-reported their distracted driving behaviours. These limitations and the opportunity for future research are discussed in more detail in the next chapter.

Chapter 7
Conclusion

7

7.1 Summary of Key Findings

- Teens appear to have social norms misperceptions and overestimate their mother's and father's engagement in (descriptive norms) and approval of (injunctive norms) distractions.

- Teens also appear to overestimate their peer distraction engagement. Teens in our study reported that both their female and male peers engaged in distractions more often compared to themselves.

- Teens' self-reported distraction engagement was positively correlated with their perceptions of their parents' engagement in and approval of distractions. Some gender differences were observed. Male teens' self-reported distraction was only positively associated with their perceptions of their same-gender parent (i.e., father) norms. These findings suggest that the same-gender parent might be a better referent for developing PNF targeting male teens.

- Teens' self-reported distraction engagement was positively correlated with their perceptions of their peers' engagement in and approval of distractions.

- Our results support the value of TPB in predicting teen self-reported distraction engagement. Perceived parent and peer distraction engagement and attitudes towards distractions were all significant predictors of self-reported distraction engagement among teens. However, effects of perceived parent and peer approval of distraction and perceived control were not significant.

- PNF based on parent norms was found to be effective in mitigating distraction among teens. When compared to other types of feedback (i.e., post-drive feedback without normative information and real-time feedback), PNF based on parent norms was the most effective intervention in reducing distraction engagement and improving driving performance among teens. Further, PNF was well accepted by teens.

- PNF based on peer norms was also found to be an effective intervention in mitigating teen driver distraction. When compared to no feedback, PNF based on same-gender and opposite-gender peer norms interventions were effective in reducing distraction engagement and improving driving performance among teens. Tailoring PNF to teen gender did not provide additional benefits, and no significant difference was observed between same- and opposite-gender peer norm feedback. Both feedback types were well accepted by teens.

7.2 Contribution to the Field

While a substantial body of literature has emerged to evaluate the application of social norms theory to the prevention of negative behaviours in different domains, no study to date has systematically tested the effectiveness of social norms interventions to address the issue of teen driver distraction. Therefore, the purpose of this dissertation was to understand the social norms underlying teen driver distraction, and to investigate the effectiveness of social norms interventions as a supplement to existing distraction mitigation systems to improve roadway safety. Overall, this dissertation provides empirical evidence to support the claim that teens overestimate the prevalence and permissiveness of driver distraction among their social referents, and PNF can be applied successfully in the driver distraction domain to mitigate teen distracted driving.

To the best of our knowledge, only one previous research (Bingham et al., 2015) has studied teen misperceptions around their parents' engagement in driver distraction (descriptive norms). This previous study did not address teen misperceptions around parent approval of distractions (injunctive norms). This dissertation contributed to the literature by extending the findings of Bingham et al. (2015) to perceived injunctive norms.

This research also contributes to the literature on PNF application in driver distraction domain. A PNF based on parent norms was systematically tested in a driving simulator experiment. Overall, our results provide empirical evidence to support the effectiveness of PNF based on parent norms in mitigating teen distraction engagement and improving their driving performance. In this experiment, three feedback types were compared: PNF based on parent norms, post-drive feedback without normative information, and real-time feedback. Results indicated that PNF based on parent norms was the most effective intervention in reducing distraction engagement and improving driving performance among teens. Further, PNF was found useful and satisfactory, and it was well accepted by teens. Real-time feedback also induced positive driving behaviours; however, teens did not find it satisfying. It also appeared that real-time feedback mitigated distraction mainly through limiting glance durations as it was triggered solely based on glance duration information, whereas PNF also decreased manual engagement in the secondary task in addition to limiting glance durations.

Finally, this dissertation contributes to the literature by systematically evaluating PNF based on peer norms and by investigating the effects of tailoring PNF to teen driver's gender. Overall, our results indicate that PNF based on same- and opposite-gender peer norms are both effective interventions in mitigating teen driver distraction. When compared to no feedback, PNF based on same- and opposite-gender peer norms resulted in reduced distraction engagement and improved driving performance among teens. Further, PNF interventions tested were found to be useful and satisfactory, and were well accepted by teens. Contrary to our hypothesis based on the social comparison theory (Festinger, 1954), no significant difference was observed between the same- and opposite-gender peer norms PNF interventions.

7.3 Limitation and Future Work

This dissertation research has several limitations and potential future directions that are highlighted in this section.

Most of the limitations have been discussed in earlier sections, such as the potential Hawthorne effect during the simulator studies as well as including different rating scales used in the survey. This section highlights the more major issues from these limitations. A major limitation of the survey study undertaken in this dissertation, like other survey studies, is the reliability of self-reported data. Participants may have under- or over-reported their distracted driving behaviours. Another limitation of the survey study and the first driving simulator experiment was that the sample was limited to teens and parents who were willing to participate in the study jointly and thus our findings are subject to this bias. The generalization of the first driving simulator experiment results is also limited by the potential selection bias associated with the social norms group.

Although the use of artificial data for parent/peer norms allowed for experimental control and none of the teens indicated any suspicion about this deception, it may still have provided teens with a somewhat artificial experience. Future work is needed to replicate these studies using actual parental and peer norms in the real-world. In addition, we were not able to compare the findings of Experiment 1 and 2, more specifically PNF based on parent norms and PNF based on peer norms, as different artificial normative data had to be used in the two experiments to ensure credibility. That comparison is left for future research.

Based on the Social Comparison Theory (Festinger, 1954), which states that socially proximal comparison referents (e.g., same age) have a greater influence than more distal comparison referents, and given that teens shift from family to group life and turn increased attention to peer social cues during adolescence (Blos, 1966; Gifford-Smith et al., 2005), we hypothesize that the effects of PNF based on peer norms may be stronger than the effects of PNF based on parent norms. In addition, as mentioned earlier, we did not find any significant differences between PNF based on same- and opposite-gender peer norms as same-gender peers might not perceived to be a more proximal reference group by teens compared to their opposite-gender peers. Future research should evaluate the effectiveness of PNF based on more proximal reference groups such as same-gender close friends or significant other.

Finally, only short-term effects of PNF were investigated in the current study, and it is not clear whether PNF results in a short-term change in behaviour, or whether new driving habits are formed which will persist. More experimental research is needed to address questions surrounding persistence.

References

Abouk, R., & Adams, S. (2013). Texting bans and fatal accidents on roadways: Do they work? or do drivers just react to announcements of bans? *American Economic Journal*, *5*(2), 179–199.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics*, *95*(9–10), 1082–1095.

Allen, J. P., & Brown, B. (2008). Adolescents, peers and motor vehicles: The perfect storm? *American Journal of Preventive Medicine*, *35*(3), 289–293.

Armitage, C. J., & Conner, M. (2001). Efficacy of the Theory of Planned Behaviour: A metaanalytic review. *The British Journal of Social Psychology*, *40*(4), 471–499.

Barraco, R. D. (2015). Gender differences in perceptions and self-reported driving behaviors among teenagers, *49*(6), 974–983.

Beck, K. H., Shattuck, T., & Raleigh, R. (2001). Parental predictors of teen driving risk. *American Journal of Health Behavior*, *25*(1), 10–20.

Beck, K. H., & Watters, S. (2016). Characteristics of college students who text while driving: Do their perceptions of a significant other influence their decisions? *Transportation Research Part F*, *37*, 119–128. https://doi.org/10.1016/j.trf.2015.12.017

Beede, K. E., & Kass, S. J. (2006). Engrossed in conversation: The impact of cell phones on simulated driving performance. *Accident Analysis and Prevention*, *38*, 415–421.

Berkowitz, A. D. (2004). The social norms approach: Theory, research, and annotated bibliography.

Berkowitz, A. D. (2005). An overview of the social norms approach.

Bernstein, J. J., & Bernstein, J. (2015). Texting at the light and other forms of device distraction behind the wheel. *BMC Public Health*, *15*, 968.

Bingham, C. R., & Ehsani, J. P. (2012). The relative odds of involvement in seven crash configurations by driver age and sex. *Journal of Adolescent Health*, *51*, 484–490.

Bingham, C. R., Zakrajsek, J. S., Almani, F., Shope, J. T., & Sayer, T. B. (2015). Do as I say, not as I do: Distracted driving behavior of teens and their parents. *Journal of Safety Research*, *55*, 21–29. https://doi.org/10.1016/j.jsr.2015.07.007

Blos, P. (1966). *On adolescence: A psychoanalytic interpretation*. New York: The Free Press of Glencoe, Inc.

Brannan, D. B. (2011). Can social norms be leveraged to change driving behavior? A thought experiment. In *5th Annual Behavior, Energy, and Climate Change Conference*. Washington D.C.

Burger, N. E., Kaffine, D. T., & Yu, B. (2014). Did California's hand-held cell phone ban reduce accidents? *Transportation Research Part A: Policy and Practice*, *66*, 162–172.

Carifio, J., & Perla, R. (2008). Resolving the 50-year debate around using and misusing Likert scales. Medical Education, 42, 1150–1152.

Carney, C., McGehee, D. V., Lee, J. D., Reyes, M. L., & Raby, M. (2010). Using an event-triggered video intervention system to expand the supervised learning of newly licensed adolescent drivers. *American Journal of Public Health*, *100*(6), 1101–1106.

Carpenter, C. S., & Nguyen, H. V. (2014). Effects of a driver cellphone ban on overall, hand- held, and hands-free cellphone use while driving: New evidence from Canada. *Health Economic*. Retrieved from http://dx.doi.org/10.1002/hec.3098

Carter, P. M., Bingham, C. R., Zakrajsek, J. S., Shope, J. T., & Sayer, T. B. (2014). Social norms and risk perception: Predictors of distracted driving behavior among novice adolescent drivers. *Journal of Adolescent Health*, *54*(5), S32–S41.

Celio, M. A., & Lisman, S. A. (2014). Examining the efficacy of a personalized normative feedback intervention to reduce college student gambling. *Journal of American College Health*, *62*, 154–164.

Chen, H., Cao, L., & Logan, D. B. (2012). Analysis of risk factors affecting the severity of intersection crashes by logistic regression. *Traffic Injury Prevention*, *13*(3), 300–307. https://doi.org/10.1080/15389588.2011.653841

Chen, H. Y. W., & Donmez, B. (2016). What drives technology-based distractions? A structural equation model on social-psychological factors of technology-based driver distraction engagement. *Accident Analysis and Prevention*, *91*, 166–174. https://doi.org/10.1016/j.aap.2015.08.015

Chen, H. Y. W., Donmez, B., Hoekstra-Atwood, L., & Marulanda, S. (2016). Self-reported engagement in driver distraction: An application of the Theory of Planned Behaviour. *Transportation Research Part F*, *38*, 151–163.

Christie, D., & Viner, R. (2005). Abc of adolescence: adolescent development. *British Medical Journal*, *330*(7486), 301–304.

Cialdini, R. B., Kallgren, C. A., & Reno, R. R. (1991). A Focus Theory of Normative Conduct: A theoretical refinement and reevaluation of the role of norms in human behavior. *Advances in Experimental Social Psychology*, *24*, 201–234.

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A Focus Theory of Normative Conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology*, *58*(6), 1015–1026.

Clapp, J. D., Lange, J. E., Russell, C., Shillington, A., & Voas, R. B. (2003). A Failed Norms Social Marketing Campaign. *Journal of Studies on Alcohol and Drugs*, *64*(3), 409.

Curry, A. E., Hafetz, J., Kallan, M. J., Winston, F. K., & Durbin, D. R. (2011). Prevalence of teen driver errors leading to serious motor vehicle crashes. *Accident Analysis & Prevention*, *43*(4), 1285–1290. https://doi.org/10.1016/j.aap.2010.10.019

Deery, H. A. (1999). Hazard and risk perception among young novice drivers. *Journal of Safety Research*, *30*(4), 225–236.

Dejong, W. (2002). The role of mass media campaigns in reducing high-risk drinking among college students. *Journal of Studies on Alcohol and Drugs*, *14*, 182–192.

Dingus, T. A., Guo, F., Lee, S., Antin, J. F., Perez, M., Buchanan-king, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. *Proceedings of the National Academy of Sciences of the United States of America*, *113*, 2636–2641.

Donmez, B., Boyle, L., & Lee, J. D. (2007a). Safety implications of providing real-time feedback to distracted drivers. *Accident Analysis and Prevention*, *39*(3), 581–590. https://doi.org/10.1016/j.aap.2006.10.003

Donmez, B., Boyle, L., & Lee, J. D. (2008a). Designing feedback to mitigate distraction. In M. A. Regan, J. D. Lee, & K. L. Young (Eds.), *Driver Distraction: Theory, Effects and Mitigation* (pp. 519–532). Boca Raton, FL: CRC Press.

Donmez, B., Boyle, L., & Lee, J. D. (2008b). Mitigating driver distraction with retrospective and concurrent feedback. *Accident Analysis & Prevention*, *40*(2), 776–786.

Donmez, B., Boyle, L. N., & Lee, J. D. (2007b). Safety implications of providing real-time feedback to distracted drivers. *Accident Analysis and Prevention*, *39*, 581–590.

Donmez, B., Boyle, L. N., Lee, J. D., & McGehee, D. V. (2006). Drivers' attitudes toward imperfect distraction mitigation strategies. *Transportation Research Part F*, *9*, 387–398.

Ehsani, J. P., Bingham, C. R., Lonides, E., & Childers, D. (2014). The impact of Michigan's text messaging restriction on motor vehicle crashes. *Journal of Adolescent Health*, *54*(5), 68–74.

Elliott, M. A., Armitage, C. J., & Baughan, C. J. (2003). Drivers' compliance with speed limits: An application of the Theory of Planned Behavior. *The Journal of Applied Psychology*, *88*(5), 964–972.

Farmer, C. M., Braitman, K. A., & Lund, A. K. (2010). Cell Phone Use While Driving and Attributable Crash Risk. *Traffic Injury Prevention*, *11*, 466–470.

Feng, J., Marulanda, S., & Donmez, B. (2014). Susceptibility to driver distraction questionnaire: Development and relation to relevant self-reported measures. Transportation Research Record, 2434, 26–34.

Ferguson, S. A. (2003). Other high-risk factors for young drivers—how graduated licensing does, doesn't, or could address them. *Journal of Safety Research*, *34*(1), 71–77. https://doi.org/10.1016/S0022-4375(02)00082-8

Festinger, L. (1954). A theory of social comparison processes. *Human Relations*, *7*, 117–140.

Fisher, D. L., Pollatsek, A., & Pradhan, A. (2006). Can novice drivers be trained to scan for information that will reduce their likelihood of a crash? *Injury Prevention*, *12*(Suppl 1), i25–i29.

Forward, S. E. (2009). The theory of planned behaviour: The role of descriptive norms and past behaviour in the prediction of drivers' intentions to violate. *Transportation Research Part F: Traffic Psychology and Behaviour*, *12*(3), 198–207.

Foss, R. D., & Goodwin, A. H. (2014). Distracted driver behaviors and distracting conditions among adolescent drivers: Findings from a naturalistic driving study. *Journal of Adolescent Health*, *54*, 50–60.

Gifford-Smith, M., Dodge, K. A., Dishion, T. J., & McCord, J. (2005). Peer influence in children and adolescents: crossing the bridge from developmental to intervention science. *Journal of Abnormal*

Child Psychology, *33*(3), 255–265.

Goodwin, A. H., O’Brien, N. P., & Foss, R. D. (2012). Effect of North Carolina’s restriction on teenage driver cell phone use two years after implementation. *Accident Analysis and Prevention*, *48*, 363–367.

Haines, M. P. (1996). *A social norms approach to preventing binge drinking at colleges and universities*. Newton, MA.

Haines, M. P., Barker, G. P., & Rice, R. (2003a). Using social norms to reduce alcohol and tobacco use in two midwestern high schools. In H. W. Perkins (Ed.), *The Social Norms Approach to Preventing School and College Age Substance Abuse: A Handbook for Educators, Counselors, and Clinicians* (1 edition, pp. 235–244). San Francisco: Jossey-Bass.

Haines, M. P., Barker, G., & Rice, R. (2003b). Using social norms to reduce alcohol and tobacco use in two midwestern high schools. In H. W. Perkins (Ed.), *The Social Norms Approach to Preventing School and College Age Substance Abuse: A Handbook for Educators, Counselors, and Clinicians* (1st ed., pp. 235–246). San Francisco: Jossey-Bass.

Haines, M. P., & Spear, S. F. (1996). Changing the perception of the norm: A strategy to decrease binge drinking among college students. *Journal of American College Health*, *45*, 134–140.

Harre, N., Foster, S., & O’Neil, M. (2005). Self-enhancement, crash-risk optimism and the impact of safety advertisements on young drivers. *British Journal of Psychology*, *96*(2), 215–230.

Hartos, J., Eitel, P., & Simons-Morton, B. G. (2002). Parenting practices and adolescent risky driving: a three-month prospective study. *Health Education & Behavior: The Official Publication of the Society for Public Health Education*, *29*(2), 194–206.

Hayward, J. C. (1972). Near miss determination through use of a scale of danger. *Highway Research Record*, *384*, 24–34. https://doi.org/TTSC 7115

Hill, L., Rybar, J., Styer, T., Fram, E., Merchant, G., & Eastman, A. (2015). Prevalence of and attitudes about distracted driving in college students. *Traffic Injury Prevention*, *16*(4), 362–367. https://doi.org/10.1080/15389588.2014.949340

Horberry, T., Anderson, J., Regan, M. A., Triggs, T. J., & Brown, J. (2006). Driver distraction: the effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. *Accident Analysis and Prevention*, *38*(1), 185–191.

Horrey, W. J., & Wickens, C. D. (2007). In-vehicle glance duration: distributions, tails, and model of crash risk. *Transportation Research Record*, *2018*(1), 22–28.

Jamieson, S. (2004). Likert scales: How to (ab)use them. Medical Education, 38, 1212–1218.

Jones, S. R., (1992), Was there a Hawthorne effect?. *American Journal of Sociology*, 98(3), 451-468.

Katila, A., Keskinen, E., Hatakka, M., & Laapotti, S. (2004). Does increased confidence among novice drivers imply a decrease in safety?: The effects of skid training on slippery road accidents. *Accident Analysis and Prevention*, *36*(4), 543–550.

Katz, D., & Allport, F. H. (1928). *Student attitudes: A report of the Syracuse University research study*. Syracuse, NY: Craftsman Press.

Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., & Ramsey, D. J. (2006). *The Impact of Driver Inattention on Near-crash/crash risk: an analysis using the 100-car naturalistic driving study data* (No. DOT Technical Report HS 810 594). Washington, D.C.

Klauer, S. G., Ehsani, J. P., McGehee, D. V., & Manser, M. (2015). The effect of secondary task engagement on adolescents' driving performance and crash risk. *Journal of Adolescent Health*, *57*, 36–43.

Klauer, S. G., Guo, F., Simons-Morton, B. G., Ouimet, M. C., Lee, S. E., & Dingus, T. A. (2014a). Distracted driving and risk of road crashed among novice and experienced drivers. *The New England Journal of Medicine*, *307*(1), 54–59. https://doi.org/10.1056/NEJMsa1204142

Klauer, S. G., Guo, F., Simons-Morton, B. G., Ouimet, M. C., Lee, S. E., & Dingus, T. A. (2014b). Distracted driving and risk of road crashes among novice and experienced drivers. *New England Journal of Medicine*, *370*(1), 54–59.

Korcuska, J. S., & Thombs, D. L. (2003). Gender role conflict and sex-specific drinking norms: Relationships to alcohol use in undergraduate women and men. *Journal of College Student Development*, *44*, 204–216.

Kwoon, O. H., Yoon, Y., & Jang, K. (2014). Evaluating the effectiveness of the law banning handheld cellphone use while driving. *Safety Science*, *70*, 50–57.

Lee, J. D. (2007). Technology and teen drivers. *Journal of Safety Research*, *38*(2), 203–213.

Lee, J. D. (2009). Can technology get your eyes back on the road? *Science*, *324*(5925), 344–346.

Lee, J. D., McGehee, D. V., Brown, T. L., & Reyes, M. L. (2002). Collision warning timing, driver distraction, and driver response to imminent rear-end collisions in a high-fidelity driving simulator. *Human Factors*, *44*(2), 314–334.

Lee, J. D., Moeckli, J., Brown, T., Roberts, S. C., Schwarz, C., Yekhshatyan, L., … Davis, C. (2013). *Distraction detection and mitigation through driver feedback*. Washington D.C.

Lee, J. D., & Strayer, D. L. (2004). Preface to the special section on driver distraction. *Human Factors*, *46*(4), 583–586.

Lerner, N., & Boyd, S. (2005). *On-road study of willingness to engage in distracting tasks*. Washington D.C. https://doi.org/DOT HS 811 547A

Lerner, N., & S.Boyd. (2005). *On-road study of willingness to engage in distracting tasks*. Washington D.C.

Lewis, M. A., & Neighbors, C. (2006). Social norms approaches using descriptive drinking norms education: A review of the research on personalized normative feedback. *Journal of American College Health*, *54*(4), 213–218.

Linkenbach, J., & Perkins, H. W. (2003a). Misperceptions of peer alcohol norms in a statewide survey of young adults. In H. W. Perkins (Ed.), *The Social Norms Approach To Preventing School and College Age Substance Abuse* (pp. 173–181). San Francisco: Jossey-Bass.

Linkenbach, J., & Perkins, H. W. (2003b). Most of us are tobacco free: An eight-month social norms campaign reducing youth initiation of smoking in Montana. In H. W. Perkins (Ed.) (1st ed., pp. 224–

234). San Francisco: Jossey-Bass.

Linkenbach, J., & Perkins, H. W. (2005). *Montana's MOST of Us® Don't Drink and drive campaign: A social norms strategy to reduce impaired driving among 21-to- 34 year-olds*. Washington D.C. https://doi.org/DOT HS 809 869

Madden, M., Lenhart, A., 2009. Teens and Distracted Driving: Texting, Talking andOther Uses of the Cell Phone Behind the Wheel. Pew Research Center, Washing-ton, D.C.

Martens, M. H. (2007). The danger of incorrect expectations in driving: the failure to respond. In *Proceedings of the Fourth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*. Washington.

McCartt, A. T., & Geary, L. L. (2004). Longer term effects of New York State's law on drivers' handheld cell phone use. *Injury Prevention*, *10*, 11–15.

McGehee, D. V., Raby, M., Carney, C., Lee, J. D., & Reyes, M. L. (2007). Extending parental mentoring using an event-triggered video intervention in rural teen drivers. *Journal of Safety Research*, *38*, 215–227.

Merrikhpour, M., & Donmez, B. (2017), Designing feedback to mitigate teen distracted driving: A social norms approach, Accident Analysis and Prevention, 104, 185-194.

Merrikhpour, M., & Donmez, B. (2016), Social norms and distractions among teenage drivers, In the Proceedings of the 2016 Canadian Association of Road Safety Professionals Conference, Halifax, NS.

Miller, D. T., & McFarland, C. (1991). When social comparison goes awry: The case of pluralistic ignorance. In J. Suls & A. Thomas (Eds.), *Social comparison: Contemporary theory and research* (pp. 287–313). Hillsdale, England: Lawrence Erlbaum Associates, Inc.

National Highway Traffic Safety Administration. (2016a). *Distracted driving 2014*. Washington D.C. https://doi.org/DOT HS 812 260

National Highway Traffic Safety Administration. (2016b). *Young drivers*. Washington D.C. Retrieved from https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812278

National Highway Traffic Safety Administration. (2017). *Traffic Safety Facts 2015 Data*. Washington D.C. https://doi.org/DOT HS 812 409

Neighbors, C., Rodriguez, L. M., Rinker, D., Gonzales, R. G., Agana, M., Tackett, J. L., & Foster, D. W. (2015). Efficacy of personalized normative feedback as a brief intervention for college student gambling: A randomized controlled trial. *Journal of Consulting and Clinical Psychology*, *83*, 500–511.

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw-Hill.

Olsen, E.O., Shults, R.A., Eaton, D.K., (2013). Texting while driving and other risky motorvehicle behaviors among US high school students. Pediatrics, 131, e1708–e1715.

Paris, H., & Den Broucke, S. V. (2008). Measuring cognitive determinants of speeding: An application of the theory of planned behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour*, *11*(3), 168–180.

Parker, D., & Manstead, A. S. (1992). Intention to commit driving violations: An application of the theory of planned behavior. *Journal of Applied Psychology*, *77*(1), 94–101.

Perkins, H. W., & Berkowitz, A. D. (1986). Perceiving the community norms of alcohol use among students: Some research implications for campus alcohol education programming. *The International Journal of the Addictions*, *21*(9–10), 961–976.

Perkins, H. W., & Craig, D. W. (2006). A successful social norms campaign to reduce alcohol misuse among college student-athletes. *Journal of Studies on Alcohol*, *67*(6), 880–889.

Perkins, H. W., Linkenbach, J., Lewis, M. A., & Neighbors, C. (2010). Effectiveness of social norms media marketing in reducing drinking and driving: a statewide campaign. *Addictive Behaviors*, *35*(10), 866–874.

Perkins, H. W., Meilman, P. W., Leichliter, J. A., Cashin, J. R., & Presley, C. A. (1999). Misperceptions of the norms for the frequency of alcohol and other drug use on college campuses. *Journal of American College Health*, *47*, 253–258.

Prentice, D. A., & Miller, D. T. (1993). Pluralistic ignorance and alcohol use on campus: Some consequences of misperceiving the social norm. *Journal of Personality and Social Psychology*, *64*(2), 243–256.

Road Safety Canada Consulting. (2011). *Road safety in Canada*.

Roberts, S. C., Ghazizadeh, M., & Lee, J. D. (2012). Warn me now or inform me later: Drivers' acceptance of real-time and post-drive distraction mitigation systems. *International Journal of Human-Computer Studies*, *70*(12), 967–979.

SAE. (2015). *Operational definitions of driving performance measures and statistics: SAE J 2944*. Retrieved from http://standards.sae.org/j2944_201506/

Scherer, D. G., Brody, J. L., Annett, R. D., Hetter, J., Roberts, L. W., & Cofrin, K. M. W. (2005). Financial compensation to adolescents for participation in biomedical research: Adolescent and parent perspectives in seven studies. *The Journal of Pediatrics*, *146*(4), 552–558.

Schroeder, C. M., & Prentice, D. A. (1998). Exposing pluralistic ignorance to reduce alcohol use among college students. *Journal of Applied Social Psychology*, *28*(23), 2150–2180.

Shinar, D., Meir, M., & Ben-Shoham, I. (1998). How automatic is manual gear shifting? *Human Factors*, *40*(4), 647–654.

Shope, J. T., & Bingham, C. R. (2008). Teen Driving: Motor-Vehicle Crashes and Factors That Contribute. *American Journal of Preventive Medicine*, *35*(3, Supplement), S261–S271. https://doi.org/10.1016/j.amepre.2008.06.022

Simons-Morton, B. G., Bingham, C. R., Falk, E. B., Li, K., Pradhan, A. K., Ouimet, M. C., … Shope, J. T. (2014). Experimental Effects of Injunctive Norms on Simulated Risky Driving Among Teenage Males. *Health Psychology*, *33*(7), 616–627. https://doi.org/http://dx.doi.org.myaccess.library.utoronto.ca/10.1037/a0034837

Simons-Morton, B. G., Klauer, S. G., Ouimet, M. C., Guo, F., Albert, P. S., Lee, S. E., … Dingus, T. A. (2015). Naturalistic Teenage Driving Study: Findings and Lessons Learned. *Journal of Safety Research*, *54*, 41–48.

Simons-Morton, B. G., Ouimet, M. C., Zhang, Z., Klauer, S. G., Lee, S. E., Wang, J., … Dingus, T. A. (2011). The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. *Journal of Adolescent Health, 49*, 587–593.

Sivak, M. (1996). The information that drivers use: is it indeed 90% visual? *Perception, 25*(9), 1081–1089.

Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental Review*, *28*, 78–106.

Taubman - Ben-Ari, O., & Katz - Ben-Ami, L. (2012). The contribution of family climate for road safety and social environment to the reported driving behavior of young drivers. *Accident Analysis and Prevention*, *47*, 1–10. https://doi.org/10.1016/j.aap.2012.01.003

Taubman - Ben-Ari, O., Mikulincer, M., & Gillath, O. (2005). From parents to children—similarity in parents and offspring driving styles. *Transportation Research Part F*, *8,* 19–29.

Van Der Laan, J. D., Heino, A., & De Waard, D. (1997). A simple procedure for the assessment of acceptance of advanced transport telematics. *Transportation Research Part C: Emerging Technologies*, *5*(1), 1–10.

Vanlaar, W., Mayhew, D., Marcoux, K., Wets, G., Brijs, T., & Shope, J. (2009). An evaluation of graduated driver licensing programs in North America using a meta-analytic approach. *Accident Analysis and Prevention, 41*(5), 1104–1111.

Victor, T., Dozza, M., Bargman, J., Boda, C. N., Engström, J., Flannagan, C., & Markkula, G. (2015). *Analysis of naturalistic driving study data: Safer glances, driver inattention, and crash risk*. Washington D.C. https://doi.org/No. SHRP 2 Report S2-S08A-RW-1

Walters, S. T., Bennett, M. E., & Miller, J. E. (2000). Reducing alcohol use in college students: A controlled trial of two brief interventions. *Journal of Drug Education*, *30*(3), 361–372.

White, K. M., Hyde, M. K., Walsh, S. P., & Watson, B. (2010). Mobile phone use while driving: An investigation of the beliefs influencing drivers' hands-free and hand-held mobile phone use. *Transportation Research Part F, 13,* 9–20.

Williams, A. F. (2003a). Graduated licensing in the United States. *ITE Journal*, *73*(9), 28–30.

Williams, A. F. (2003b). Teenage drivers: Patterns of risk. *Journal of Safety Research*, *34*(1), 5–15.

Wilson, F.A., Stimpson, J.P., (2010). Trends in driver fatalities from distracted drivingin the United States, 1999 to 2008. *American Journal of Public Health*, 100, 2213–2219.

Winter, J., Dodou, D., (2010). Five-Point Likert Items: t test versus Mann-Whitney-Wilcoxon, *Journal of Practical Assessment, Research & Evaluation, 15(11).*

Zhou, R., Wu, C., Rau, P. P., & Zhang, W. (2009). Young driving learners' intention to use a handheld or hands-free mobile phone when driving. *Transportation Research Part F*, *12*, 208–217.

Appendices

A) Survey

Teen Driver Study

Participant Information

4. How often do you drive a motor vehicle? *

- Almost every day
- A few times a week
- A few times a month
- A few times a year
- I have not driven a motor vehicle in the past year

5. Over the last year, how many kilometers did you drive? *

- Under 5,000 km
- Between 5,001 km and 15,000 km
- Between 15,001 km and 25,000 km
- Between 25,001 km and 35,000 km
- Between 35,001 km and 45,000 km
- Over 45,001km
- None
- I don't know

6. What percentage of your driving time is spent driving in urban, city environment? *

- 0 – 20%
- 21 – 40%
- 41 – 60%
- 61 – 80%
- 81 – 100%

7. What percentage of your driving time is spent in rural or suburban town environment? *

- 0 – 20%
- 21 – 40%
- 41 – 60%
- 61 – 80%
- 81 – 100%

8. Does your mother (or primary female caregiver) drive? *

- Yes
- No

9. Does your father (or primary male caregiver) drive? *

- Yes
- No

Technology Experience

10. 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, navigation systems, ATMs, digital cameras, computers, etc.)? *

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

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

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

12. How familiar are you with the following devices and functions?

	Very unfamiliar	Somewhat unfamiliar	Somewhat familiar	Familiar	Very familiar	Don't use the technology
Your cell phone and its functions/capabilities	○	◉	○	○	○	○
Keying a text message on your cell phone	○	◉	○	○	○	○
Navigation system that is mounted inside your vehicle and its functions/capabilities	○	◉	○	○	○	○
Keying a destination in a navigation system that is mounted inside your vehicle	○	◉	○	○	○	○

Driving Behaviour

In the following section we ask you to answer questions in the context of the scenario depicted below, a two-lane rural road where traffic conditions are low and there is good weather. When answering the following questions, please think about your experiences over the last year while driving in environments similar to the one illustrated below.

Please answer according to your actual experience rather than what you think your experience should be.

On average how often you think you, your parents, and friends your age have engaged in each of the following tasks **over the last year** while driving in an environment similar to the image above?

13. Talk on a hand-held cell phone while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

14. Talk on the phone using a hands-free device (e.g., Bluetooth headset)

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

15. Read a text message on a hand-held device (e.g., cell phone) while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

16. Respond to a text message on a hand-held device (e.g., cell phone) while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

17. Have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone) while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

18. Read email on a hand-held device (e.g., cell phone) while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

19. Manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

20. Manually enter an address on a built-in or mounted navigational system while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

21. Update or check social media such as Facebook, Twitter, or Instagram while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

22. Play digital games such as Angry Birds, Farmville, or Words with Friends while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

23. Watch online videos while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

24. Chat with passengers if there are any while driving

	Never	Rarely	Sometimes	Often	Very Often
You	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○
Friends your age	○	○	○	○	○

25. Eat something messy like a taco while driving

	Never	Rarely	Sometimes	Often	Very Often
You	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○
Friends your age	○	○	○	○	○

26. Drink a hot beverage while driving

	Never	Rarely	Sometimes	Often	Very Often
You	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○
Friends your age	○	○	○	○	○

27. Read extended text such as a magazine, an e-book, or the web while driving

	Never	Rarely	Sometimes	Often	Very Often	Don't/ Doesn't use the technology
You	○	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

28. Groom (e.g., comb hair, apply makeup, floss teeth) while driving

	Never	Rarely	Sometimes	Often	Very Often
You	○	○	○	○	○
Your Mother (or primary female caregiver)	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○
Friends your age	○	○	○	○	○

On average how much would your parents and friends your age approve or disapprove if you engage in each of the following tasks while driving in an environment similar to the image above?

29. Talk on a hand-held cell phone while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

30. Talk on the phone using a hands-free device (e.g., Bluetooth headset) while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

31. Read a text message on a hand-held device (e.g., cell phone) while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

32. Respond to a text message on a hand-held device (e.g., cell phone) while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

33. Have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone) while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

34. Read email on a hand-held device (e.g., cell phone) while driving

	Strongly Disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

35. Manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

36. Manually enter an address on a built-in or mounted navigational system while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

37. Update or check social media such as Facebook, Twitter, or Instagram while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

38. Play digital games such as Angry Birds, Farmville, or Words with Friends while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

39. Watch online videos while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

40. Read extended text such as a magazine, an e-book, or the web while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○	○

41. Chat with passengers if there are any while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

42. Eat something messy like a taco while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

43. Drink a hot beverage while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

44. Groom (e.g., comb hair, apply makeup, floss teeth) while driving

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	Not applicable
Your Mother (or primary female caregiver)	○	○	○	○	○	○
Your Father (or primary male caregiver)	○	○	○	○	○	○
Friends your age	○	○	○	○	○	○

Risk Perception

45. How risky would you find the following tasks while driving in an environment similar to the image above? Please check a number on a scale of 1 to 10 that best describes your opinion.

1 2 3 4 5 6 7 8 9 10

1= "no additional risk beyond my normal driving", 5= "an average driving situation", and 10= "very likely I would be involved in an accident". *

	1	2	3	4	5	6	7	8	9	10
Talk on a hand-held cell phone	○	○	○	○	○	○	○	○	○	○
Talk on the phone using a hands-free device (e.g., Bluetooth headset)	○	○	○	○	○	○	○	○	○	○
Read a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Respond to a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Read emails on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle	○	○	○	○	○	○	○	○	○	○
Manually enter an address on a built-in or mounted navigational system	○	○	○	○	○	○	○	○	○	○
Adjust the audio system using controls on the console	○	○	○	○	○	○	○	○	○	○
Update or check social media such as Facebook, Twitter, or Instagram	○	○	○	○	○	○	○	○	○	○
Play digital games such as Angry Birds, Farmville, or Words with Friends	○	○	○	○	○	○	○	○	○	○
Watch online videos	○	○	○	○	○	○	○	○	○	○
Read extended text such as a book, magazine, an e-book, or the web	○	○	○	○	○	○	○	○	○	○
Chat with passengers if there are any	○	○	○	○	○	○	○	○	○	○
Eat something messy like a taco	○	○	○	○	○	○	○	○	○	○
Drink a hot beverage	○	○	○	○	○	○	○	○	○	○
Groom (e.g., comb hair, apply makeup, floss teeth)	○	○	○	○	○	○	○	○	○	○

When answering the following questions, please consider an environment similar to the one illustrated below.

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

bad 1 2 3 4 5 6 7 good

1 would correspond to "bad", 4 would correspond to "neither bad nor good", and 7 would correspond to "good"

46. For me, talking on a hand-held cell phone while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

47. For me, talking on a hands-free cell phone while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

48. For me, reading a text message on a hand-held device (e.g., cell phone) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

49. For me, responding to a text message on a hand-held device (e.g., cell phone) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

50. For me, having a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

51. For me, reading email on a hand-held device (e.g., cell phone) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

52. For me, reading extended text such as a book, a magazine, an e-book, or the web while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

53. For me, manually entering an address into a navigation app on a smartphone that is NOT mounted inside the vehicle while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

54. For me, adjusting the audio system using controls on the console while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

55. For me, updating or checking social media such as Facebook, Twitter, or Instagram while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

56. For me, playing digital games such as Angry Birds, Farmville, or Words with Friends while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

57. For me, watching online videos while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

58. For me, chatting with passengers while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

59. For me, eating something messy like a taco while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

60. For me, drinking a hot beverage while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

61. For me, to groom (e.g., comb hair, apply makeup, floss teeth) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

When answering the following questions, please consider an environment similar to the one illustrated below.

For the following question, please indicate to what extent you agree or disagree with each statement.

62. While driving, I have no difficulty to... *

	Strongly disagree	Disagree	Neutral	Agree	Strongly ag
talk on a hand-held cell phone	○	○	○	○	○
talk on the phone using a hands-free device (e.g., Bluetooth headset)	○	○	○	○	○
read a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○
respond to a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○
have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)	○	○	○	○	○
read email on a hand-held device (e.g., cell phone)	○	○	○	○	○
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle	○	○	○	○	○
manually enter an address on a built-in or mounted navigational system	○	○	○	○	○
adjust the audio system using controls on the console	○	○	○	○	○
update or check social media such as Facebook, Twitter, or Instagram	○	○	○	○	○
play digital games such as Angry Birds, Farmville, or Words with Friends	○	○	○	○	○
watch online videos	○	○	○	○	○
read extended text such as a book, magazine, an e-book, or the web	○	○	○	○	○
chat with passengers if there are any	○	○	○	○	○
eat something messy like a taco	○	○	○	○	○
drink a hot beverage	○	○	○	○	○
groom (e.g., comb hair, apply makeup, floss teeth)	○	○	○	○	○

63. I have complete control over whether I drive and ... *

	I don't use the technology	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
talk on a hand-held cell phone	○	○	○	○	○	○
talk on the phone using a hands-free device (e.g., Bluetooth headset)	○	○	○	○	○	○
read a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
respond to a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
read email on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle	○	○	○	○	○	○
manually enter an address on a built-in or mounted navigational system	○	○	○	○	○	○
adjust the audio system using controls on the console	○	○	○	○	○	○
update or check social media such as Facebook, Twitter, or Instagram	○	○	○	○	○	○
play digital games such as Angry Birds, Farmville, or Words with Friends	○	○	○	○	○	○
watch online videos	○	○	○	○	○	○
read extended text such as a book, magazine, an e-book, or the web	○	○	○	○	○	○

64. I have complete control over whether I drive and ... *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
chat with passengers if there are any	○	○	○	○	○
eat something messy like a taco	○	○	○	○	○
drink a hot beverage	○	○	○	○	○
groom (e.g., comb hair, apply makeup, floss teeth)	○	○	○	○	○

65. I change my engagement in each of these tasks when my parent(s) is with me in the car. Please answer according to your actual behaviour rather than what you think your behaviour should be. *

	I don't use the technology	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Talk on a hand-held cell phone	○	○	○	○	○	○
Talk on the phone using a hands-free device (e.g., Bluetooth headset)	○	○	○	○	○	○
Read a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
Respond to a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
Have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
Read email on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
Manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle	○	○	○	○	○	○
Manually enter an address on a built-in or mounted navigational system	○	○	○	○	○	○
Adjust the audio system using controls on the console	○	○	○	○	○	○
Update or check social media such as Facebook, Twitter, or Instagram	○	○	○	○	○	○
Play digital games such as Angry Birds, Farmville, or Words with Friends	○	○	○	○	○	○
Watch online videos	○	○	○	○	○	○
Read extended text such as a book, magazine, an e-book, or the web	○	○	○	○	○	○

66. I change my engagement in each of these tasks when my parent(s) is with me in the car. Please answer according to your actual behaviour rather than what you think your behaviour should be. *

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Chat with passengers if there are any	○	○	○	○	○
Eat something messy like a taco	○	○	○	○	○
Drink a hot beverage	○	○	○	○	○
Groom (e.g., comb hair, apply makeup, floss teeth)	○	○	○	○	○

Appendix B- Screening Questionnaire

You are invited to participate in a driving simulator experiment about distracted driving behaviour among teen drivers (17-19 years). You will be asked to complete questionnaires **and/or** drive a driving simulator. The driving simulator is located in the Human Factors and Applied Statistics Laboratory (HFASt) at the University of Toronto St. George campus. Throughout the experiment, user input via the steering wheel and pedals as well as eye movement patterns of the participant will be recorded. All data obtained are for research purpose only, and will remain completely confidential.

If you wish to continue please answer the following series of questions to verify your eligibility for the experiment. If you meet the requirements, we will get back to you asap to schedule a session. In case you have any questions or concerns about the experiment, please contact us at teendriverstudy.hfast@gmail.com.

1. Which of the following best describes you? *

- I am parent/caregiver of a teen driver.
- I am a teen driver.
- Other

2. What is your first name? *

[ ]

3. What is your last name? *

[ ]

4. What is your gender? *

- ○ Male
- ○ Female
- ○ Other

5. What is your age? *

[ ]

6. What is your e-mail address? *

[ ]

7. What is your phone number?

[ ]

8. Choose your preferred method of contact: *

- ○ E-mail
- ○ Phone
- ○ Either

9. Do you currently hold a valid government issued driver's license? *

- ○ Yes
- ○ No

10. What are your current driver's licenses (select as many as apply)? *

- ☐ G1
- ☐ G2
- ☐ G
- ☐ Other (please specify) ________

---

11. Which year did you get your G1?

____

---

12. Which year did you get your G2?

____

---

13. Which year did you get your G?

____

---

14. Do any of your primary caregivers (e.g., parents) drive? *

- ○ Only one of them (please specify their relationship with you, e.g., mother, father, step father, etc.) ________
- ○ Both of them (please specify their relationship with you) ________
- ○ None of them ________

---

15. As a participant in this study, would you be willing to fill out an online questionnaire? *

- ○ Yes
- ○ No
- ○ Undecided ________

16. As a participant in this study, would you be willing to participate in the driving simulator experiment? *

- Yes
- No
- Undecided

We are looking for participants whose one of their primary caregivers is also willing to participate in our experiment by filling out an online questionnaire. The parent who accompanies teen participant should also have a valid driver's license. They will also have a chance to win an iPad mini/Starbucks gift card.

19. As a participant, are any of your primary caregivers interested in filling out an online questionnaire? *

- Yes, both of my primary caregivers are interested.
- Yes, one of my primary caregivers is interested.
- No
- Undecided

21. Please provide their name, email address, and phone number so we can contact them.

Primary caregiver 1: First Name

Last Name

Relation to You

E-mail Address

Phone Number

Primary caregiver 2: First Name

Last Name:

Relation to You

E-mail Address

Phone Number

22. Which of the following best describes you? *

- I live with both of my primary caregivers.
- I live with one of my primary caregivers.
- I don't live with my primary caregivers.
- I live alone.
- Other (please specify)

23. How did you obtain driver education (select as many as apply)? *

- Driving school
- Private instructor
- Primary caregiver
- Other (please specify)

24. How often do you drive a motor vehicle? *

- Almost every day
- A few times a week
- A few times a month
- A few times a year
- I have not driven a motor vehicle in the past year

25. In which areas do you drive more often (select as many as apply)? *

- Urban, city environment
- Rural or suburban town environment
- Highways or high-speed expressways

26. Over the last year, how many kilometers did you drive? *

- Under 5,000 km
- Between 5,001 km and 15,000 km
- Between 15,001 km and 25,000 km
- Between 25,001 km and 35,000 km
- Between 35,001 km and 45,000 km
- Over 45,001km
- None
- I don't know

---

27. What percentage of your driving time is spent driving in urban, city environment? *

- 0 - 20%
- 21 - 40%
- 41 - 60%
- 61 - 80%
- 81 - 100%

---

28. What percentage of your driving time is spent in rural or suburban town environment? *

- 0 - 20%
- 21 - 40%
- 41 - 60%
- 61 - 80%
- 81 - 100%

---

29. Do you need to wear glasses for driving? *

- Yes
- No

---

30. Do you need to wear glasses for reading? *

- Yes
- No

31. If you wear glasses for driving, can you wear contact lenses for the experiment? This will help us to track your eye glances during the experiment. *

- Yes
- No

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.

32. Have you ever driven in a driving simulator? *

- No, never
- Once or twice
- Multiple times
- Regularly

34. If you have used a driving simulator before, did you ever experience simulator sickness? *

- Yes
- No

36. Do you frequently experience migraine headaches? *

- Yes
- No

38. Do you experience motion sickness? *

- Yes
- No

40. Do you experience claustrophobia? *

- Yes
- No

42. Are you pregnant?

- Yes
- No

Appendix C- Consent form

Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

Human Factors & Applied Statistics

Participant Consent Form

Title: Designing Feedback to reduce Teens' Distracted Driving Behaviour

Investigators:

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 in or withdraw from 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 looks at how different types of safety systems might influence teens' engagement with distracting tasks while driving. The goal is to investigate the effect of different types of feedback on driving behaviour, and as a participant you will be asked to:

Drive through a simulated rural environment

Fill out a series of questionnaires before and after the experimental trials

Procedure

This study contains three phases. In the first phase, you will fill out a questionnaire in order to provide your demographic information, and some information on your driving behaviour as well as what you think about the driving behaviour of your teen. You will then be introduced to the simulator, and have time to test it and become comfortable driving with it. In the second phase, you will drive through the scenarios of the experiment. 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. There will be five driving scenarios of about 7 minutes each, with breaks in between. In the final phase, you will fill out an exit questionnaire.

Risks

There are no major risks involved with this experiment, the tasks are not physiologically demanding, or psychologically stressing. 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 if you are interested in driving simulators you will be able to use and test out a state of the art driving simulator where you will have the opportunity to safely experience situations that are relevant to real-life distracted driving. Last, we hope that you will personally benefit from the driving feedback during/after the drives, through which you may become more aware of your own distracted driving behaviour.

Compensation

In appreciation of the time you have given to this study, you will receive $20 for your participation plus a bonus up to $5 based on the number of completed secondary tasks during the simulator study. Further, you have the chance of winning an iPad mini.

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 be identifiable only 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 three web-cameras. One camera will be pointed at you, one will capture the steering wheel, and the final camera the overall scene. We will use two other cameras on and near the dashboard to track and record where you are looking during the experiment. The videos will be seen only 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.

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 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

Appendix D – Advanced Transport Telematics Acceptance Assessment Questionnaire (Van Der Laan et al., 1997).

Please indicate your opinion about the safety system (i.e., your driving report or real time auditory warning) you experienced in the past drives. Answer each of the following questions by checking the number that best describes your opinion. For example, if you were asked to rate "The Weather in Toronto" on the following scale,

Bad 1 2 3 4 5 Good

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

ID: 8

129. I thought the safety system I just used was: *

	1	2	3	4	5	
Useful	○	○	○	○	○	Useless
Pleasant	○	○	○	○	○	UnPleasant
Bad	○	○	○	○	○	Good
Nice	○	○	○	○	○	Annoying
Effective	○	○	○	○	○	Superfluous
Irritating	○	○	○	○	○	Likeable
Assisting	○	○	○	○	○	Worthless
Undesirable	○	○	○	○	○	Desirable
Raising alertness	○	○	○	○	○	Sleep-inducing

Appendix E – Experiment II, Pre-experiment Questionnaire

4. How often do you drive a motor vehicle? *

- Almost every day
- A few times a week
- A few times a month
- A few times a year
- I have not driven a motor vehicle in the past year

5. Over the last year, how many kilometers did you drive? *

- Under 5,000 km
- Between 5,001 km and 15,000 km
- Between 15,001 km and 25,000 km
- Between 25,001 km and 35,000 km
- Between 35,001 km and 45,000 km
- Over 45,001km
- None
- I don't know

6. What percentage of your driving time is spent driving in urban, city environment? *

- 0 – 20%
- 21 – 40%
- 41 – 60%
- 61 – 80%
- 81 – 100%

7. What percentage of your driving time is spent in rural or suburban town environment? *

- 0 – 20%
- 21 – 40%
- 41 – 60%
- 61 – 80%
- 81 – 100%

8. 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, navigation systems, ATMs, digital cameras, computers, etc.)? *

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

ID:

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

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

ID:

10. How familiar are you with the following devices and functions? *

	Very unfamiliar	Somewhat unfamiliar	Somewhat familiar	Familiar	Very familiar	Don't use the technology
Your cell phone and its functions/capabilities	○	○	○	○	○	○
Keying a text message on your cell phone	○	○	○	○	○	○
Navigation system built in/mounted on the inside of your vehicle and its functions/capabilities	○	○	○	○	○	○
Keying a destination into a navigation system built in/mounted on the inside of your vehicle	○	○	○	○	○	○

In the following section we ask you to answer questions in the context of the scenario depicted below, a two-lane rural road where traffic conditions are low and there is good weather.
Please answer according to your actual experiences rather than what you think your experience should be.

ID

On average how often do you think you and teens your age have engaged in each of the following tasks over the last year while driving in an environment similar to the image above?

12. Talk on the phone using a hands-free device (e.g., Bluetooth headset) *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

13. Read a text message on a hand-held device (e.g., cell phone) while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

14. Respond to a text message on a hand-held device (e.g., cell phone) while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

15. Have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone) while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

16. Read email on a hand-held device (e.g., cell phone) while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

17. Manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

18. Manually enter an address on a built-in or mounted navigational system while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

19. Adjust the audio system using controls on the console *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

20. Update or check social media such as Facebook, Twitter, or Instagram while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

21. Play digital games such as Angry Birds, Candy Crush, etc. while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

22. Watch online videos while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

23. Read extended text such as a magazine, an e-book, or the web while driving *

	Never	Rarely	Sometimes	Often	Very Often	Don't use the technology
You						
Male teens your age						
Female teens your age						

24. Chat with passengers if there are any while driving *

	Never	Rarely	Sometimes	Often	Very Often
You					
Male teens your age					
Female teens your age					

25. Eat something messy like a taco while driving *

	Never	Rarely	Sometimes	Often	Very Often
You					
Male teens your age					
Female teens your age					

26. Drink a hot beverage while driving *

	Never	Rarely	Sometimes	Often	Very Often
You					
Male teens your age					
Female teens your age					

27. Groom (e.g., comb hair, apply makeup, floss teeth) while driving *

	Never	Rarely	Sometimes	Often	Very Often
You					
Male teens your age					
Female teens your age					

ID:

On average how much do you think would teens your age approve or disapprove if you engage in each of the following tasks while driving in an environment similar to the image above?

28. Talk on a hand-held cell phone while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

29. Talk on the phone using a hands-free device (e.g., Bluetooth headset) while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

30. Read a text message on a hand-held device (e.g., cell phone) while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

31. Respond to a text message on a hand-held device (e.g., cell phone) while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

32. Have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone) while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

33. Read email on a hand-held device (e.g., cell phone) while driving *

	Strongly Disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

34. Manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

35. Manually enter an address on a built-in or mounted navigational system while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

36. Adjust the audio system using controls on the console *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

37. Update or check social media such as Facebook, Twitter, or Instagram while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age	○	○	○	○	○	○
Female teens your age	○	○	○	○	○	○

38. Play digital games such as Angry Birds, Candy Crush, etc. while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age						
Female teens your age						

39. Watch online videos while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age						
Female teens your age						

40. Read extended text such as a magazine, an e-book, or the web while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve	I don't use the technology
Male teens your age						
Female teens your age						

41. Chat with passengers if there are any while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve
Male teens your age					
Female teens your age					

42. Eat something messy like a taco while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve
Male teens your age					
Female teens your age					

43. Drink a hot beverage while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve
Male teens your age					
Female teens your age					

44. Groom (e.g., comb hair, apply makeup, floss teeth) while driving *

	Strongly disapprove	Disapprove	Neutral	Approve	Strongly approve
Male teens your age	○	○	○	○	○
Female teens your age	○	○	○	○	○

45. How risky would you find the following tasks while driving in an environment similar to the image above? Please check a number on a scale of 1 to 10 that best describes your opinion.

1= "no additional risk beyond my normal driving"
5= "an average driving situation"
10= "very likely I would be involved in an accident" *

	1	2	3	4	5	6	7	8	9	10
Talk on a hand-held cell phone	○	○	○	○	○	○	○	○	○	○
Talk on the phone using a hands-free device (e.g., Bluetooth headset)	○	○	○	○	○	○	○	○	○	○
Read a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Respond to a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Read emails on a hand-held device (e.g., cell phone)	○	○	○	○	○	○	○	○	○	○
Manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle	○	○	○	○	○	○	○	○	○	○
Manually enter an address on a built-in or mounted navigational system	○	○	○	○	○	○	○	○	○	○
Adjust the audio system using controls on the console	○	○	○	○	○	○	○	○	○	○
Update or check social media such as Facebook, Twitter, or Instagram	○	○	○	○	○	○	○	○	○	○
Play digital games such as Angry Birds, Candy Crush, etc.	○	○	○	○	○	○	○	○	○	○
Watch online videos	○	○	○	○	○	○	○	○	○	○
Read extended text such as a book, magazine, an e-book, or the web	○	○	○	○	○	○	○	○	○	○
Chat with passengers if there are any	○	○	○	○	○	○	○	○	○	○
Eat something messy like a taco	○	○	○	○	○	○	○	○	○	○
Drink a hot beverage	○	○	○	○	○	○	○	○	○	○
Groom (e.g., comb hair, apply makeup, floss teeth)	○	○	○	○	○	○	○	○	○	○

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

bad 1 2 3 4 5 6 7 good

1 would correspond to "bad", 4 would correspond to "neither bad nor good", and 7 would correspond to "good"

49. For me, talking on a hand-held cell phone while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

50. For me, talking on a hands-free cell phone while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

51. For me, reading a text message on a hand-held device (e.g., cell phone) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

52. For me, responding to a text message on a hand-held device (e.g., cell phone) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

53. For me, having a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

69. For me, playing digital games such as Angry Birds, Candy Crush, etc. while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

70. For me, watching online videos while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

71. For me, reading extended text such as a book, a magazine, an e-book, or the web while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

72. For me, chatting with passengers while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

73. For me, eating something messy like a taco while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

74. For me, drinking a hot beverage while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

75. For me, grooming (e.g., comb hair, apply makeup, floss teeth) while driving is: *

	1	2	3	4	5	6	7	
Pleasant	○	○	○	○	○	○	○	Unpleasant
Bad	○	○	○	○	○	○	○	Good
Wise	○	○	○	○	○	○	○	Unwise

For the following question, please indicate to what extent you agree or disagree with each statement.

83. While driving, I am able to, without difficulty *

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
talk on a hand-held cell phone	○	○	○	○	○
talk on the phone using a hands-free device (e.g., Bluetooth headset)	○	○	○	○	○
read a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○
respond to a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○
have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)	○	○	○	○	○
read email on a hand-held device (e.g., cell phone)	○	○	○	○	○
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle	○	○	○	○	○
manually enter an address on a built-in or mounted navigational system	○	○	○	○	○
adjust the audio system using controls on the console	○	○	○	○	○
update or check social media such as Facebook, Twitter, or Instagram	○	○	○	○	○
play digital games such as Angry Birds, Candy Crush, etc.	○	○	○	○	○
watch online videos	○	○	○	○	○
read extended text such as a book, magazine, an e-book, or the web	○	○	○	○	○
chat with passengers if there are any	○	○	○	○	○
eat something messy like a taco	○	○	○	○	○
drink a hot beverage	○	○	○	○	○
groom (e.g., comb hair, apply makeup, floss teeth)	○	○	○	○	○

84. I have complete control over whether I drive and ... *

	I don't use the technology	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
talk on a hand-held cell phone	○	○	○	○	○	○
talk on the phone using a hands-free device (e.g., Bluetooth headset)	○	○	○	○	○	○
read a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
respond to a text message on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
have a text message conversation involving several texts in a row on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
read email on a hand-held device (e.g., cell phone)	○	○	○	○	○	○
manually enter an address into a navigation app on a smartphone that is NOT mounted inside the vehicle	○	○	○	○	○	○
manually enter an address on a built-in or mounted navigational system	○	○	○	○	○	○
adjust the audio system using controls on the console	○	○	○	○	○	○
update or check social media such as Facebook, Twitter, or Instagram	○	○	○	○	○	○
play digital games such as Angry Birds, Candy Crush, etc.	○	○	○	○	○	○
watch online videos	○	○	○	○	○	○
read extended text such as a book, magazine, an e-book, or the web	○	○	○	○	○	○

85. I have complete control over whether I drive and ... *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
chat with passengers if there are any	○	○	○	○	○
eat something messy like a taco	○	○	○	○	○
drink a hot beverage	○	○	○	○	○
groom (e.g., comb hair, apply makeup, floss teeth)	○	○	○	○	○