Longitudinal Study of the Effect of Simulator Experience on the Behavior Modification of Adult Drivers

Principal Investigator (PI) Name, Title and Contact Information:

PI: Sharad K. Maheshwari, Professor
Business Administration, School of Business
Hampton University
Hampton,, VA 23668
Sharad.maheshwari@hamptonu.edu, (757)727-5605

Co-PI: Kelwyn A. D'Souza
Dept. of Management, School of Business
Hampton University
Hampton,, VA 23668
Kelwyn.dsouza@hamptonu.edu, (757)727-5037

conducted for

NCITEC

August 2016

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ABSTRACT

Cell-phone and other hand-held electronic devices use has been increasing in society. The past research studies show that a vast majority of young and adult drivers are using cell phones while driving. Adult drivers are increasingly using more electronic devices while driving including "Texting While Driving,' despite many state and locality banning/restricting such practices. This activity causes distraction from the basic task of driving and results in hundreds of thousands of accidents including thousands of fatalities. Many governmental and non-governmental agencies are making educational efforts to teach drivers of danger of distraction caused by cell phone use while driving. Previous research conducted by same team shows that simulator based education positively impacted the risk perception of adult drivers towards danger of "cell phone usage in driving." However, in that study there was no time gap between education and assessment of drivers' perception of risk (Maheshwari, 2016).

This research assesses the long-term impact of the issues in educational efforts. Main objective of the research was to measure long-term change in the risk perception of adult drivers. Previous field experiment extended to 93 subjects of the previous study. Post education survey was administered again on these previous subjects. The results were used to assess in change in the risk perception over time. There was 24-26 months time difference between both studies. Only 30 previous subjects were available to answer the survey.

The results show that improvements in the drivers' perception of safety remain statistically high after two plus years of the driving simulator experience. However, this improvement in the safety perception was less than recoded right after the simulator experience. The sample was very small (27 valid responses) to conduct other statistical tests for demographic, risk and other environmental factors. It should also be acknowledged that this study did not have control group hence internal validity of the results was weak due to history, maturation, etc. Selection bias may have also influenced the outcome.
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ACKNOWLEDGEMENTS

The authors thank the Hampton University's Presidential Scholars recipients for serving as Transportation Scholars for the duration of this project.

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INTRODUCTION

There are numerous research studies indicating texting while driving among adult drivers has increased multifold (for review see: Maheshwari, 2016). During 2013-2014, a research study was conducted in Hampton University to assess the impact of simulator education on adult drivers. In that work, a sample of 100 adult drivers was subjected to a simulator treatment to show them how texting impact driving judgment. Results show that drivers were generally not aware of texting-while-driving's impact on the quality of their driving. Significant majority of the drivers in the sample had indicated that they will control texting while driving in future. However, that was a cross-sectional study, which does not give any long-term impact of such treatment (Maheshwari, 2016). About two years later, same subjects were contacted again to assess the risk perception of texting-while-driving. This was to determine if the driving simulator experience had any long-term impact on safety perception of drivers.

LITERATURE REVIEW

For extensive literature review on the driver distraction due to texting while driving refer to previous study under the same project (Maheshwari, 2016). A small portion of the related literature review is included here. A few longitudinal studies related to distracted-driving have been conducted. Most of those studies are focused on long-term impact of law/rules changes in a state or a locality. These bans are not always successful. McCartt & Geary (2004) studied long term effect on cell phone ban in New York State and reported that effect decline over time. However in later study by McCartt, et al (2010), an analysis of the New York, Connecticut and DC ban on handheld devices had reported that ban does reduce handheld device use over a long period of time. McCartt, Kidd & Teoh (2014) conducted an extensive review of state laws and their effectiveness on safety and reported that the evidence is not conclusive if these laws are having intended effect on safety. Due to relatively recent phenomenon and even newer laws/rules banning handheld devices there is no clear evidence of effectiveness yet. Gostin & Jacobson (2010) concluded in a study of effectiveness of cell phone related laws that effect of law and regulation is limited and must be accompanied with "deactivation technologies installed by car manufacturers" and "vigorous health education and enforcement campaigns to sustain longer-term behavior change." There are number of studies on effectiveness of public service announcements or other educational efforts against texting while driving (like Maheshwari& D'Souza, 2012). Miller (2009) advocates that solution of texting while driving lies in law enforcement partnering with educational efforts. Beside this, numbers of US companies are releasing youtube video, public service announcement (PSA), documentaries to highlight and to

educate on danger of texting while driving (like a documentary produced by AT&T, 2010). Billboards trying to educate drivers about danger of texting while driving appear in about 67% of the market in USA (Anonymous, 2010). "Death by Cell Phone" billboard is produced by National Safety Council (2009) which appeared in number of US cities. Educational efforts also include designing and conducting safety courses. One study in Massachusetts reported 70% reduction in accident involving those who had taken the crash course offered on distraction while driving (Chordas, 2010). Simulator based training has also been conducted. In a simulator training study, drivers show increased the awareness towards hidden dangers while driving (Vlakveld, et al., 2011).

Effect of educational efforts in modifying perception and behavior has been studied in many other contexts. A sample of such work is included here. Pevrot (1999) studied effect of modifying behavior of diabetic patient though education. It was reported that education could potentially be used as intervention technique to alter patient behavior. Albarracín, et al (2003) reported that persuasion could lead to behavioral change among HIV patient. Kastner (1998) found that behavior therapy changes teenager aggressive behavior overtime. Kruse & Card (2004) studied 2nd graders attitude and behavior change towards environment one month after an educational camp. If educational efforts have short-term and long-term impact in changing behavior in other fields, it can be expected that driver education should lead to similar results in modifying behavior.

OBJECTIVES

The main objectives of this project was to assess long-term impact of educational program in changing adult drivers' perception towards cell phone use (including texting) while driving. The details of this objective are provided below:

- Assessment of the long-term effect on changes in safety perceptions of adult drivers after simulation education/experience.

- Assessment of the effect of demographic, environmental and risk factors on long-term changes in safety perceptions of adult drivers after simulation education/experience.

SCOPE

As indicated before, this study is extension of a previous study to assess the effectiveness of educational efforts in reducing the negative impact of distracted driving, especially distraction caused by the use of cell phones. In this study is an effort to measure longevity of a simulator based education on adult drivers. That is in this study, the changes in perception of safety of cell

phone use while driving using a driving simulator after two years or more has been studied. This study adds to the literature by understanding the long-term effectiveness of one single simulator based experience in modifying drivers' safety perception of cell usage in driving.

METHODOLOGY

This research was focused on cell phone distraction among adult drivers. For this study, an adult drivers is a driver with 7 or more years of driving experience. In Spring of 2014, This study conducted a field expeirement using a driving simulatorr along with another study. Schema for the previous experiment is presented in the Firgure 1. Schema for the extension study is presented in the Figure 2.

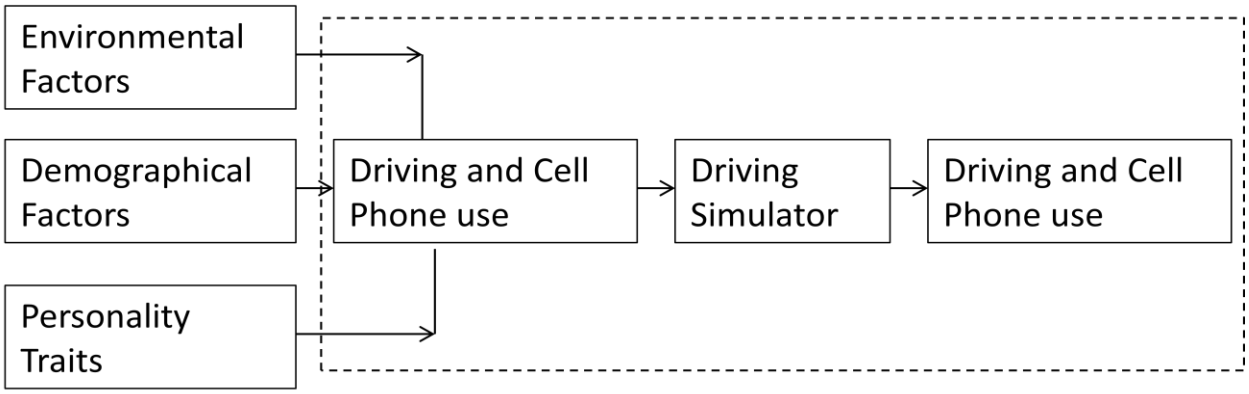

Figure 1. Schema of the Previous Experimental Design

Figure 2. Schema of New Experimental Design

In the previous study, drivers were randomly selected in the City of Hampton. There was no control group in that study. This extended field experiment which would have better with a control group. When initial phase was conducted this phase was not planned. Lack of control group may raise several internal validity issues. However, at this stage control could not be selected. This will reduce the validity of the experiment. Experimental framework is presented in Figure 3.

R O1 X O2 O3 (treatment group only)

Effect1: (O2-O3)

Effect2: (O1-O3)

Where,

R	-Randomness in selection
O1	-Pre-assessment
X	-Treatment Simulator Experience
O2	-Post-assessment
O3	- Post-assessment after 2 plus years

Figure 3. Experimental Design Framework

Instrument Design

Two instruments were designed in previous study, based on the literature review and previous study (Maheshwari & D'Souza, 2012). The post-experiment instrument from the previous study was modified for this experiment (see Appendix 1). Two additional questions are added in the instrument for post-experiment. Post-experiment survey instrument had six questions on safety perception questions and two new questions were based on overall impact of the simulator study. Same questions were asked in the pre and post survey instruments in the previous study.

Data Collection

The sampling frame for this study was 93 subjects who completed the simulator experiment in 2014. Proper IRB approval was obtained from Hampton University before the data collection started. The survey was conducted over the phone. A consent form was designed and part of it was orally read to each participant (See Appendix 2). Data was collected over the phone by research assistants in April and May 2016. Only 27 participants responded to the survey. Majority of phone numbers were unreachable. No compensation was offered for participation. Raw data from both pre and post-instrument is presented in the Appendix 3. The data entry and editing were carried at the time of collection itself.

RESULTS AND DISCUSSION

Data analysis was conducted using Microsoft Excel and SPSS 13.0. All survey data was coded numerically except the comments question variable. A complete codebook is included in the

Appendix 4. List of variables is presented in Table 1. Beside raw variables listed in Table 1, one composite variable, safety perception score, was also used in the analysis. The safety perception score was sum of safety perception of reading, replying, and initiating text messages as well as perception of safety of emailing, internet search and direction search. There are three safety perception scores, pre and post survey scores from previous study (Maheshwari 2016) as well as survey scores based on the re-administration of post survey two year later. Effect of the simulator experience is measured as the differences of re-administered safety scores with pre and post-test scores of safety perception variables. Safety perception score is sum of V1PL to V6PL.

Table 1. Definitions of Raw Variables

Variable#	Description
V0PL	Do you remember participating in driving simulator study?
V00PL	Has simulator experience had impact on driving behavior?
V1PL	Is Cell Phone Use Safe: Post-Test Re-administered
V2PL	Consider Sending Text Safe: Post-Test Re-administered
V3PL	Consider Reading Text Safe: Post-Test Re-administered
V4PL	Consider Email Reading Safe: Post-Test Re-administered
V5PL	Consider Internet Search Safe: Post-Test Re-administered
V6PL	Consider Direction Search Safe: Post-Test Re-administered

Out of 27 subjects, two respondents had no recollection of the simulator expericne. Data show that out of 27 valid responses, 48% (13 out of 27) said that simulator expeience had no impact on their driving behavior (Figure 4).

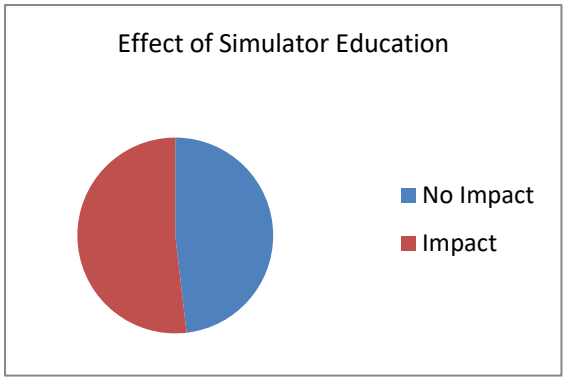

Figure 4. Long-term Influence of Simulator Education as Reported by Subjects

The effect of the simulation education on the safety perception of participants was defined as the difference of SafetyPerception scores: pre-test and re-administered post-test; and post-test and re-administered post-test. These scores were calculated by adding six safety perception variables. The SafetyPerception scores and effects for 27 subjects are presented in the Table 2.

Table 2. SafetyPerception Scores and Effect Variables

#	**SafetyPerception (O1)**	**SafetyPerception_Post (O2)**	**SafetyPerception_Re-admin. (O3)**	**Effect1 (O3-O1)**	**Effect2 (O3-O2)**
5	11	9	12	1	3
6	19	6	10	-9	4
7	9	6	9	0	3
8	12	12	16	4	4
9	14	6	8	-6	2
14	25	14	10	-15	-4
18	21	8	12	-9	4
19	15	11	8	-7	-3
20	22	11	9	-13	-2
21	14	6	10	-4	4
26	8	14	13	5	-1
31	18	8	12	-6	4
39	19	12	7	-12	-5
43	10	13	10	0	-3
51	14	12	11	-3	-1
53	13	13	14	1	1
55	12	9	12	0	3
60	7	8	14	7	6
67	8	9	7	-1	-2
69	18	11	7	-11	-4
72	12	7	10	-2	3
74	16	6	10	-6	4
77	11	9	11	0	2
80	18	6	6	-12	0
88	25	6	10	-15	4
96	13	12	11	-2	-1
99	13	6	11	-2	5

Average SafetyPerception was 14.70 over six factors or an average of 2.45 for each factor before the simulator experience. This indicated that participants considered cell phone use to be unsafe to neutral. Standard deviation of perception per factor was about 2.02. The average SafetyPerception_Post was 9.25 over six factors or an average of 1.54 for each factor. That is after the experience in the simulator, participants' opinion shifted for cell phone use while driving to very unsafe to unsafe from unsafe to neutral. Furthermore, standard deviation per safety perception factor has also reduced to 1.15. This indicates variability in the perception has also reduced, showing greater consensus on perception of safety. The average SafetyPerception_Post_Re-administered was 10.37 over six factors or an average of 1.73 for each factor. That is, even after two years of the simulator experience in the simulator, participants' SafetyPerception was better than pre-test perceptions, however, it was lower than SafetyPerception post-test. Standard deviation per safety perception factor has also reduced to 0.97 in SafetyPerception_Post_Re-administered.

The average Effect1 (SafetyPerception_Post_Re-administered - SafetyPerception_Pre-test) was -4.33 over all six factors (-0.72 per factor). The Effect measured between SafetyPerceptions_Post - SafetyPerceptions_Pre was -5.44 (Maheshwari 2016). This indicates loss in SafetyPreception over two year period. To assess the significance of Efftect1, a paired t-test was conducted. The p-value was less than 0.002, indicating high statistical significance. Thus, simulation experience has an long-term impact in improving participating drivers' safety perception. Approximately 82% of participants had either same or improved safety perception after simulator experience after two years.

The average Effect2 (SafetyPerception_Post_Re-administered - SafetyPerception_Post-test) was 1.11 over all six factors (0.19 per factor). This indicates loss in SafetyPreception over two year period. To assess the significance of loss of the SafetyPerception (Efftect2), a paired t-test was conducted. The p-value was less than 0.089, indicating statistical significance at 90%. This indicates that statistically significant loss in the SafetyPerception over two year period. However, this loss was not large enough to wipeout all the gain in the SafetyPerception from the simulation education.

Roughly 48% of the subjects indicated that simulator experience had no impact on their driving behavior. To test difference between subjects who indicated that simulator experience had influenced their driving versus who indicated it had not influenced a t-test was conducted. Test showed that their was no difference (p-value 0.44) in these two groups.

Demographic, Risk, Environmental & Driving Skill Factors and Long-term Effect of Simulator Experience

Four different sets of factors, demographic (6 variables), risk behavior (11 variables), environmental (3 variables) & driving skill (3 variables), were studied in previous study (Maheshwari, 2016). Out of 23 different variables 6 variables were significantly related to SafetyPerception Effect in that study. These variables are listed in Table 3.

Table 3. Variables Significantly Related to Effect in Previous Study (Maheshwari, 2016)

Variable	**p-value**
Employment Type	0.09297*
AgeCat	0.02127*
Do Crazy Things	0.056*
Primary Driver	0.098*
Percentage of Freeway Driving	0.049*
Follow Speed Limits	0.049*

The effect of these six variables on Effect1 (SafetPerception_Post_Re-administered - SafetPerception_Pre) was tested again using one-factor ANOVA analysis. None of these variables show any statistical significance. Results are tabulated in Table 4. This is largely due to the fact that sample size was very small for one-factor ANOVA analysis.

Table 4. One-way ANOVA results of Selected Variables Vs. Effect1

Variable	**p-value**
Employment Type	0.6314
AgeCat	0.7120
Do Crazy Things	0.1476
Primary Driver	0.8341
Percentage of Freeway Driving	0.1358
Follow Speed Limits	0.8483

CONCLUSIONS

It is clear from the results that drivers' perception of safety of using cell phones remains significantly altered after two years of simulator experience. Approximately, 82% of the drivers' safety perception of using cell phone driving either remained same or or improved compared to

their perception prior to the simulator experience. Improvements in safety perceptions remain highly significant after two years despite safety perception somewhat significant deterioration in the safety perception over two years. Major results are summarized below:

- 82% drivers reported same or improved safety perception after two years of a single simulator experience.
- SafetyPerceptionScore before simulator was 14.70 and was 10.37 two year a single simulator experience. That is, drivers considered cell phone use to Unsafe to Neutral prior to the experiment and considered cell phone use to Very unsafe to Unsafe two years after the experiment.
- Overall improvement after two years (improvement was measured as Effect, which was difference of pre and post-re-administered Safety Perception Scores) was statistically significant with a p-value less than 0.002%.
- 48% drivers reported that single simulator experience had no impact on their driving habits. However, there was no difference in improvement of SafetyPerceptions between drivers who reported impact of simulator experience in their driving vs. who reported no such influence.
- No other variable was able to explain the retention of the improvement in SafetyPerception two years after the simulator education.
- None of the six variables which significantly explained improvement in previous study (Maheshwari, 2016) were significant for Effect1.

It is also important to mention limitations of the study. Experiment has certain very obvious internal and external validity issues. It is a very small study which is limited to a small geographical area, thus, has limited external validity. Lack of control group introduced many internal validity issues as well. Major limitations are listed below:

- Original sampling frame was a very limited. A small Virginia city is not fully representative of drivers in the region or state.
- Re-sample gave even smaller sample of 27. With original 40 variables plus 8 new variables limit the power of the experiment significantly.
- No control group was used to compare three different data points, pre, post and post-re-administered.
- Lack of control group for Post_Re-administered data leave room for internal validity issues like History, Maturation, etc.
- Selection in the Post_Re-administered survey is also possible source of bias as only 27 participants out of 100 previous participants responded.

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APPENDIXES

Appendix 1

Survey Instruments

School of Business	Sharad Maheshwari
Department of Management	Driving Study Long term impact

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TELEPHONE INTERVIEW DATA COLLECTION SHEET

1. Your driving.

Please respond to the following questions as accurately as possible.

0, Do you remember driving simulator experience? ○ Yes ○ No

00, Did driving simulator experience had any impact on your cell phone usage while driving?? ○ Yes ○ No

1.	Do you feel using your cell phone while driving is safe?	☐ Very unsafe ☐ Safe	☐ Unsafe ☐ Very Safe	☐ Neither
2.	Do you consider SENDING a text message safe while driving?	☐ Very unsafe ☐ Safe	☐ Unsafe ☐ Very safe	☐ Neither
3.	Do you consider READING a text message safe while driving?	☐ Very unsafe ☐ Safe	☐ Unsafe ☐ Very safe	☐ Neither
4.	Do you consider READING email safe while driving?	☐ Very unsafe ☐ Safe	☐ Unsafe ☐ Very safe	☐ Neither
5.	Do you consider conducting Internet searches safe while driving?	☐ Very unsafe ☐ Safe	☐ Unsafe ☐ Very safe	☐ Neither
6.	Do you consider conducting direction SEARCHING safe while driving?	☐ Very unsafe ☐ Safe	☐ Unsafe ☐ Very safe	☐ Neither

Appendix 2
IRB Consent Form

HAMPTON UNIVERSITY

HAMPTON, VIRGINIA 23668

CONSENT FORM

TEXTING WHILE DRIVING AMONG ADULTS: FOLLOWUP STUDY

I, _____, consent to participate in driving simulator research conducted by the Hampton University research team. The main purpose of this study is to gather information from young drivers' attitude change towards Texting While Driving after a driving simulator experience. The goal of this study is to find what educational and public services programs can be developed which can reduce the tendency among adult drivers to reduce use of certain type of electronic communication while operating an automobile.

Participants has been the part of the previous student conduct in Spring 2014**. Participation and answering of questions are voluntary**. There is no obligation on any participant to provide information unwillingly. You have right to withdraw from the process any time without any explanation or loss.

All data collected will be used strictly for the purpose stated above and will be completely confidential. The "Texting While Driving" research team will provide copy of the consent form if you desire so. You can obtain a copy of the final project report from Drs. Sharad Maheshwari and Kelwyn D'Souza(see address below) at the conclusion of the project on Aug, 2016.

You can contact principal investigators to the project, Dr. Sharad Maheshwari/Dr. Kelwyn D'Souza (see address below) or the chair of institutional research board (IRB) of Hampton University (see address Below) for any concerns related to this study. This form is valid only if approved and signed by the IRB chair.

Participant signature_____ Date _____

PI: Dr. Sharad Maheshwari
Dr. Kelwyn D'Souza
School of Business, HU
Hampton, VA 23668
757-727-5605/5037

IRB Chair: Dr. Abiodun Adibi, Chair
Hampton University IRB
Du Pont Hall Room # 101
Hampton, VA 23668
757-727-5419

Approved [Yes( ) No ( )]

_____ Date_____

Dr. Abiodun Adibi
Chairperson, HU IRB

Appendix 3

Raw Data from Survey Instrument

Raw Data

#	Sub Reached	V00PL	V0PL	V1PL	V2PL	V3PL	V4PL	V5PL	V6PL
1	Phone Disconnected								
2	Phone Disconnected								
3	Phone Disconnected								
4	Phone Disconnected								
5	Yes	2	2	2	2	2	2	2	2
6	Yes	1	1	5	1	1	1	1	1
7	Yes	1	2	1	2	2	1	1	2
8	Yes	1	2	2	3	4	3	2	2
9	Yes	1	2	2	2	1	1	1	1
10	Phone Disconnected								
11	Incomplete participation								
12	Refused								
13	Phone disconnected								
14	Yes	1	1	2	2	1	1	1	3
15	Phone disconnected								
16	Did not answer								
17	Phone disconnected								
18	Yes	1	1	4	2	2	1	1	2
19	Yes	1	1	2	1	1	1	1	2
20	Yes	1	2	1	1	2	2	1	2
21	Yes	1	1	1	2	2	1	2	2
22	Phone disconnected								
23	Phone disconnected								
24	Phone disconnected								
25	Did not answer								
26	Yes	1	2	2	2	2	2	2	3
27	Phone disconnected								
28	Phone disconnected								
29	Phone disconnected								
30	Phone disconnected								
31	Yes	1	2	2	2	2	2	2	2
32	Phone disconnected								
33	Phone disconnected								
34	Phone disconnected								
35	Phone disconnected								
36	Phone disconnected								
37	Phone disconnected								

Raw Data (Continued)

#	V0PL	V00PL	V0PL	V1PL	V2PL	V3PL	V4PL	V5PL	V6PL
38	Phone disconnected								
39	Yes	1	1	1	1	2	1	1	1
40	Phone disconnected								
41	Phone disconnected								
42	Incomplete participation								
43	Yes	1	1	2	1	2	2	1	2
44	Phone disconnected								
45	Phone disconnected								
46	Phone disconnected								
47	Phone disconnected								
48	Phone disconnected								
49	Phone disconnected								
50	Phone disconnected								
51	Yes	1	1	1	2	3	3	1	1
52	Incomplete participation								
53	Yes	1	2	2	2	3	3	2	2
54	Phone disconnected								
55	Yes	1	1	2	2	2	2	2	2
56	Did not answer								
57	Phone disconnected								
58	Phone disconnected								
59	Phone disconnected								
60	Yes	1	1	2	2	3	3	2	2
61	Incomplete participation								
62	Phone disconnected								
63	Phone disconnected								
64	Phone disconnected								
65	Phone disconnected								
66	Phone disconnected								
67	Yes	1	1	1	1	2	1	1	1
68	Incomplete participation								
69	Yes	1	2	1	2	1	1	1	1
70	Phone disconnected								
71	Phone disconnected								
72	Yes	1	1	1	2	2	1	2	2
73	Phone disconnected								
74	Yes	1	1	1	2	2	1	2	2

Raw Data (Continued)

#	V0PL	V00PL	V0PL	V1PL	V2PL	V3PL	V4PL	V5PL	V6PL
75	Phone disconnected								
76	Did not answer								
77	Did not answer	1	2	1	2	2	2	2	2
78	Phone disconnected								
79	Phone disconnected								
80	Yes	1	1	1	1	1	1	1	1
81	Phone disconnected								
82	Phone disconnected								
83	Phone disconnected								
84	Phone disconnected								
85	Phone disconnected								
86	Phone disconnected								
87	Phone disconnected								
88	Yes	1	1	1	1	3	3	1	1
89	Phone disconnected								
90	Phone disconnected								
91	Incomplete participation								
92	Phone disconnected								
93	Phone disconnected								
94	Did not answer								
95	Phone disconnected								
96	Yes	2	2	2	2	2	2	2	1
97	Incomplete participation								
98	Phone disconnected								
99	Yes	1	2	2	1	3	3	1	1
100	Phone disconnected								

Appendix 4
Variables' Code Book

Code Book

Variable#	Q #	Description	Details				
V0PL	Q1.1	Do you remember simulator experiment	Yes	no			
		Code	1	2			
V00PL	Q1.2	Did simulator had any impact on your driving	Yes	No			
		Code	1	2			
V1PL	Q1.3	cell phone is safe	very unsafe	unsafe	neither	safe	very safe
		Code	1	2		4	5
V2PL	Q1.4	sending text is safe	very unsafe	unsafe	neither	safe	very safe
		Code	1	2		4	5
V3PL	Q1.5	reading is safe	very unsafe	unsafe	neither	safe	very safe
		Code	1	2		4	5
V4PL	Q1.6	email reading is safe	very unsafe	unsafe	neither	safe	very safe
		Code	1	2		4	5
V5PL	Q1.7	internet search is safe	very unsafe	unsafe	neither	safe	very safe
		Code	1	2		4	5
V6PL	Q1.8	direction search is safe	very unsafe	unsafe	neither	safe	very safe
		Code	1	2		4	5