Technical Report UMTRI-2006-17 June 2007

Frequency of Distracting Tasks People Do while Driving: An Analysis of the ACAS FOT Data

SAfety VEhicles using adaptive Interface Technology (SAVE-IT Project)

Jessica Oberholtzer, Serge Yee, Paul A. Green, Hong Eoh, Lan Nguyen, and Jason Schweitzer

umtri
HUMAN FACTORS

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTRI-2006-17		
4. Title and Subtitle Frequency of Distracting Tasks People Do while Driving: An Analysis of the ACAS FOT Data		5. Report Date June 2007 6. Performing Organization Code accounts 049178, 049183
7. Author(s) Jessica Oberholtzer, Serge Yee, Paul A. Green, Hong Eoh, Lan Nguyen, and Jason Schweitzer		8. Performing Organization Report No. 2006-18
9. Performing Organization Name and Address The University of Michigan Transportation Research Institute (UMTRI) 2901 Baxter Rd, Ann Arbor, Michigan 48109-2150 USA		10. Work Unit no. (TRAIS) 11. Contract or Grant No. Contract DRDA DTRS57-02-R-2003
12. Sponsoring Agency Name and Address Delphi Delco Electronic Systems One Corporate Center, M/C E110 Box 9005, Kokomo, IN 46904-9005		13. Type of Report and Period Covered 1/05-6/07 14. Sponsoring Agency Code

15. Supplementary Notes

SAVE-IT project

16. Abstract

This report describes further analysis of data from the advanced collision avoidance system (ACAS) field operational test, a naturalistic driving study. To determine how distracted and nondistracted driving differ, a stratified sample of 2,914 video clips of the drivers' faces and forward scene was coded to identify (1) where the driver was looking, (2) where their head was facing, (3) the secondary task performed, (4) what their hands were doing, and (5) the driving conditions. A sample of the clips from the first pass (balanced to equalize distracted and nondistracted clips) was examined frame by frame.

Key findings include:

1. The most common secondary tasks were conversing, chewing gum, grooming, and using a cell phone, in that order. The most common subtasks were conversing on a cell phone, chewing gum, grooming with a hand, and biting one's lips while chewing gum, in that order.
2. Depending on the analysis, 7 to 16% of all secondary tasks involved 2 or more secondary tasks occurring together, with 9 of the 10 most common combinations involving conversation or chewing gum.
3. Conversation tended to occur more frequently for older drivers and women, and on minor roads; and less often between midnight and 6:00 a.m., and when the outside temperature was below freezing.
4. Using the phone occurred more frequently for young drivers, for men, and in lighter traffic; and less often between midnight and 6:00 a.m.

17. Key Words	18. Distribution Statement
Distraction, Attention, Driving Performance, Crashes, ITS, Human Factors, Ergonomics, Safety, Usability, Telematics,	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classify. (of this report)	20. Security Classify. (of this page)	21. No. of pages	22. Price
(None)	(None)	106	

Form DOT F 1700 7 (8-72) Reproduction of completed page authorized

FREQUENCY OF DISTRACTING TASKS PEOPLE DO WHILE DRIVING: AN ANALYSIS OF THE ACAS FOT DATA

UMTRI Technical Report 2006-17, June, 2007

Jessica Oberholtzer, Serge Yee,
Paul Green, Hong Eoh, Lan Nguyen,
and Jason Schweitzer

University of Michigan
Transportation Research Institute
Ann Arbor, Michigan
USA

1 Primary Issues

What are the types and frequencies of secondary tasks that drivers perform?
How often did each subtask occur?
How often did two or more secondary tasks occur in the same clip?
How did age group and driver sex affect secondary task performance?
How did road type, traffic, and speed affect secondary task performance?
How did time of day and day of week affect secondary task performance?

2 Methods

Pass 1: Stratified sample (shown below) of 2,914 4-s (@ 5 Hz) video clips of driver's face from advanced collision avoidance system (ACAS) field operational test (naturalistic driving study) coded for:

1. Driving conditions
2 & 3. Where the driver was looking and where the driver's head was pointed
4. What the driver's hands were doing
5. Which secondary tasks were being carried out

Age	Sex	Road						TOTAL # Clips	
		Limited Access		Major		Minor			
		Inter-state	Free-way	Major Arterial	Minor Arterial	Col-lector	Local		
Young	Women	103	101	40	105	106	80	535	1048
	Men	104	103	48	100	107	51	513	
Middle	Women	105	80	56	106	103	80	530	956
	Men	100	48	22	103	106	47	426	
Old	Women	81	80	15	80	101	57	414	910
	Men	105	95	39	103	102	52	496	
TOTAL		598	507	217	597	625	367	**2914**	

Pass 2: Sample of 403 distracted and 416 normal driving clips (15,962 frames)

3 Results and Conclusions

What are the types and frequencies of secondary tasks that drivers perform?

Secondary Task	Pass 1 (4-s clips, N = 2,914)		Pass 2 (5 Hz frames, N = 15,962)	
	#	**Overall %**	**#**	**Overall %**
No Secondary Task	1599	54.9	10210	64.0
Converse	572	19.6	1897	11.9
Chew Gum	288	9.9	1429	9.0
Groom	222	7.6	904	5.7
Use Cell Phone	141	4.8	838	5.2
Use In-Car System	107	3.7	253	1.6
Internal Distraction	80	2.7	273	1.7
Eat/Drink	71	2.4	419	2.6
Smoke	35	1.2	219	1.4
Read	5	0.2	28	0.2
Chew Tobacco	0	0	0	0
Write	0	0	0	0
Type	0	0	0	0
Total	**3120**	**107.1**	**16470**	**103.2**

How often did each subtask occur (15,962 frames)?

Subtask	Frames (#, %)		Subtask	Frames (#, %)	
Converse on phone	792	5.0	Chew food	165	1.0
Chew gum	787	4.9	Glance to internal distract.	156	1.0
Groom with hand	756	4.7	Tongue motion: chew. gum	148	0.9
Bite lips: chew gum	469	2.9	Speak to passenger	119	0.7
Glance to in-car sys	175	1.1	Hold cigar/cigarette	117	0.7
Listen to passenger	166	1.0	Drink with straw	112	0.7

How often did 2 or more secondary tasks occur in the same clip (# clips, % clips)?

Task	**Use Pho.**	**Eat/ Drink**	**Smoke**	**Gum**	**Groom**	**Read**	**In-Car Sys.**	**Int. Dist**	**Con.**
Use Phone	115 **(3.9)**	4	1	10	3	0	1	5	1
Eat/ Drink	4	53 **(1.8)**	1	0	1	1	1	4	6
Smoke	1	1	26 **(0.9)**	0	2	0	2	1	2
Chew Gum	10	0	0	221 **(7.6)**	7	0	9	5	34
Groom	3	1	2	7	148 **(5.1)**	0	4	4	53
Read	0	1	0	0	0	3 **(0.1)**	0	0	0
Use In-Car Sys.	1	1	2	9	4	0	67 **(2.3)**	1	22
Internal Dist.	5	4	1	5	4	0	1	42 **(1.4)**	17
Con-verse	1	6	2	34	53	0	22	17	436 **(15.0)**
Total	140 **(4.8)**	71 **(2.4)**	35 **(1.2)**	286 **(9.8)**	222 **(7.6)**	4 **(0.1)**	107 **(3.7)**	79 **(2.7)**	571 **(19.6)**

Triple Concurrent Tasks: Conversation & In-Car System Use & Internal Distraction - 1
Chewing Gum & Cell Phone & Reading - 1

How did age group and driver sex affect secondary task performance (% clips)?

Task	**Age Group**			**Mean**
	Young	**Middle**	**Old**	
Converse ***	18.0	16.8	24.4	**19.6**
Use Phone ***	9.9	2.9	1.0	**4.8**
Eat/Drink **	2.7	3.2	1.2	**2.4**
Smoke ***	1.5	2.0	0.0	**1.2**

Task	**Driver Sex**		**Mean**
	Women	**Men**	
Converse ***	24.0	15.1	**19.6**
Use Phone ***	3.3	6.4	**4.8**
Smoke ***	2.1	0.2	**1.2**
Use In-Car System **	2.7	4.6	**3.7**

*** = $p < 0.001$, ** = $p < 0.01$

How did road type, traffic, and speed affect secondary task performance (% clips)?

Secondary Task	Road Type						Mean
	Inter-state	Free-way	Arterial	Minor Arterial	Connector	Local	
Converse **	15.1	21.3	16.8	18.9	20.6	25.9	**19.6**
Eat/Drink *	3.9	1.2	3.6	2.9	1.9	1.4	**2.4**

Secondary Task	Pooled Target Count (Traffic)						Mean
	0	1	2	3	4	5 +	
Converse *	16.0	18.9	22.6	21.4	16.0	15.2	**19.6**
Chew Gum **	14.7	10.0	10.4	7.5	5.8	8.7	**9.9**
Groom *	5.5	5.1	7.9	9.7	10.2	10.9	**7.6**
Use Cell Phone ***	1.3	4.6	5.0	4.4	8.4	13.0	**4.8**
Internal Distraction **	3.6	3.5	3.1	1.4	0.9	0.0	**2.8**

How did time of day and day of week affect secondary task performance (% clips)?

Significant Secondary Task	Time Group								Mean
	24:00-2:59	3:00-5:59	6:00-8:59	9:00-11:59	12:00-14:59	15:00-17:59	18:00-20:59	21:00-23:59	
Converse ***	18.9	2.4	12.0	23.7	20.6	19.7	22.0	17.0	**19.6**
Use Cell Phone ***	0.0	0.0	2.5	3.0	5.0	6.8	3.2	8.9	**4.8**

Secondary Task	Day of the Week							Mean
	Sun	Mon	Tues	Wed	Thurs	Fri	Sat	
Converse **	24.0	15.0	15.6	17.9	17.0	21.8	22.5	**19.6**
Use Cell Phone ***	2.4	11.2	4.1	5.1	2.7	3.5	3.7	**4.8**
Eat/Drink *	1.3	2.7	1.3	4.8	1.1	2.4	2.9	**2.4**
Converse **	24.0	15.0	15.6	17.9	17.0	21.8	22.5	**19.6**
Use Cell Phone ***	2.4	11.2	4.1	5.1	2.7	3.5	3.7	**4.8**
Eat/Drink *	1.3	2.7	1.3	4.8	1.1	2.4	2.9	**2.4**

PREFACE

This report is one of a series that describes the second phase of the University of Michigan Transportation Research Institute (UMTRI)'s work on the SAVE-IT project, a federally-funded project for which Delphi serves as the prime contractor and UMTRI as a subcontractor. The overall goal of this project is to collect and analyze data relevant to distracted driving, and to develop and test a workload manager. That workload manager should assess the demand of a variety of driving situations and in-vehicle tasks. Using that information, the workload manager would determine, for each driving/workload situation, what information should be presented to the driver (including warnings), how that information should be presented, and which tasks the driver should be allowed to perform. UMTRI's role is to collect and analyze the driving and task demand data that served as a basis for the workload manager, and to describe that research in a series of reports.

In the first phase, UMTRI completed literature reviews, developed equations that related some road geometry characteristics to visual demand (using visual occlusion methods), and determined the demands of reference tasks on the road and in a driving simulator.

The goals of this phase were to determine: (1) what constitutes normal driving performance, (2) where, when, and how secondary tasks occur while driving, (3) whether secondary tasks degrade driving and by how much, (4) which elements of those tasks produce the most interference, (5) how road geometry and traffic affect driving workload, (6) which tasks drivers should be able to perform while driving as a function of workload, and (7) what information a workload manager should sense and assess to determine when a driver may be overloaded.

In the first report of this phase (Yee, Green, Nguyen, Schweitzer, and Oberholtzer, 2006), UMTRI developed a second-generation scheme to code: (1) secondary driving tasks that may be distracting (eating, using a cell phone, etc.), (2) subtasks of those tasks (grooming, using a tool, etc.), (3) where drivers look while on the road, and (4) other aspects of driving. The scheme was then used to code video data consisting of face clips and forward scenes from the advanced collision avoidance system (ACAS) field operational test (FOT). The ACAS FOT was a major study in which instrumented vehicles collected a combined 100,000 miles of driving data for about 100 drivers, who used those vehicles for everyday use (Ervin, Sayer, LeBlanc, Bogard, Mefford, Hagan, Bareket, and Winkler, 2005).

In this report, Oberholtzer, Yee, Green, Nguyen, and Schweitzer (2006) used the second-generation UMTRI coding scheme to determine how often various secondary tasks and subtasks occur as a function of the type of road driven, driver age, driver sex, and other factors. In addition, Yee, Nguyen, Green, Oberholtzer, and Miller (2006) performed an analysis to identify the visual, auditory, cognitive, and psychomotor (VACP) demands of all subtasks observed and determined how often those subtasks were performed. The goal of this analysis was to gain insight on how much, and to what degree, various aspects of subtask demand (VACP dimensions) affect driving.

In a subsequent study, Eoh, Green, Schweitzer, and Hegedus (2006) examined various combinations of measures (e.g., steering wheel angle and throttle) to analyze their joint distribution as a function of road type. This was done by pairing or grouping these measures to identify abnormal driving. By using the nonparametric distributions that describe these measures, pairs of thresholds were used to identify when particular maneuvers (e.g., lane changes) occurred on various road types. Success in this study was truly mixed, with high detection performance in some situations and poor detection in others. Nonetheless, some of these thresholds were descriptive enough to be used for a preliminary workload manager.

To support a more precise description of driving, Green, Wada, Oberholtzer, Green, Schweitzer, and Eoh (2006) developed distribution models that describe many of the driving performance measures examined.

Finally, to help characterize different driving situations and tasks, Schweitzer and Green (2007) asked subjects to rate clips of scenes from the ACAS FOT data relative to 2 anchor clips of expressway driving (1 of light and 1 of heavy traffic). Scenes of expressways, urban roads, and suburban driving were used for these ratings. Subjects also identified whether they would manually tune a radio, dial a cell phone, or enter a navigation destination in each of the clips. This data was used to determine the probability that each of the 3 tasks would be performed on each road type as a function of rated workload. In addition, the analysts used the ACAS driving performance data to develop equations that relate workload ratings to the driving situation (e.g., amount of traffic, headway to a lead vehicle, etc.).

The next task is for Delphi to use the findings from these reports to develop and test a workload manager.

TABLE OF CONTENTS

INTRODUCTION **1**
Issues 3
PREVIOUS STUDIES OF DISTRACTION AND IN-VEHICLE TASKS **4**
Overview of Reports Reviewed – How the Research Was Conducted 4
Key Findings 8
Patterns in the Literature 30
The Need for This Analysis 31
METHOD **33**
Database Examined 33
How the Face Clips Were Sampled and Coded 35
RESULTS **37**
1. What are the types and frequencies of secondary tasks that drivers perform? 37
2. How often did two or more secondary tasks occur in the same clip? 40
3. How did age group and driver sex affect secondary task performance? 43
4. How did road type, traffic and speed affect secondary task performance? 45
5. How did time of day, lighting level, and day of week affect secondary task performance? 49
6. How did outside temperature affect secondary task performance? 52
7. How often did each subtask occur? 53
CONCLUSIONS **58**
1. What are the types and frequencies of secondary tasks that drivers perform? 58
2. How often did two or more secondary tasks occur in the same clip? 58
3. How did age group and driver sex affect secondary task performance? 58
4. How did road type, traffic and speed affect secondary task performance? 59
5. How did time of day and day of week affect secondary task performance? 59
6. How did outside temperature and light level affect secondary task performance? 60
7. How often did each subtask occur? 60
REFERENCES **61**
APPENDIX A – CONCURRENT SECONDARY TASKS **65**
APPENDIX B – SECONDARY TASK FREQUENCY BY AGE GROUP AND DRIVER SEX CHARACTERISTICS **67**
APPENDIX C – TASK FREQUENCY BY ROAD TYPE, TRAFFIC AND SPEED CHARACTERISTICS **69**
APPENDIX D – TASK FREQUENCY BY TIME OF DAY AND DAY OF WEEK CHARACTERISTICS **79**
APPENDIX E – TASK FREQUENCY BY TEMPERATURE AND LIGHTING LEVEL CHARACTERISTICS **85**
APPENDIX F – DETAILED EXPLANATION OF SUBTASKS **87**

INTRODUCTION

For most of the 20th century, the motor vehicle driver's primary task has remained the same: to steer the vehicle in its path, control its speed, and not collide with other vehicles, pedestrians, or other objects. More recently, with the advent of telematics, the collection of tasks drivers perform has changed. Drivers must now divide their attention between the primary driving task and the ever widening assortment of telematics systems for navigation, communication, collision warning, lane departure warning, and so forth. Telematics systems are intended to make driving safer, easier, and more convenient but may actually end up putting the driver, the passengers, and those outside the vehicle at greater risk due to increased driver distraction.

The Merriam-Webster Online dictionary (http://www.m-w.com/cgi-bin/dictionary) defines distraction as, " **1 :** the act of distracting or the state of being distracted; *especially* **:** mental confusion, **2 :** something that distracts; *especially* **: AMUSEMENT."** Furthermore, it defines distract as, "**1a :** to turn aside **: DIVERT b :** to draw or direct (as one's attention) to a different object or in different directions at the same time, **2 :** to stir up or confuse with conflicting emotions or motives." Thus, in this context, a distraction is something that draws, diverts, or directs the driver's attention away from the primary task of controlling the vehicle.

Driver distraction may also refer to a situation where the aggregate demand of tasks performed exceeds some limitation and causes overload of information processing capabilities. In this situation, the driver is essentially performing multiple tasks in parallel (the primary driving task and the distracting task), and the combination of these tasks may overload a single attentional resource (visual, auditory, cognitive, or psychomotor) or some combination of them (Wickens, 1984). Even if the distracting task has fairly low demand, it may cause overload if the driver is near the limit of his or her information processing capability. When a driver is overloaded, performance of the primary and/or secondary task may decline, be delayed, not performed at all, etc. This performance decrement may compromise driving safety, so understanding the effect of overload is especially important in regards to driving.

This overload situation is quite different from the attraction situation described previously, as are the strategies used to deal with it. However, there is no one definition for either term that is standard throughout the literature. So, consistent with general usage, both situations will be referred to as distraction in this report.

A detailed attempt to define driver distraction was presented by Toska (2005) at the International Conference on Distracted Driving (www.distracteddriving.ca/english/documents/ENGLISH-DDProceedingsandRecommendations.pdf), which describes both the context of the problem and several definitions (Table 1).

Table 1. Definitions of Driver Distraction from Tasca (2005)

Source	Definition as cited by Tasca (2005)
Ranney, Garrott, and Goodman, 2000	"Driver distraction may be characterized as any activity that takes a driver's attention away from the task of driving. Any distraction from rolling down a window to using a cell phone can contribute to a crash Four distinct categories of distraction: - Visual (e.g., looking away from roadway) - Auditory (e.g., responding to ringing cell phone) - Biomechanical (e.g., adjusting CD player) - Cognitive (e.g., lost in thought)."
Stutts, Reinfurt, Staplin, and Rodgman, 2001	"Distraction occurs when a driver is delayed in recognition of information needed to safely accomplish the driving task because some event, activity, object or person (both inside and outside the vehicle) compelled or tended to induce the driver's shifting attention away from the driving task (citing Treat, 1980)."
Beirness, Simpson, and Desmond, 2002	"Need to distinguish distraction from inattention…Distracted driving is part of the broader category of driver inattention. Presence of a triggering event or activity distinguishes driver distraction as a subcategory of driver inattention."
Green, 2004	"'Driver distraction'" is not a scientifically defined concept in the human factors literature. As used by the layperson, it refers to drawing attention to different object, direction or task. A distraction grabs and retains the driver's attention."
Tosca, 2005	"Distraction occurs when there is…a voluntary or involuntary diversion of attention from primary driving tasks not related to impairment (from alcohol/drugs, fatigue or a medical condition). Diversion occurs because the driver is: performing an additional task (or tasks) or temporarily focusing on an object, event or person not related to primary driving tasks. Diversion reduces a driver's situational awareness, decision-making and/or performance resulting in any of the following outcomes—collision, near-miss, corrective action by the driver and/or another road user."

There are a number of strategies that have been proposed to decrease opportunities for driver distraction and thereby reduce distraction-related crashes (Green, 2004). Among them are (1) imposing regulations that would make it illegal to perform certain distracting tasks while driving (such as using a cell phone), and (2) implementing systems, such as a workload manager, to reduce distraction while driving.

Both strategies have their advantages and disadvantages. Passing new regulations can be difficult and success is usually a matter of political will as product suppliers and manufacturers often oppose the regulations. Furthermore, the regulatory strategy is reactive and requires proof of considerable risk, namely a significant number of crash-related deaths, so that crash statistics can be used to support, and pass, regulations. Given the rapid advances of telematics and the slow process of regulation, regulations may be developed well after they are needed, if at all. Finally, the focus of such regulations is often very narrow, such as cell phone use, and ignores other tasks of concern. Fortunately, once a regulation is passed, compliance is often very high.

A workload manager makes a continual real-time assessment of driving performance to determine when the driver is overloaded and suppresses introduction of additional distractions. For example, if a driver is in heavy traffic, in the rain, or on a curvy road, an incoming phone call (an added demand) could be automatically routed to an answering machine instead of ringing as normal to prevent introducing additional demand and distraction-related error in these already demanding driving conditions. Workload managers can be developed as vehicles are being developed, so there are no implementation delays. Furthermore, a workload manager could be linked to a warning system to greatly enhance its effectiveness by reducing false alarms and presenting the warning only when needed (usually when the driver is distracted). Despite the possible benefits of such safety systems (e.g., workload managers), drivers may feel they are an invasion of privacy and be unwilling to use them.

Issues

To design a workload manager, one needs to know which tasks (and subtasks) are distracting, how often they occur, and when they occur. More specifically, to support analyses comparing normal and distracted driving, the following questions were addressed:

1. What are the types and frequencies of secondary tasks that drivers perform?
2. How often did two or more secondary tasks occur in the same clip?
3. How did age group and driver sex affect secondary task performance?
4. How did road type, traffic, and speed affect secondary task performance?
5. How did time of day, lighting level, and day of week affect secondary task performance?
6. How did outside temperature affect secondary task performance?
7. How often did each subtask occur?

PREVIOUS STUDIES OF DISTRACTION AND IN-VEHICLE TASKS

Overview of Reports Reviewed – How the Research Was Conducted

To date, the frequencies of distracting tasks have only been examined in several studies, though they all are of high quality. In this section, the methods used to collect data are described first, followed an overview of the crash databases available. A comparison of findings appears in a third section.

It should be noted that this topic has been reviewed before (e.g., General Assembly of the Commonwealth of Pennsylvania, 2001; Stevens and Minton, 2001; Glaze and Ellis, 2003; and Royal, 2003), including reviews conducted in Phase 1 of the SAVE-It project (Eby and Kostyniuk, 2004a, c, which also identified research needs).

Wang, Knipling, and Goodman (1996)

This is the first well-known study in the U.S. to examine the crash statistics for normal and distracted/inattentive driving and examine causal factors. The data set used for this analysis was obtained from the Crashworthiness Data System (CDS), an in-depth analysis in which field teams investigate about 5,000 tow-away crashes each year, involving passenger cars, pickup trucks, and vans. They reported that distraction was a contributing factor in between 13 and 26% of crashes.

Stutts, Reinfurt, Staplin, and Rodgman (2001)

This AAA-funded report follows up on research done by Wang, Knipling, and Goodman (1996). Based on 1995-1999 CDS data the authors examined the conditions distraction-related crashes occurred in and the tasks those crashes involved. (See also Stutts, Reinfurt, and Rodgman, 2001). The CDS database also contains text descriptions of each crash. But because there is no standard language for describing crashes, there is no substantial basis for solid statistical inferences based on counts of particular words or phrases. However, the data is suggestive of the causes of crashes and that those causes are wide in variety. Narratives from the state of North Carolina crash reports were used in addition to the CDS descriptions since they were available in electronic form. These narratives reinforce the statistical data, providing additional information on how and why crashes occur. Following are 3 verbatim examples of crash narratives:

> DR OF V1 STATED SHE HAD TAKEN HER EYES OFF OF THE RD TO CHECK HER BABY & WHEN SHE LOOKED UP V2 WAS IN FRONT OF HER & SHE WAS UNABLE TO STOP. DR OF V2 STATED HE HAD SLOWED TO TURN INTO A PARKG LOT & WAS STRUCK FROM BEHIND.

> V1 WAS CHANGING THE RADIO STATION AND WHEN HE LOOKED UP HE

> RAN OFF THE RD JERKED THE WHEEL TO THE LEFT CAUSING THE VEH TO CROSS THE RD AND STRUCK A SMALL TREE AND THEN TURNED OVER.
>
> DRl STATED THAT SHE REAR ENDED V2 AS SHE WAS ANSWERING HER CELLULAR PHONE. DR2 STATED THAT HE STOPPED FOR TRAFFIC WHEN Vl REAR ENDED V2.

<u>Stutts, Feaganes, Rodgman, Hanlett, Meadows, Reinfurt, Gish, Mercadante, and Staplin (2003)</u>

Also funded by AAA, the report is a continuation of research done in Stutts, Reinfurt, Staplin, and Rodgman (2001). The document reports on a naturalistic driving study to obtain more refined data on the frequency and nature of distractions. (See also Stutts, Feaganes, Reinfurt, Rodgman, Hamlett, Gish, and Staplin, 2005.) In that study, video and other recording equipment was installed in cars to collect naturalistic driving data from 70 drivers, split into 5 age groups (18-29, 30-39, 40-49, 50-59, and 60+ years). Three video cameras were installed in each car to record (at 10 Hz) the driver, the front seat, and the forward scene. The drivers were recruited from Chapel Hill, North Carolina, and from just outside of Philadelphia, Pennsylvania.

Three experienced analysts coded each clip independently (3 hours / driver total) and compared results. The initial overall agreement among the analysts was 65% to 70%, and differences were resolved through discussion.

In summary, the 2 AAA-funded Stutts studies provide reasonable, reliable data that distraction-related crashes were occurring. However, keep in mind that when the studies were carried out the market and penetration for new vehicle technology, such as cell phones, was low, as was the total number of crashes related to the new technology.

<u>Eby and Kostyniuk (2004a)</u>

This literature review report discusses previous experiments and research findings to data and identifies research needs. The report reviews and assesses various crash databases commonly used to determine the frequency of distraction-related crashes. It also investigates distraction-related data that was not directly measured, such as police report comments on the events leading up to the crash.

Table 2 shows the databases they considered as candidates for examining distraction crashes, with GES (General Estimates System) and CDS (used by Wang, Knipling, and Goodman, 1996) being favored because both databases represent national, not regional, samples of crashes and code distraction in detail. (Database analysis is summarized in the next section. See also Eby and Kostyniuk (2004d) for crash rate tables.)

Table 2. Crash Databases Examined in Eby and Kostyniuk (2004a)

Database	Content	Comment
National Automotive Sampling System General Estimates System (GES)	Nationally representative probability sample of all police-reported crashes. Coded from police reports	Distraction variable has 19 categories but only a few codes are used; many states do not code distraction; for 45% of the cases distraction was not reported.
National Automotive Sampling System Crashworthiness Data System (CDS)	Representative, random nationwide sample of about 5,000 police-reported crashes involving passenger vehicles where at least 1 vehicles was towed (more severe crashes), investigated in detail	Distraction variable has 14 categories; for over 50% of the cases, distraction is unknown.
Fatality Analysis Reporting System (FARS)	Nationally representative sample of all crashes that involve at least 1 fatality (most severe crashes); data includes police reports, witness statements, and autopsy reports.	Code for driver-related factor (which includes inattention); also code for electronic device use; few distraction crashes are reported.
Highway Safety Information System (HSIS)	Data from 8 states used to relate road features to crashes	Distraction data not as detailed as CDS, GES, or FARS and varies from state to state
Geographic Information System (GIS) databases	Data on road network, traffic, crashes, pavement condition, population, and land use	Focus on roads and crashes, region specific

Eby and Kostyniuk (2004b)

This report presents a detailed analysis of 985 distraction-related crashes from the 2001 National Accident Sampling System Crashworthiness Data System (NASS-CDS) database. The report examined distraction-related crash frequency in relation to many factors including time of day, driver sex, and driver age.

The document also includes an examination of the triggering event for distraction-related crashes and what crash types are most likely to be associated with driver distraction. Distractions included: an exterior incident, looking at scenery/landmark, passengers, adjusting the entertainment system, listening to music, using a cell phone, using a navigation system, eating or drinking, adjusting other vehicle controls, dealing with moving objects in the vehicle, and smoking. Eby and Kostyniuk (2004a) concluded that single-vehicle run-off-the-road and rear-end crash scenarios were likely to be associated with distraction, while intersection/crossing path, lane-change/merge, head on, etc. crash scenarios were less likely to be associated with distraction.

Automotive Collision Avoidance System (ACAS) Field Operational Test (FOT) (Ervin, Sayer, LeBlanc, Bogard, Mefford, Hagan, Bareket, and Winkler (2005) and Sayer, Mefford, Shirkey, and Lantz (2005))

Ervin et al. report the results of the automotive collision avoidance system (ACAS) field operational test (FOT), conducted in 2002-2003. The ACAS FOT was a naturalistic driving study in which 90 subjects drove instrumented cars unaccompanied by experimenters. Subjects used the test vehicles as their personal vehicles for day-to-day driving for a 4-week period. The first week of data collection provided baseline data as neither the adaptive cruise control (ACC) nor the forward collision warning (FCW) were active. The ACC and FWC systems were active throughout weeks 2-4 in order to assess the ACAS system's performance. Baseline data is especially important to SAVE-IT.

Two cameras were used to collect video data of the forward scene (at 1 Hz) and the driver's face (at 5 Hz). Both cameras collected 4-second clips every 5 minutes and when crash-related events occurred. Additional equipment was also installed to collect data (at 10 Hz) on about 400 engineering variables (speed, yaw angle, etc.).

Sayer, Mefford, Shirkey, and Lantz (2005) is an additional analysis of the ACAS FOT data that became available after the analysis described in this report was completed. Sayer et al. determined the frequency of driver distraction as well as the frequency of individual distracting tasks. Data from all 4 weeks was used to compare driver distraction during normal driving (baseline) with driving when the ACC and FCW were active. Clips where the vehicle speed dropped below 25 mi/hr at any time were disregarded, as ACC and FCW are not operational below that speed. Five percent of the remaining clips were selected at random, yielding 898 clips. Clips in which the manual or adaptive cruise control were engaged were removed, leaving 614 clips (3.4% of total clips) distributed across 66 drivers. That final sample was coded by a single analyst and spot-checked by a researcher. The first-generation UMTRI coding scheme (the one used by Ervin et al., 2005) was used for coding.

In the course of their analysis, the authors found that about 18% of all driving involved some sort of distraction. This is of particular importance for the SAVE-IT analysis as it provides a basis for determining how many clips would need to be coded for SAVE-IT so that overall sample size and individual cell sizes are large enough to examine factors of interest and to provide statistically significant results.

Road Departure Curve Warning (RDCW) FOT (Sayer, Devonshire, and Flannagan, 2005)

When the additional analysis of the ACAS data described in this report was almost complete, the RDCW FOT results became available. In that study, naturalistic driving data from 36 drivers in instrumented vehicles was collected over 4 weeks. A total of 1,440 5-second clips from about 87,000 miles of driving was coded using the initial UMTRI coding scheme. The first week of the study provided baseline data, where the warning systems were inactive. The systems were active over the 3 subsequent weeks. Data from all 4 weeks was used for this examination. Although the sample is smaller than ACAS, the video quality is better.

100-Car Study (Dingus, Klauer, Neale, Petersen, Lee, Sudweeks, Perez, Hankey, Ramsey, Gupta, Bucher, Doerzaph, Jermeland, and Knipling, 2006)

When the analysis of this project was almost complete, the 100-Car Study results became available. In that study, naturalistic driving data from 241 drivers in instrumented vehicles was collected for about 1 year. The main goal of the study was to determine the relationship between driving events (crashes, near crashes, and critical incidents) and their causes or contributing factors (driver proficiency, traffic conditions, inattention, etc.). The sample of drivers selected to participate in this study had higher crash risk than the general driving population (young and male drivers are overrepresented in comparison to the general driving population, and participants tended to drive more mileage than the average driver).

Continuous video data was collected through 3 interior cameras (driver's face, passenger side, and forward over the driver's shoulder) and 2 road scene cameras (forward and rear view). Also installed was equipment to collect additional data (such as lateral acceleration and yaw rate). From the continuously collected video data an event based subset (triggered by crashes, significant acceleration, etc.) was created and used as the basis for further analysis.

Key Findings

Wang, Knipling, and Goodman (1996)

This study showed that distraction-related crashes were not unusual and contributed to about 13% of all crashes. In 46% of all crashes studied, the driver's state of alertness (sleepy, distracted, looked but did not see, unknown, or attentive) was unknown. Thus, if the frequency of distraction remained the same throughout the crashes with unknown information, the percentage of distraction-related crashes would be approximately 26%, double the reported value of 13%.

Table 3 shows how frequently various factors led to crashes. According to this data, secondary tasks were infrequent contributors to crashes. "Distracted while adjusting radio, cassette, CD" was named a causal factor in just 2.1% of all crashes and "Distracted while dialing, talking or listening to phone" in just 0.1%. Keep in mind this data is from 1996 when cell phone market penetration was lower, as was penetration of other sophisticated in-vehicle devices.

Table 3. Percentage of CDS Crashes Involving Inattention/Distraction-Related Crashes, Sorted by Frequency

Causal factor	**% of Drivers**	**% of Crashes**
Unknown/no driver	38.4	45.7
Attentive or not distracted (no problem)	46.7	28.8
Looked but did not see	5.6	9.7
Distracted by outside person, object, or event	2.0	3.2
Sleepy or fell asleep	1.5	2.6
Distracted/inattentive, details unknown	1.5	2.6
Other distraction (unspecified)	1.3	2.2
Distracted while adjusting radio, cassette, CD	1.2	2.1
Distracted by other occupant	0.9	1.6
Distracted by moving object in vehicle (e.g., bee)	0.3	0.5
Distracted while adjusting climate controls	0.2	0.3
Distracted while using other device/object in vehicle	0.1	0.2
Eating or drinking	0.1	0.2
Smoking related	0.1	0.2
Distracted while dialing, talking, or listening to phone	0.1	0.1

Source: Wang, Knipling, and Goodman (1996)

Wang et al. also found that distraction crashes were relatively more likely in good weather than in rain, snow, hail, or sleet (Table 4). Distraction-related crashes were most likely to occur under clear driving conditions and when the driver was attentive.

Table 4. Crash Type According to Weather

Weather Row % Column %	**Sleepy**	**Distracted**	**Looked but did not see**	**Unknown**	**Attentive**	**Total**
Clear	2.6 80.3	14.0 85.6	10.6 88.7	46.3 81.8	26.5 74.0	100.0 80.7
Rain	2.8 14.2	9.8 10.0	5.4 7.5	46.0 13.6	36.0 16.7	100.0 13.4
Snow/hail/ sleet	Too few cases	11.3 4.4	6.6 3.5	37.4 4.3	43.1 7.7	100.0 5.2
Total crashes	2.6 100.0	13.2 100.0	9.7 100.0	45.7 100.0	28.8 100.0	100.0 100.0

Interestingly, the speed distribution for distraction crashes was similar to that for crashes in which the driver was attentive (Table 5). Note that the cause of the crash is unknown in nearly half of the cases examined, indicating that the percentages of the known causes are likely to be vastly underestimated based on the Wang et al. data.

Table 5. Crash Type According to Speed Limit

Speed Limit (mi/hr) Row % Column %	**Sleepy**	**Distracted**	**Looked but did not see**	**Unknown**	**Attentive**	**Total**
0-35	1.3 21.4	12.1 39.5	9.5 42.6	48.3 45.4	28.8 43.2	100.0 43.2
40-50	1.9 26.2	14.2 39.7	12.3 46.7	46.3 37.6	25.4 32.4	100.1 36.8
55-60	2.3 14.0	13.9 16.6	6.6 10.7	41.9 14.6	35.3 19.3	100.0 15.8
>=65	24.4 38.4	13.3 4.2	Too few cases	26.5 2.4	35.7 5.1	99.9 4.1
Total crashes	2.6 100.0	13.2 100.0	9.7 100.0	45.7 100.0	28.8 100.0	100.0 99.9

Eby and Kostyniuk (2004b)

Eby and Kostyniuk (2004b) conducted a fairly thorough analysis of temporal effects showing day of the week had no effect, but time of day did, with distraction-related crashes being relatively more likely between 9:00 a.m. and 5:00 p.m. (Figure 1).

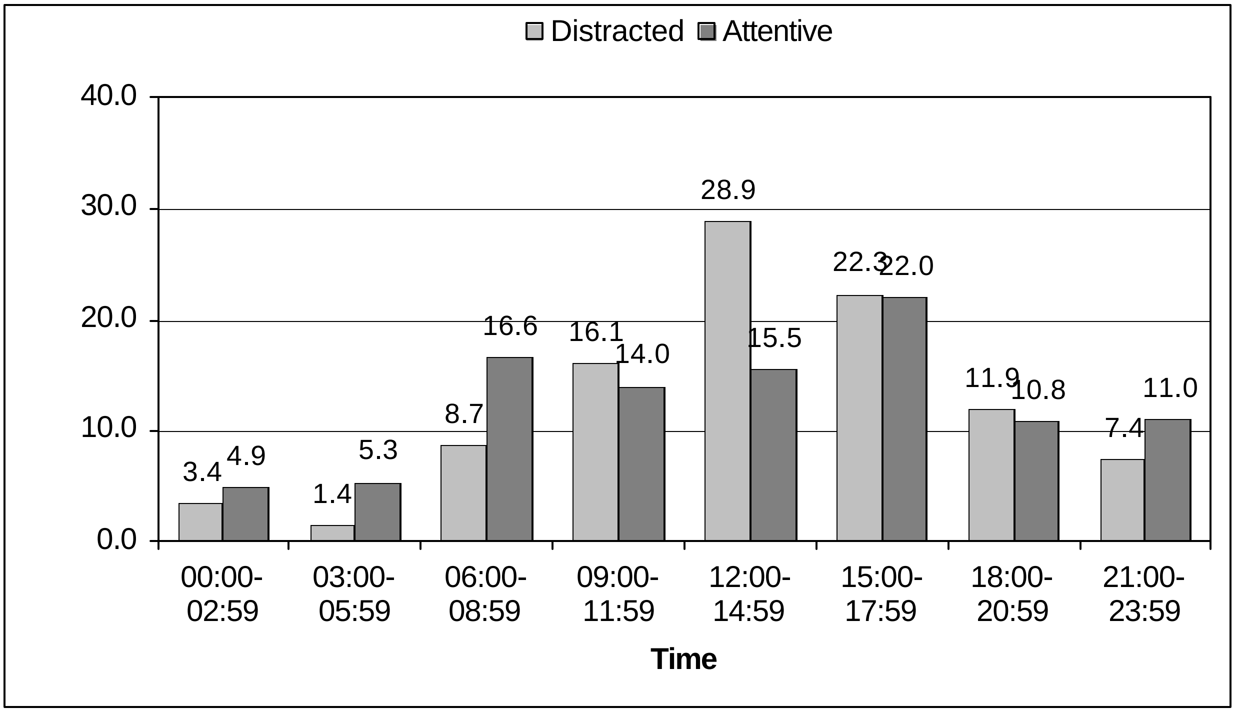

Figure 1. Distracted and Attentive Crashes as a Function of Time of Day
Source: Eby & Kostyniuk (2004b)

They also found there were no significant sex differences, but that distraction-related crashes occurred much more frequently for younger and middle-aged drivers than for drivers over age 55.

Overall, they found that distraction-related crashes occur more often than attentive crashes for same trafficway, same direction; intersecting path; same trafficway, opposite direction; and most noticeably for change trafficway, vehicle turning crashes. Attentive crashes occurred more often than distraction-related crashes in only the single driver crash type. Overall, the literature suggests that rear-end crashes are relatively more likely for distracted drivers.

One of the more important findings from Eby and Kostyniuk (2004b), reported by others as well, concerns the relationship between crash geometry and distraction type (Table 6). This table suggests that treating all distractions as equivalent may not be appropriate because of differences in the relative frequency of occurrence of crash types.

Table 6. Percent of Crashes Caused by Each Distraction
According to Crash Type

Distraction	Crash Type				
	Single driver	Same trafficway, same direction	Inter-secting path	Change trafficway, vehicle turning	Same trafficway, opposite direction
Looked, but did not see	1.4	21.3	59.7	87.0	4.7
By other occupants	25.8	8.3	21.4	4.9	40.1
By moving object in vehicle	5.4	3.2		0.2	4.3
While talk/listening cell phone	4.1	1.4	0.1	0.8	
While dialing cell phone	1.8	0.3			
While adj. climate controls	2.9	0.1		0.3	24.8
While adj. radio	1.8	3.6	0.1	0.5	1.4
While using other device/object integral to vehicle	0.8	1.3	0.4	0.0	0.3
While using/ reaching device/object brought into vehicle	8.9	8.4	0.2		0.4
Distracted by outside person, object, or event	21.2	20.7	1.9	2.7	10.0
Eating or drinking	7.7	0.7	0.6	0	2.0
Smoking related	1.2	0.2	1.7	0.3	3.0
Distraction details unknown	2.5	3.5	2.7	1.4	2.9
Other, distraction/ inattention	14.5	27.2	11.2		6.3

Another interesting finding from Eby and Kostyniuk is their overall estimate of the relative contribution to crashes of various factors, based on their own analysis of crash data and the literature. Table 7 shows those findings sorted by the level of distraction. Notice that vehicle-related and carry in devices are considered to be moderate distractions.

Table 7. Distractor Types and Features According to Literature Reviewed

Distractor	Level of distraction	Contribution to distraction-related crashes	Important to detect?
Exterior distraction (rubbernecking)	High - frequent and may be of long duration	Largest contributor according to many studies	Yes - hard to detect
Passengers	High - frequent (passengers present in about 1/3 of trips) and may have long duration	Large contributor	Yes - easy to detect
Eating/ drinking	High - frequent (over 70% of drivers engaged in eating or drinking while vehicle was moving) and may have long duration	Small contributor, factor in up to 5% of distraction-related crashes	Yes - hard to detect
Using an object brought into the vehicle (includes personal grooming)	Moderate (depending upon activity type) - frequently performed and may have long duration (grooming present in 45-60% of trips, reading or writing in 40%)	Small contributor	Fairly important - hard to detect
Adjusting vehicle controls	Moderate to high - extremely frequent (100% of drivers adjusted vehicle control while driving	Large contributor	Yes - easy to detect
Cellular phones	Moderate - fairly frequent and increasing (during the day 3-5% of drivers converse on cell-phones) may have very long duration	Small contributor, not frequently cited	Yes - may be hard to detect
Smoking	Moderate - frequency unknown (7% of drivers smoked while vehicle was in motion)	Small contributor, factor in up to 5% of distraction-related crashes	Yes - hard to detect
Navigation systems/ telematics	Unknown, expected to be high - frequency unknown, expected to be high	Unknown, expected to be large contributor	Yes - easy to detect

<u>Stutts, Reinfurt, Staplin, and Rodgman (2001)</u>

Table 8 shows the extent to which the frequency of distractions varies from year to year. Changes on the order of 2% are fairly common. Therefore, analysis focuses on the 5-year mean. According to findings based on this adjustment, distractions due to entertainment systems and other occupants are associated with about 11% of all crashes, climate controls with 3%, and both using a phone and eating/drinking with less than 2%.

Table 8. Annual Differences in Distractions Based on Weighted CDS Data
(Column Percentages and Standard Errors)

Distraction	1995	1996	1997	1998	1999	Overall
Outside person, object, event	28.1[1] (6.9)[2]	35.1 (4.7)	35.4 (6.4)	19.8 (5.5)	34.3 (4.1)	29.4 (2.4)
Adjusting radio/cassette/CD	14.1 (1.6)	4.7 (1.5)	0.4 (0.3)	23.5 (12.5)	5.7 (2.4)	11.4 (3.7)
Other occupant	11.8 (1.7)	12.8 (4.3)	10.6 (5.6)	7.5 (2.4)	12.7 (3.0)	10.9 (1.7)
Moving object in vehicle	3.5 (2.5)	6.2 (3.1)	2.5 (1.0)	2.2 (1.0)	7.6 (4.0)	4.3 (1.6)
Other device/object	Not Available	2.6 (1.1)	4.1 (2.5)	5.3 (3.2)	2.7 (1.2)	2.9 (0.8)
Vehicle/climate controls	4.1 (1.2)	1.6 (0.9)	3.4 (1.0)	2.4 (1.4)	2.7 (0.8)	2.8 (0.6)
Eating, drinking	1.8 (0.6)	1.3 (0.5)	0.3 (0.2)	1.6 (0.7)	3.3 (1.8)	1.7 (0.3)
Using/dialing cell phone	1.2 (0.6)	2.8 (1.7)	3.5 (1.4)	0.3 (0.1)	0.8 (0.7)	1.5 (0.5)
Smoking related	1.6 (0.9)	0.5 (0.4)	1.6 (0.5)	0.01 (0.01)	1.2 (0.7)	0.9 (0.2)
Other distraction	17.1 (6.0)	19.7 (3.0)	35.0 (7.2)	35.3 (9.4)	21.9 (5.7)	25.6 (3.1)
Unknown distraction	16.7 (7.5)	12.9 (3.1)	3.0 (2.0)	2.1 (0.9)	7.2 (2.3)	8.6 (2.7)

[1] Column percent
[2] Standard error
"Weighted" - adjustments to the sample to be representative of the U.S.
Source: Stutts, Reinfurt, Staplin, and Rodgman (2001)

Table 9 shows that task frequency was associated with driver age. Drivers over age 50 were much less likely to engage in distracting tasks and to be distracted by other occupants (<10% vs. 20 – 30%). However, drivers in the oldest age group (65+) were more likely to be distracted by an outside object than drivers in any other age group. One interesting finding is the high rate of crashes caused by eating and drinking among 50- to 64-year-olds.

Table 9. Relative Frequency of Various Types of Distractions
(Mean and Standard Error)

Distraction	Age				
	<20	**20-29**	**30-49**	**50-64**	**65+**
Outside person, object, event	27.0[1] (5.9)[2]	29.0 (4.3)	27.5 (2.1)	33.3 (9.2)	42.8 (13.5)
Adjusting radio/cassette/CD	28.9 (12.1)	7.9 (3.3)	7.3 (3.3)	0.6 (0.4)	0.2 (0.2)
Other occupant	10.7 (2.0)	17.8 (4.7)	9.8 (2.4)	1.5 (1.0)	2.6 (1.0)
Moving object in vehicle	5.0 (4.4)	2.4 (0.9)	6.5 (4.1)	3.6 (2.1)	0.1 (0.1)
Other device/object	1.3 (0.6)	2.7 (0.9)	4.2 (1.6)	4.4 (3.2)	1.4 (1.0)
Vehicle/climate controls	3.1 (1.5)	2.1 (0.5)	3.3 (1.2)	3.4 (2.0)	1.8 (1.7)
Eating, drinking	1.1 (0.1)	1.4 (0.6)	1.1 (0.4)	7.9 (2.1)	0.5 (0.6)
Using/dialing cell phone	0.1 (0.1)	0.7 (0.4)	3.3 (1.2)	0.1 (0.1)	2.3 (2.1)
Smoking related	0.9 (0.4)	1.1 (0.3)	1.0 (0.5)	0.3 (0.3)	0.0 (0.0)
Other distraction	19.4 (4.2)	22.6 (4.5)	25.7 (3.1)	34.5 (6.0)	45.0 (11.7)
Unknown distraction	2.5 (0.6)	12.4 (2.9)	10.5 (3.8)	10.3 (6.0)	3.2 (1.5)
Overall	**23.0**	**26.8**	**34.0**	**9.2**	**7.1**

[1] Column percent
[2] Standard error

Source:
http://www.aaafoundation.org/projects/distraction/Distraction_phase1_files/table6.gif

The distribution of distraction also varied slightly due to sex, as men are shown to be more likely to be involved in distraction-related crashes (Table 10).

Table 10. Percentage of Distraction-Related Crashes by Sex (Mean, Standard)

Distraction	**Men**	**Women**
Outside person, object, event	28.9 (3.9)	30.5 (2.7)
Adjusting radio/cassette/CD	10.3 (2.4)	13.1 (8.4)
Other occupant	11.2 (2.4)	10.6 (2.0)
Moving object in vehicle	4.2 (2.5)	4.7 (2.0)
Other device/object	2.2 (0.9)	4.1 (1.7)
Vehicle/climate controls	2.3 (0.9)	3.6 (1.3)
Eating, drinking	2.0 (0.7)	1.3 (0.6)
Using/dialing cell phone	1.7 (0.5)	1.2 (0.7)
Smoking related	0.9 (0.2)	0.9 (0.4)
Other distraction	28.3 (3.1)	22.0 (4.1)
Unknown distraction	8.0 (3.1)	8.1 (2.9)
Overall	**63.1**	**36.9**

Table 11 shows how the frequency of distraction-related crashes varies according to driving situation. A particularly noteworthy finding is that driver-initiated volitional tasks (e.g., using controls, eat/drinking, and using a phone) appear to occur less often in adverse weather.

Table 11. Percentage of Distraction-Related Crashes by Several Factors (Mean, Standard Error)

Distraction	Percent of crashes involving			
	Non-daylight	Adverse weather	Non-passenger Car	> 1 Occupant
Outside person, object, event	29.9 (3.5)	16.2 (4.9)	23.7 (2.2)	27.5 (3.1)
Adjusting radio/cassette/CD	63.7 (12.1)	46.0 (16.4)	21.7 (5.9)	63.6 (20.8)
Other occupant	38.9 (9.8)	16.4 (3.3)	24.6 (10.3)	99.8 (0.2)
Moving object in vehicle	40.4 (5.6)	4.0 (2.6)	20.2 (10.0)	5.6 (3.2)
Other device/object	26.4 (9.4)	2.2 (1.0)	26.2 (10.2)	19.1 (11.0)
Vehicle/climate controls	40.6 (11.6)	5.6 (5.6)	23.0 (5.1)	51.7 (14.3)
Eating, drinking	31.2 (9.2)	11.9 (6.5)	46.6 (8.2)	11.3 (2.1)
Using/dialing cell phone	53.0 (12.5)	11.1 (7.9)	45.9 (17.4)	14.0 (8.4)
Smoking related	88.2 (5.3)	0.5 (0.5)	37.9 (13.5)	27.2 (8.6)
Other distraction	25.4 (4.0)	6.7 (2.5)	33.6 (4.6)	25.3 (4.6)
Unknown distraction	19.3 (3.7)	14.1 (7.0)	37.7 (12.1)	37.1 (11.1)
Overall	**34.2**	**15.5**	**28.0**	**38.7**

Stutts, Feaganes, Rodgman, Hanlett, Meadows, Reinfurt, Gish, Mercadante, and Staplin (2003)

Table 12 shows the duration of various distractions in terms of percentage of driving time. Conversing was the most common distracting task (15%, consistent with their prior research) followed by eating/drinking (4.6%), internal distractions (3.8%), smoking (1.6%), using audio controls (1.4%), and using a cell phone (1.3%). Table 12 also shows the differences in driver behavior between when the vehicle was moving and stopped. Those differences are used to calculate the adjusted distraction frequencies. The adjusted frequencies show the likelihood a distraction would occur if the distraction were universal. As an example, smoking was only observed less than 2% of the time overall and only 7% of all drivers smoked. However, for smokers, smoking occurred over 1/5 of the time.

Table 12. Percentage of Drivers and Driving Time Engaged in Distracting Tasks

Potential Distraction	**% of Total time While vehicle moving**	**% of Drivers engaging in activity**	**Adjusted % of total time while vehicle moving**
Using cell phone	1.3	34.3	3.8
Eating, drinking	1.45	71.4	2.0
Preparing to eat/drink	3.16	58.6	5.4
Using audio controls	1.35	91.4	1.5
Smoking	1.55	7.1	21.1
Reading/writing	0.67	40.0	1.8
Grooming	0.28	45.7	0.6
Other occupants:			
- Baby distraction	0.38	8.6	4.4
- Child distraction	0.29	12.9	2.2
- Adult distraction	0.27	22.9	1.2
Conversing	15.32	77.1	19.9
Internal distraction	3.78	100.0	3.8
External distraction	1.62	85.7	1.9
Total (without converse)	**16.10**	**--**	**49.7**
Total (with converse)	**31.42**	**--**	**69.6**

For eating and drinking, the data from part 1 of the study (the frequency of crashes from various distractions) is inconsistent with the data from part 2 (the frequency of occurrence). Otherwise, the 2 sets seem consistent, though in some cases, differences in coding do not allow for a direct comparison.

Table 13 provides a variety of additional details about distractions, duration statistics in particular. Notice that smoking activities averaged almost 4.5 minutes in duration and phone calls averaged 1.5 minutes. Other tasks took less time.

Table 13. Frequency and Duration of Distracting Events
(includes when vehicle stopped)

Potential Distracting Event	Frequency	Total Duration (min.)	% Total Duration	Mean Duration (sec.)	Minimum Duration (sec.)	Maximum Duration (sec.)
Cell phone / pager						
Phone not in use	168	12246.0	98.5	4373.6	2.3	11027.7
Dialing phone	122	26.1	0.2	12.9	1.0	65.7
Answering ringing phone	15	2.0	<0.1	7.9	1.3	19.7
Talking / Listening	100	154.4	1.2	92.7	1.2	1264.2
Eating or drinking						
Not eating or drinking	962	11856.4	95.4	739.5	<0.1	11027.7
Preparing to eat/drink	1503	385.8	3.1	15.4	<0.1	755.5
Eating (bringing hand to mouth)	904	95.8	0.8	6.4	<0.1	350.0
Drinking (hand to mouth)	1028	89.6	0.7	5.2	0.3	104.9
Spilled/dropped food or drink	12	0.8	<0.1	4.1	0.2	17.6
Music / audio						
Music / audio not on	299	3408.7	27.4	684.0	0.5	11027.7
Radio on	1215	7645.5	61.5	377.6	0.3	10601.6
Cassette tape on	127	408.0	3.3	192.8	1.4	2209.4
CD on	65	356.0	2.9	328.6	2.7	2723.4
Unknown music / audio on	106	470.2	3.8	266.1	0.9	3412.9
Manipulating audio controls	1539	140.1	1.1	5.5	<0.1	80.3
Smoking						
Not smoking	111	12228.0	98.4	6609.8	12.0	11098.6
Lighting cigarette, pipe, etc.	38	2.6	<0.1	4.1	0.9	10.2
Smoking	45	195.8	1.6	261.1	13.2	1043.2
Finishing smoking	17	2.1	<0.1	7.3	0.8	23.7
Reading/writing or grooming						
Not reading or grooming	597	12290.3	98.9	1235.2	<0.1	11027.7
Reading / writing	303	93.1	0.8	18.4	<0.1	282.4
Grooming	229	45.1	0.4	11.8	1.0	340.0
Occupant distraction						
No occupant distraction	305	12312.0	99.1	2422.0	0.9	11098.6
Distracted by baby	114	44.6	0.4	23.5	0.8	192.6
Distracted by child	81	34.8	0.3	25.8	0.7	1124.2
Distracted by adult	48	37.1	0.3	46.3	1.1	608.8
Conversing						
Not conversing	1614	10506.0	84.5	390.6	<0.1	11098.6
Conversing	1558	1922.5	15.5	74.0	<0.1	4827.0
Internal distraction						
No internal distraction	4153	11800.7	94.9	170.5	<0.1	4351.3
Manipulating vehicle controls	2095	168.4	1.4	4.8	<0.1	283.8
Falling object	11	–	–	–	–	–
Insect distracting (Event)	1	–	–	–	–	–
Pet distracting (Event)	14	3.1	<0.1	13.2	0.5	47.0
Reach/lean/look for/etc.	2246	283.6	2.3	7.6	<0.1	1351.0
Other internal distraction	481	172.7	1.4	21.6	<0.1	496.3
External distraction						
No external distraction	725	12136.9	97.7	1004.6	<0.1	10848.6
External distraction	659	291.6	2.3	26.6	0.4	770.5

Source: Stutts, et al. (2003)

Automotive Collision Avoidance System (ACAS) Field Operational Test (FOT) (Ervin, Sayer, LeBlanc, Bogard, Mefford, Hagan, Bareket, and Winkler (2005) and Sayer, Mefford, Shirkey, and Lantz (2005))

The baseline data collected during the first week is especially important since data collected during that period was later examined in the SAVE-IT project (this report). Table 14 shows a summary of a sample of 172 face clips from that week, of which 17% (29 clips) involved some distraction. Of those 17%, 6% of the distracting activities were cell phone relates, 4% were conversational distractions (with a passenger), 4% were grooming distractions (“low involvement”), and the remaining 3% consisted of a variety of other distracting activities, each of which alone comprised less that 1% of the remaining distracted data. Although the sample size is small, the level of cell phone use in this study compared to that reported by Stutts et al. (2001 and 2003) shows a marked increase, and is consistent with the increased market penetration in the elapsed time between those analyses and this one.

Table 14. Distraction Frequency from the ACAS Study, Week 1 (no ACC or FWS)

Distraction	Young		Middle		Old		Total
	Women	Men	Women	Men	Women	Men	
Cell phone; conversation, in use	4	5		2			11 (6.4)
Cell phone: reaching for							
Cell phone: dialing							
Conversation			3	2	1	1	7 (4.1)
Drinking: high involvement							
Drinking: low involvement				1			1 (0.6)
Eating: low involvement							
Eating: high involvement			1				1 (0.6)
Grooming: low involvement	1	1	1	1		2	6 (3.5)
Grooming: high involvement							
Headset/hands-free phone: conversation							
Headset/hands-free phone: reaching for handset							
Headset/hands-free phone: unsure if activity		2					2 (1.2)
In-car system use							
None							
Null	26	32	26	15	24	20	143 (83.1)
Other/multiple behaviors							
Smoking: lighting a cigarette							
Smoking: reaching for cigarettes or lighter							
smoking						1	1 (0.6)
TOTAL	31	25	21	31	40	24	172

Source: Ervin, Sayer, LeBlanc, Bogard, Mefford, Hagan, Bareket, and Winkler (2005)

As shown in Table 15, drivers engaged in distracting activities 18% of the time in week 1 (baseline driving) and 19% of the time in weeks 2-4 (when FCW as active). Overall, there were few week-to-week changes in task frequency with the exception of conversation, and, to a lesser extent, cell phone use. Conversation frequency showed a marked increase after week 1, possibly because during weeks 2-4, drivers described the then operational ACC and FCW systems to passengers. Cell phone usage appears to decrease after week 1. The authors have no hypotheses as to why this occurred and given the small sample size, data collection period, and frequency of events, the differences could be due to random variation.

Table 15. Frequency of Distraction Behavior

Distraction	Manual	FCW				Total
	Week 1	Week 2	Week 3	Week 4	Mean	
Phone: any activity	11 (7%)	4 (3%)	9 (6%)	2 (1%)	5 (3%)	26 (4%)
Hands-free phone: any activity	2 (1%)		5 (3%)	1 (1%)	2 (1%)	8 (1%)
Conversation	7 (4%)	13 (9%)	12 (8%)	14 (9%)	13 (9%)	46 (7%)
Drinking	1 (1%)	1 (1%)	1 (1%)		0.7 (1%)	3 (0.5%)
Eating			1 (1%)		0.3 (1%)	1 (0.2%)
Grooming	5 (3%)	7 (5%)	3 (2%)	2 (1%)	4 (3%)	17 (3%)
Other/multiple behaviors		1 (1%)	1 (1%)	1 (1%)	1 (1%)	3 (0.5%)
Smoking	1 (1%)	1 (1%)	3 (2%)	3 (2%)	2.3 (2%)	8 (1%)
None	132 (83%)	117 (81%)	112 (76%)	139 (86%)	122.7 (81%)	500 (81%)
Total clips	160	144	148	162	151.3	614
Clips with distracting tasks	28 (18%)	27 (19%)	36 (24%)	23 (14%)	28.7 (19%)	114 (19%)

Source: Sayer, Mefford, Shirkey, and Lantz (2005)

The most common distraction was conversation (7%), followed by cell phone-related activities (4%), and grooming (3%). Ervin et al. (2005) reported that the overall percentage of time when distracting tasks were performed is 17%, similar to the results of this analysis, which shows 18%. The individual task percentages are also very close to those reported by Ervin et al.

Road Departure Curve Warning (RDCW) FOT (Sayer, Devonshire, and Flannagan, 2005)

As shown in Table 16, a distraction occurred in 34% of the clips, a value greater by a factor of almost 2 than was reported in the ACAS FOT using a similar coding scheme. Why the frequency increased is unknown. The variation is unlikely to be random as the percentage of secondary tasks, not counting conversation, was stable from week to week (33% in week 1, 36% in week 2, 34% in week 3, and 33% in week 4).

Table 16. Frequency of Various Distractions

Task	Subtask	#	%	#	%	Multiple tasks
None				954	66.3	
Conversation				219	15.2	21
Grooming	Low involvement	95	6.6	96	6.5	26
	High involvement	1	0.1			
Cell phone	Conversation	72	5	76	5.3	10
	Reaching for	0	0			
	Dialing	2	0.1			
	Conversation: hands free	1	0.1			
	Reach for headset	0	0			
	Headset: unsure of task	1	0.1			
Eat/drink	Eating: low involvement	16	1.1	28	1.9	2
	Eating: high involvement	2	0.1			
	Drinking: low involvement	9	0.6			
	Drinking: high involvement	1	0.1			
Other	In-car system use	5	0.3	36	2.5	5
	Smoking	8	0.6			
	Smoking: reaching for cigarettes/lighter/ashtray	1	0.1			
	Smoking: lighting	0	0			
	Miscellaneous	22	0.2			
Multiple				31	2.2	
Total				1440	100	

Source: Sayer, Devonshire, and Flannagan (2005)

Note: Involvement is a subjective evaluation of secondary task demand.

As shown in Table 17, there were very striking age and sex differences. Younger subjects spoke to passengers less, but much more on the phone, and were more involved in eating and drinking. Older subjects were much less likely to be on the phone. Men talked to their passengers less, were on the phone more, and ate/drank less.

Table 17. Percentage of Exposure Clips Containing Secondary Tasks by Age Group and Sex

Secondary task	Age group			Sex	
	Younger	Middle	Older	Male	Female
Conversation (*n* = 219)	29.2	35.6	35.2	41.1	58.9
Grooming (*n* = 96)	37.5	35.4	27.1	54.2	45.8
Cellular phone (*n* = 76)	55.3	36.8	7.9	53.9	46.1
Eating/drinking (*n* = 28)	46.4	32.1	21.4	42.9	57.1
Multiple (*n* = 31)	38.7	41.9	19.4	45.2	54.8
Other (*n* = 36)	47.2	41.7	11.1	41.7	58.3
Mean percentage:	42.4	37.3	20.3	46.5	53.5

Figure 2 shows that the largest single source of exposure was limited access roads, though that may reflect the data collection procedure, which did not record data for very low speeds or for the first few minutes of driving, much of which was on local roads or minor surface roads. Also note that drivers were less likely, per unit of exposure (the ratio of the bar heights), to be engaged in secondary tasks when traveling on limited access roads.

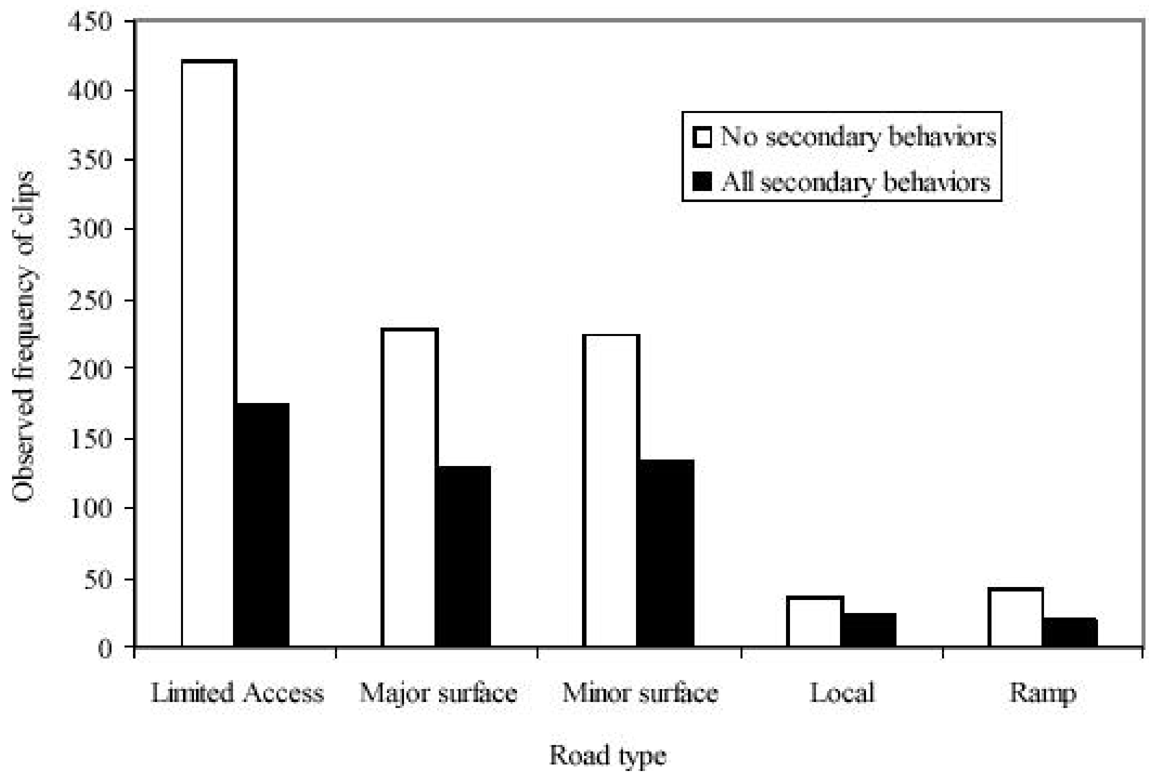

Figure 2. Frequency of Tasks by Road Type

Figure 3 shows the absolute frequency of various tasks as a function the road being driven. Although there were some differences (e.g., conversation was slightly relatively less likely on major surface roads than other types), no differences stood out.

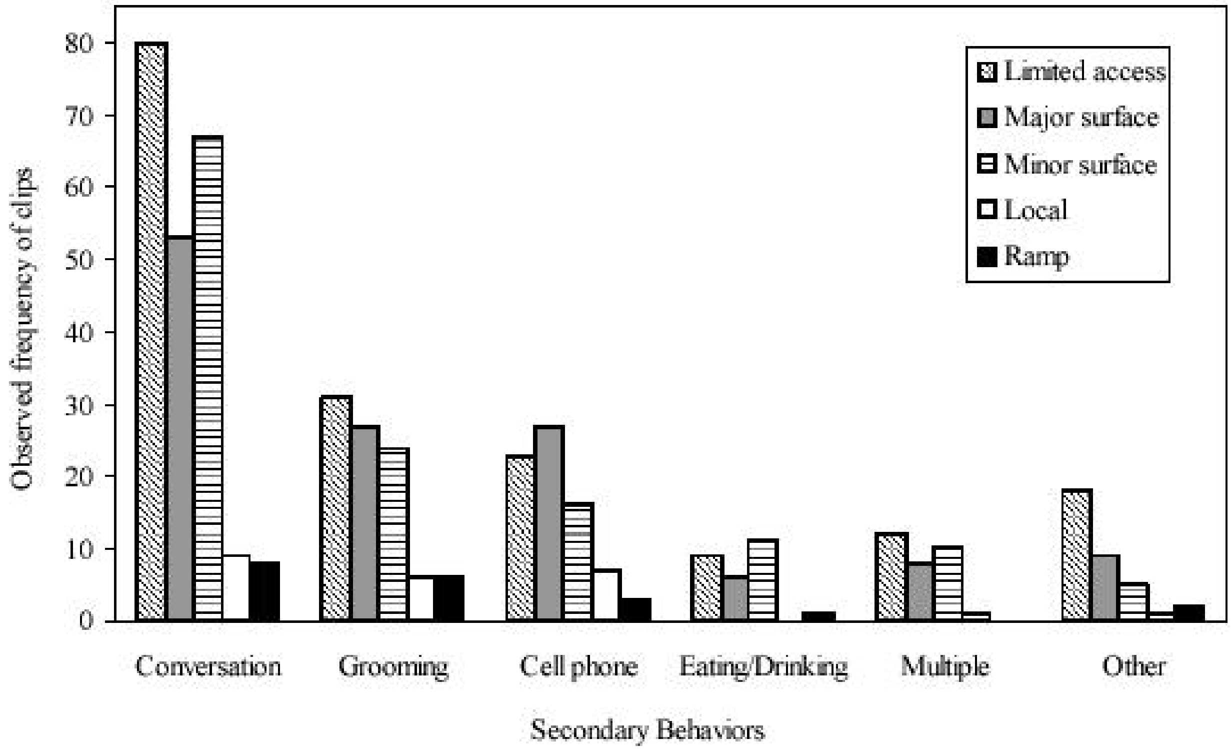

Figure 3. Observed Frequency of Secondary Behaviors According to Road Type

Table 18 shows the relatively likelihood of performing a task during the day vs. at night depended upon the task, when compared with the 80/20 day/night split for no task. For example, drivers were relatively more likely to be on the phone at night (32% of the phone clips), but less likely to be eating/drinking (4%), though these percentages need to be viewed with some caution due to limited sample sizes. For example, the percentage reported for eating/drinking represents 1 occurrence out of 28.

Table 18. Percentage of Exposure Clips by Time of Day and Road Condition

Secondary task	Time of day		Road condition	
	Day	**Night**	**Dry**	**Wet/snow-covered**
None (*n* = 954)	80.0	20.0	88.1	11.9
Conversation (*n* = 219)	68.5	31.5	84.9	15.1
Grooming (*n* = 96)	79.2	20.8	90.6	9.4
Cellular phone (*n* = 76)	67.1	32.9	90.8	9.2
Eating/drinking (*n* = 28)	96.4	3.6	89.3	10.7
Multiple (*n* = 31)	71.0	29.0	100.0	0.0
Other (*n* = 36)	80.6	19.4	91.7	8.3
Mean percentage:	77.5	22.5	90.8	9.2

"Night" began at *civil twilight*, or at 96° solar zenith angle, and "day" was defined as any time when the solar zenith angle was below 96°.

Interestingly, whether the road was dry or wet/snow covered seemed to have no effect on the extent to which most secondary tasks were engaged, though conversation was slightly more likely.

As noted in Table 19, curvature seemed to have no effect on the engagement in secondary tasks, though maybe phone use decreased slightly. In contrast, secondary tasks were slightly more common when brakes were being used. Driving on curves and using brakes are higher demand situations, and one would expect rational drivers to perform secondary tasks less frequently in these situations.

Table 19. Percentage of Exposure Clips by Curvature and Brake Use

Secondary task	Curvature		Brake use (during any part of the clip)	
	Curve	**No curve**	**Brakes**	**No brakes**
None (*n* = 954)	11.7	88.3	13.0	87.0
Conversation (*n* = 219)	13.2	86.8	16.9	83.1
Grooming (*n* = 96)	17.7	82.3	19.8	80.2
Cellular phone (*n* = 76)	6.6	93.4	13.2	86.8
Eating/drinking (*n* = 28)	14.3	85.7	28.6	71.4
Multiple (*n* = 31)	6.5	93.5	22.6	77.4
Other (*n* = 36)	13.2	86.8	8.3	91.7
Mean percentage:	11.7	88.3	17.5	82.5

Some very interesting data on the duration of glances away from the road as a function of the distracting task is shown in Table 20. Though there is no data on distributions, the reported means are very low (almost all are less than 1 s), especially since reported durations include both the transitions to and from the road. Standard practice SAE 2396 (Society of Automotive Engineers, 1999) says to include only the return glance, so the reported values in this case are slightly inflated. The data shown in this table (copied as shown in the original report) indicates accuracies to the nearest .01 s even though the data was recorded at 10 Hz (nearest .1 s). Interestingly, the mean time for no secondary task was in the middle of the range of glance away time, and the second glance away was slightly longer than the first. In addition, of all of the glance away times, glances related to cellular phone use were briefest. The authors have no explanation to explain the rank order of these means.

Table 20. Frequency and Duration (s) of Glance Away From the Forward Scene, According to Secondary Behavior

Secondary task	**First glance**			**Second glance**		
	#	**%**	**Mean duration**	**#**	**%**	**Mean duration**
None (*n* = 954)	531	55.7	0.70	315	33.0	0.85
Conversation (*n* = 219)	133	60.7	0.73	79	36.1	0.78
Grooming (*n* = 96)	59	61.5	0.82	32	33.3	0.72
Cellular phone (*n* = 76)	41	53.9	0.55	23	30.3	0.58
Eating/drinking (*n* = 28)	19	67.9	0.64	12	42.9	0.88
Multiple (*n* = 31)	18	58.1	0.80	12	38.7	0.62
Other (*n* = 36)	24	66.7	0.87	16	44.4	1.12
Means:	117.9	60.6	0.73	69.9	37.0	0.79

<u>100-Car Study (Dingus, Klauer, Neale, Petersen, Lee, Sudweeks, Perez, Hankey, Ramsey, Gupta, Bucher, Doerzaph, Jermeland, and Knipling, 2006)</u>

A key result from the 100-Car Study concerns the relationship between inattentive and attentive events as a function of event severity (Figure 4). For crashes the ratio was 2.6 to 1, for near crashes it was 1.9 to 1, and for incidents it was 0.4 to 1. Thus data from incidents will underestimate the role of distraction. As a footnote, many events not often recorded as crashes (e.g., curb strikes) were recorded as crashes in this data set.

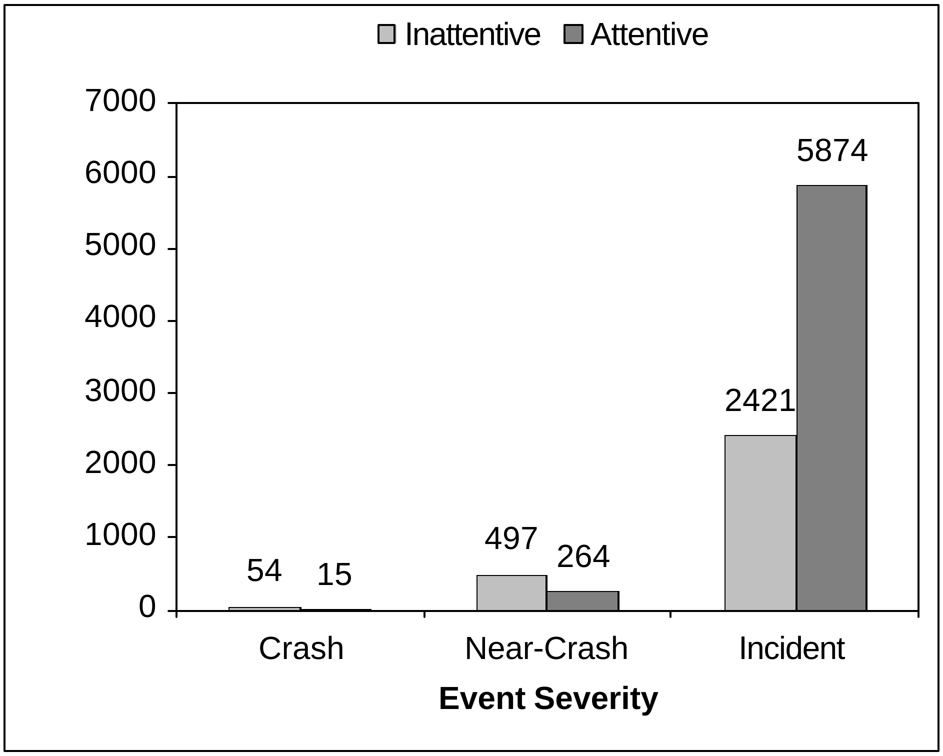

Figure 4. Frequency of Inattentive and Attentive Crashes According to Severity of Event

Table 21 shows the frequency with which secondary tasks were noted for various events, frequencies that were usually closely linked to each other. Note that wireless device tasks (mostly associated with phones) were by far most common, occurring almost twice as often as any other distraction. Curiously, wireless devices were associated with a greater fraction of crashes (50%) than of near crashes or incidents (33 and 35%), respectively. Given the small number of crashes, this could be a statistical artifact. Also notice that daydreaming, which has not been listed in previous tables, appears here.

Table 21. Task Frequency and Crash Event Occurrence.

Task	Incident		Near crash		Crash	
	n	**%**	**n**	**%**	**n**	**%**
Wireless device	454	35	32	33	10	50
Passenger related	213	16	1	1	1	5
Internal distraction	120	9	16	16	3	15
Vehicle related	119	9	9	9	1	5
Personal hygiene (grooming)	106	8	7	7	0	0
Dining (eating)	90	7	10	10	2	10
External distraction	66	5	9	9	1	5
Talking/shouting-no passenger apparent	74	6	6	6	0	0
Smoking	35	3	0	0	0	0
Daydreaming	8	1	6	6	1	5
Other	23	2	2	2	1	5
Total	1308		98		20	

Source: Developed from data from Neale, Dingus, Klauer, Sudweeks, and Goodman (2005)

Figure 5 provides further insight into wireless device tasks, with conversation as the most commonly cited causal factor in crashes and dialing a cell phone as the second most commonly cited. For incidents, talking/listening was cited about 5 times more often than dialing. Keep in mind that the cell-phone crash data is based on 10 crashes.

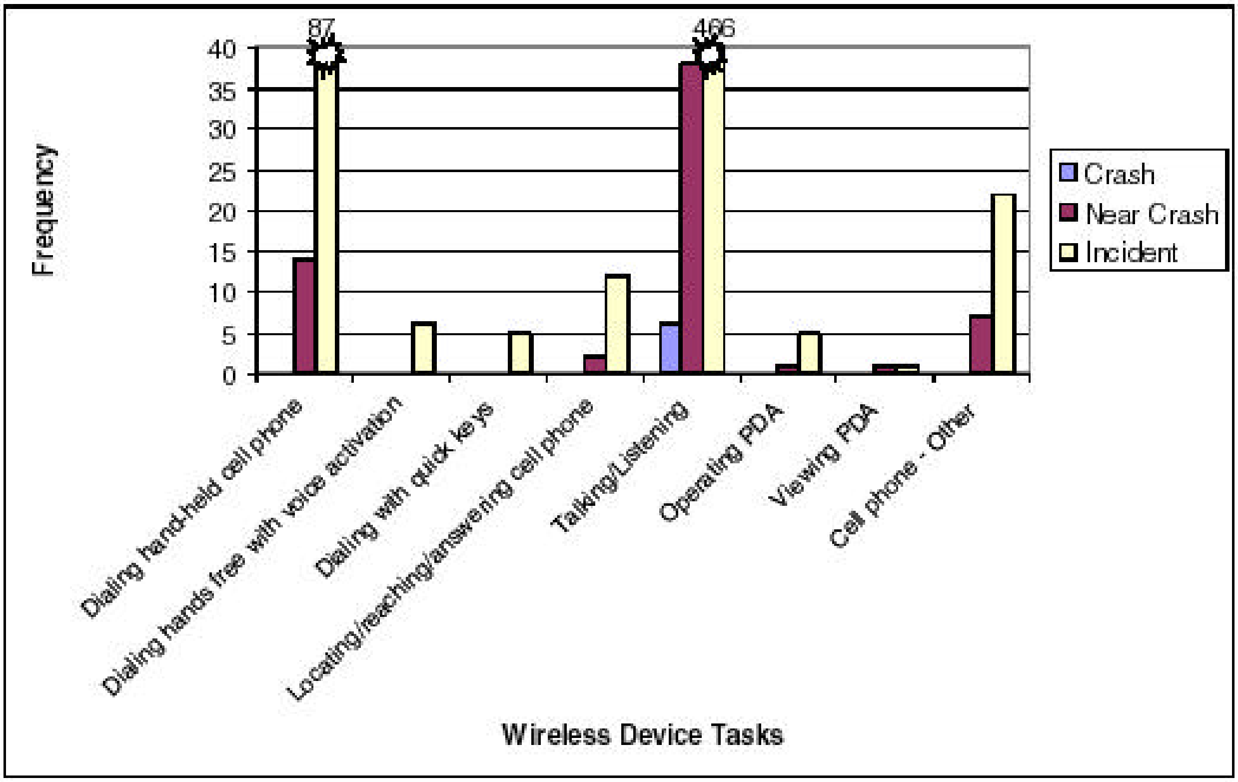

Figure 5. Frequency of Wireless Device Tasks According to Event Severity
Source: Neale, Dingus, Klauer, Sudweeks, and Goodman (2005)

Patterns in the Literature

Table 22 provides a comparison of the results from studies conducted to date. Note that such comparisons are extremely difficult because the distractions are not coded the same way across studies, and some use different statistics. For example, a percentage of time measure was available for 3 studies, but not for the preliminary release of the 100-car study so the percentage of events was computed. Even where comparable measures were collected, differences were common (less so for the 2 Sayer et al. studies which involved similar subjects driving similar roads). Given the care displayed to conduct these studies, the lack of agreement was not expected, though some changes, such as increased cell phone use over time, were expected. If anything, this lack of agreement highlights the need for a consistent scheme such as that provided in Yee, Green, Nguyen, Schweitzer, and Oberholtzer (2006) and used later in this report.

Table 22. Reported Frequency of Various Distracting Tasks

Task	Study			
	Stutts et al., 2003 % of time while vehicle is moving	**Sayer et al., 2005, ACAS FOT % of time**	**Sayer et al., 2005, RDCW FOT % of time**	**Neale et al., 2005, 100–Car Study % of events**
Use cell phone	1.3	4 (=3 [any phone] + 1 [hands free])	5.3	32.3
Eat/drink	4.61 (=1.45 [prepare] + 3.16 [perform])	2 (=1 [drink] + 1 [eat])	1.9	6.9 (dining only)
Use in-car system	1.35 (use audio controls)	--	0.3	--
Smoke	1.55	2	0.6	1.5
Read/write	0.67	--	--	--
Groom	0.28	3	6.5	6.9
Converse	15.32	9	15.2	6.0
Internal distraction	3.78	--	--	9.9
Other/ multiple[4]	2.56	1	4.9 (= 2.5 [other] + 2.2 [multiple])	1.5

The Need for This Analysis

As shown in the section that follows, the literature provides some useful information on when and how often distracting tasks are performed, and provides useful insights into the tasks of concern (e.g., cell phone use, eating, drinking, and internal and external distractions) and the conditions under which they occur (more likely under “good” driving conditions, but performed in all kinds of situations). Some of that research occurred while this research was being conducted. There is some conflicting evidence about the overall frequency of distracting tasks. Furthermore, there is no data in the literature on the frequency and intensity of visual, auditory, and cognitive demands experienced by drivers, but that assessment (Yee, Nguyen, Green, Oberholtzer, and Miller, 2006) requires a data set in which secondary tasks have been coded. Furthermore, to assess the effect of distraction on driving performance as was required for this project, determining distraction (as indicated by engagement in a secondary task, looking away from the road, or some other means) also required a data set in which secondary task engagement was coded. It was for those reasons that this analysis was conducted.

METHOD

Database Examined

To distinguish between normal and distracted driving, driving performance data from the advanced collision avoidance system (ACAS) field operational test (FOT), a naturalistic driving study, was examined in detail (Ervin, Sayer, LeBlanc, Bogard, Mefford, Hagan, Bareket, and Winkler, 2005). This experiment, conducted in 2002-2003, assessed the combined effect of adaptive cruise control (ACC) and forward crash warning (FCW) systems on real-world driving performance. Data collection lasted 12 months and involved a fleet of ten 2002 Buick LeSabre passenger cars, each equipped with ACC and FCW systems. Each car was also equipped with 2 monochrome cameras (for the forward scene and the driver's face) and additional instrumentation that recorded over 400 engineering variables (speed, steering wheel angle, etc.) at 10 Hz. Data collection began 5 minutes after each trip began, so exposure to local roads was underrepresented in the sample. The face video data was recorded once every 5 minutes for 4 seconds at 5 Hz. The forward road scene video data recorded continuously at 1 Hz.

A total of 96 subjects drove the test vehicles. Equal numbers of men and women, in their 20s, 40s, and 60s, participated in the study. Fifteen of the subjects drove for 3 weeks, and 81 drove for 4 weeks. The first week of testing was for baseline, naturalistic data without the ACAS system in operation, and that data set is examined here.

The ACAS data was coded based on road type (9 categories), age group (3 categories), and driver sex (2 categories). The 9 road types, described in Table 23, were: (0) ramp, (1) interstate, (2) freeway, (3) arterial, (4) minor arterial, (5) collector, (6) local, (7) unpaved, and (8) unknown. The 3 age groups were: young (21-30), middle (41-50), and old (61-70). Thus, there were 36 cells (6 road types x 3 age groups x 2 driver sexes) of interest.

Table 23. Road Types in ACAS Data Set

Super-class	Road type	# Clips in full ACAS data set	Description
Limited Access	Interstate	7393	A road that is not a grade that has limited access, limited crossings, and a U.S. DOT interstate designation
	Freeway	4043	A road that is not a grade that has limited access and limited crossing, but does not have a U.S. DOT interstate designation
Major	Arterial	1340	A primary road that allows for high volume, high speed traffic movement with access at grade and few speed changes
	Minor arterial	4884	A secondary road with high volume traffic and lower speed traffic than arterials that connects collectors
Minor	Collector	6221	A road that distributes traffic among neighborhoods and has moderate volume traffic that generally connects with arterials and limited access roadways
	Local	2605	A road used to distribute traffic in and around neighborhoods that has low volume and low speed traffic
	Unpaved	201	A road generally used to distribute traffic to rural destinations that has very low volume traffic and low to moderate speed traffic
	Ramp	551	Roads that are not at grade that serve as connections between limited access roads
	Unknown	7495	A driving area not designated as a public roadway such as a parking lot or public/private facility
	TOTAL	34733	

For this report, clips from ramps and unpaved roads were excluded from further analysis due to low frequency and, in the case of unpaved roads, difficulty determining lane position and other measures. Clips from unknown roads were also excluded from further analysis since differences due to road type is a key point in this study. The number of clips for each of the 6 remaining road types varied considerably, so for some parts of the analysis, the 6 road types were grouped into 3 superclasses (limited access, major road, and minor road). Limited access roads had the highest overall exposure with 33% of all clips, followed by minor roads with 24%, and major roads with 18%. Clips excluded due to road type (those from unpaved, ramp, and unknown roads) represent about 24% of all clips.

How the Face Clips Were Sampled and Coded

The coding scheme described in Yee, Green, Nguyen, Schweitzer, and Oberholtzer (2006) was used for this analysis to identify: (1) driving conditions, (2) where the driver was looking, (3) where the driver's head was pointed, (4) what the driver's hands were doing, and (5) which secondary tasks were being carried out (Table 24). Items 2, 3 4, and 5 were considered to determine when driver was distracted.

Table 24. Secondary Tasks Coded

None	Eat/drink
Converse	Smoke
Chew gum	Read
Use cell phone	Chew tobacco
Use in-car system	Write
Internal distraction	Type

Coding was done in 2 passes. Each clip was coded by 2 of the 3 analysts who worked independently and then resolved any coding differences through discussion. In Pass 1, analysts watched each clip to determine whether the subject engaged in a secondary task at any time during the 4-second clip. Pass 2 was a frame-by-frame analysis, where analysts determined the duration of each secondary task and subtask performed and the exact frame(s) in which each occurred.

Pass 1 clips were selected so that the number of clips in each road class, each age group, and both driver sex bins were approximately equal. The authors determined that coding 3,000 clips from the ACAS FOT video data was feasible and would provide a sample with sufficiently high frequency of secondary tasks and subtasks that differences due to road type, age, and sex could be examined. Sampling in this manner maximizes the sensitivity of tests to these differences but weakens estimates of the overall frequency of tasks. The effect of this bias can be approximated and effectively removed by comparing the data in Table 25 with the actual frequency of occurrence from the ACAS FOT data. Problems revealed during later analysis forced analysts to exclude some clips, reducing the final sample size to 2,914 clips.

Table 25. Distribution of the Complete Pass 1 Sample (N=2,914 clips)

Age	Sex	Road type						TOTAL	
		Limited access		Major		Minor			
		Inter-state	Free-way	Major arterial	Minor arterial	Col-lector	Local		
Young	Women	103	101	40	105	106	80	535	1048
	Men	104	103	48	100	107	51	513	
Middle	Women	105	80	56	106	103	80	530	956
	Men	100	48	22	103	106	47	426	
Old	Women	81	80	15	80	101	57	414	910
	Men	105	95	39	103	102	52	496	
TOTAL		598	507	217	597	625	367	2914	

In Pass 2, analysts performed a frame-by-frame analysis on a selection of Pass 1 clips. Each clip contained about 20 frames and it was impossible to code each Pass 1 clip (about 58,000 frames) with the available resources. To maximize the sensitivity of tests examining the differences between distracted and normal driving, the difference of primary interest, a subset of Pass 1 clips, was selected for Pass 2 coding such that the number of normal and distracted clips (based on secondary task performance) was approximately equal. The final Pass 2 sample included 403 distracted and 416 normal clips, yielding 15,962 frames. (Distracted clips were identified in Pass 1.) Again, this selection process introduced a bias in the frequency of driver distraction for Pass 2 clips, but the relative frequency of individual secondary tasks and subtasks was not affected. During Pass 2 coding analysts recorded the distracting subtask performed (if any) as well as the driver's head, eye, and hand position. Drowsiness was not coded in Pass 2, since drowsiness is a driver state and not a secondary task.

For the purposes of this report, distraction was based on secondary task performance. Secondary tasks affect driver performance to varying degrees, and for some tasks (e.g., chewing gum), the effect may be quite small and difficult to detect (Yee, Nguyen, Green, Oberholtzer, and Miller, 2006). When work on this report began, the relative demand of different secondary tasks and the point at which overload occurs were unknown.

This report deals with secondary task frequency, so Pass 1 data is primarily used for analysis. Pass 2 results are sometimes used for comparison and are included in the appendices. In addition, even though Pass 1 data included drowsiness as a secondary task, drowsiness is not considered in this report so that Pass 1 and Pass 2 data can be compared directly.

RESULTS

1. What are the types and frequencies of secondary tasks that drivers perform?

The frequency of secondary tasks from Pass 1 and Pass 2 is shown in Table 26, below. Since the Pass 1 and Pass 2 results are based on different sample sizes and the Pass 2 sample is a distraction-rich sample derived from the Pass 1 sample, the secondary task frequencies from each pass should not be equal. Another notable difference between the data from each sample is that in Pass 1, an entire 4-s clip was labeled as distracted if a task occurred at any time in the clip. In Pass 2, only the frames in which the task occurred were labeled as distracted (each frame was about 1/5 of a second in length). However, within each pass, the frequency of tasks relative to each other within each pass can be compared. Table 26 shows the number and percentage of clips/frames in the Pass 1 and Pass 2 sample that included each secondary task; only the percentage values are comparable across passes. Overall percentage was calculated as follows:

$$\text{Overall \%} = \left(\frac{\text{\# Secondary Task Clips (Frames)}}{\text{Total \# of Clips (Frames) in Sample}}\right) * 100$$

i.e., for cell phone:

$$\text{Overall Cell Phone \%} = \left(\frac{141}{2914}\right) * 100 = 4.8\%$$

Table 26. Pass 1 and Pass 2 Secondary Task Frequency and Overall Task Percentage

Secondary task	Pass 1 (4-s clips, N = 2914)		Pass 2 (5 Hz frames, N = 15962)	
	#	Overall %	#	Overall %
No secondary Task	1599	54.9	10210	64.0
Converse	572	19.6	1897	11.9
Chew gum	288	9.9	1429	9.0
Groom	222	7.6	904	5.7
Use cell phone	141	4.8	838	5.2
Use in-car system	107	3.7	253	1.6
Internal distraction	80	2.7	273	1.7
Eat/drink	71	2.4	419	2.6
Smoke	35	1.2	219	1.4
Read	5	0.2	28	0.2
Chew tobacco	0	0	0	0
Write	0	0	0	0
Type	0	0	0	0
Total	**3120**	**107.1**	**16470**	**103.2**

In spite of the various differences between samples, results from both passes were surprisingly similar. The largest difference was for conversation, where the Pass 1 task percentage (19.6%) was almost double the Pass 2 task percentage (11.9%). Note that, although used in Pass 1 coding, drowsiness was not considered a secondary task for this report, which slightly changed the overall rate of secondary tasks.

Note that because multiple tasks sometimes occurred within the same clips (or frame) the total number of tasks for each pass exceeded the total number of clips (frames) (3,120 tasks for Pass 1 in only 2,914 clips). Secondary task combinations are discussed in greater detail in the next section.

Table 27 shows the task percentages, calculated as follows:

$$\text{Task \%} = \left(\frac{\text{\# Secondary Task Clips (Frames)}}{\text{Total \# Clips (Frames) - \# of No Secondary Task Clips (Frames)}} \right) * 100$$

i.e., for cell phone:

$$\text{Cell Phone Task \%} = \left(\frac{141}{2914 - 1599} \right) * 100 = 10.7\%$$

Table 27. Comparison of Pass 1 and Pass 2 Secondary Task Percentages

Secondary task	Pass 1 task %	Pass 2 task %
Converse	43.5	33.0
Chew gum	21.9	24.8
Groom	16.9	15.7
Use cell phone	10.7	14.6
Use in-car system	8.1	4.4
Internal distraction	6.1	4.7
Eat/drink	5.4	7.3
Smoke	2.7	3.8
Read	0.4	0.5
Chew tobacco	0	0
Write	0	0
Type	0	0
Total	115.7	108.8

The results from both passes are quite similar. However, once again, the biggest difference seems to be in conversation (about 7%). Other secondary tasks such as cell phone use, eating/drinking, chewing gum, and in-car system use were between 2 and 4% different. Table 27 is organized according to Pass 1 secondary task percentages. Note that the order of secondary task frequencies according to Pass 2 is slightly different: Eating/drinking and in-car system use occupy opposite spots in the two rankings. In both samples, conversation is by far the most frequent secondary task, followed by chewing gum, grooming, and cell phone use. No instances of chewing tobacco, writing, or typing were observed in either Pass 1 or Pass 2.

Both Pass 1 and Pass 2 data sets are biased, but each in its own way. Remember that Pass 1 clips were selected so that each age group x sex x road type cell included the same number of clips (although this was impossible for some combinations). Pass 2 data, on the other hand, was selected so that the number of secondary task clips was approximately equal to the number of clips that did not include a secondary task. Because of this difference, the Pass 1 and Pass 2 frequencies and percentages (as shown in Table 27) are independently useful, but are not comparable to each other. Pass 1 data provides a more realistic representation of the actual frequency of secondary tasks during normal driving. To make data from both samples comparable, the distracted driving bias was removed from Pass 2 data in the following way:

Determine the percentage of secondary task clips in both passes.

Pass 1:

2,914 (total clips) – 1,599 (no secondary task clips) = 1,315 secondary task clips
Percentage of secondary task clips to total: 1,315 / 2,914 = 0.451 x 100 = **45.1%**

Pass 2:

Percentage of secondary task clips to total: 403 / 819 = 0.492 x 100 = **49.2%**

Determine weighting factor

45.1 / 49.2 = **0.92**

By multiplying the Pass 2 secondary task frequencies by this weighting factor, the secondary task bias is removed from Pass 2 and the two samples are comparable. For example, the original Pass 2, no secondary task percentage was 64.0%. Multiplying that by the weighting factor yields 58.9% (64.0 x 0.92 = 58.9). The Pass 1 and weighted Pass 2 secondary task percentages for all secondary tasks are shown in Table 28.

Additional analysis, which was beyond the scope of this project, could be done to weight each category by exposure. This could be done for individual categories, such as road type, but not for combinations of categories, such as road type x age group, because the needed combinatorial data from the original ACAS sample were unavailable.

Table 28. Overall Task Percentages for Pass 1, Pass 2, and Weighted Pass 2 Data by Pass 1 Secondary Task Frequency (Weighting factor = 0.92.)

Secondary task	Pass 1	Pass 2	
	Overall %	Overall %	Overall weighted %
No secondary task	54.9	64.0	58.9
Converse	19.6	11.9	10.9
Chew gum	9.9	9.0	8.3
Groom	7.6	5.7	5.2
Use cell phone	4.8	5.2	4.8
Use in-car system	3.7	1.6	1.5
Internal distraction	2.7	1.7	1.6
Eat/drink	2.4	2.6	2.4
Smoke	1.2	1.4	1.3
Read	0.2	0.2	0.2
Chew tobacco	0	0	0
Write	0	0	0
Type	0	0	0
Total	**107.1**	**103.3**	**95.0**

Note that the total percentage of secondary tasks is lower than 100 for the weighted Pass 2 data because secondary task clips were overrepresented in Pass 2. The weighted Pass 2 total percentage of 95% indicates that due to the bias in selection, the sample size would have to be larger in order to produce the same results. The weighted Pass 2 percentages will not be used for further analysis, although it is important to point out how the two samples compare and the effect of using different selection criteria for each.

2. How often did two or more secondary tasks occur in the same clip?

In Pass 1 clips, drivers occasionally performed 2 or even 3 secondary tasks in a single 4-second clip. Secondary tasks performed in the same clip will be referred to as concurrent tasks as drivers perform them at more or less the same time. There were a total of 202 clips where a driver performed 2 concurrent tasks and only 2 clips where a driver performed 3 concurrent tasks, for a total of 204 concurrent task clips. (See Appendix A.) There were 1,111 clips that contained a single secondary task, so concurrent task clips comprise 15.5% ([204/1,315]*100) of all secondary task clips, and 7.0% ([204/2,914]*100) of all Pass 1 clips (Table 29).

Table 29. Frequency of Independent and Double Concurrent Secondary Task Clips, Pass 1

Secondary task	**Use cell phone**	**Eat/ drink**	**Smoke**	**Chew gum**	**Groom**	**Read**	**Use in-car system**	**Internal distraction**	**Converse**
Use cell phone	115 **(3.9)**	4	1	10	3	0	1	5	1
Eat/drink	4	53 **(1.8)**	1	0	1	1	1	4	6
Smoke	1	1	26 **(0.9)**	0	2	0	2	1	2
Chew gum	10	0	0	221 **(7.6)**	7	0	9	5	34
Groom	3	1	2	7	148 **(5.1)**	0	4	4	53
Read	0	1	0	0	0	3 **(0.1)**	0	0	0
Use in-car System	1	1	2	9	4	0	67 **(2.3)**	1	22
Internal distraction	5	4	1	5	4	0	1	42 **(1.4)**	17
Converse	1	6	2	34	53	0	22	17	436 **(15.0)**
Total	140 **(4.8)**	71 **(2.4)**	35 **(1.2)**	286 **(9.8)**	222 **(7.6)**	4 **(0.1)**	107 **(3.7)**	79 **(2.7)**	571 **(19.6)**

Triple Concurrent Tasks: Conversation & In-Car System Use & Internal Distraction - 1
Chewing Gum & Cell Phone & Reading - 1

Pass 2 data has a lower incidence of concurrent tasks, which is not surprising since Pass 2 used a smaller time window (0.2 seconds). Pass 2 concurrent tasks must be performed in the same frame, not just the same clip, so nearly simultaneously. In Pass 2 there were a total of 508 frames where a driver performed 2 concurrent tasks and 0 frames where a driver performed 3 concurrent tasks. There were 5,244 frames that contained a single secondary task, so concurrent task frames comprise 8.8% ([508/5,752]*100) of all secondary task frames. The Pass 1 triple task combinations were conversation & in-car system use & internal distraction, and chewing gum & cell phone use & reading.

Table 30 shows all Pass 1 concurrent task combinations that occurred more than 4 clips, an arbitrary cut off to make the data manageable and a value below which occurrences were too rare to be statistically meaningful. Expected frequencies were determined by multiplying the overall probabilities of each task. For example, the expected frequency for Smoking (1.2%) while Chewing Gum (9.9%) would be 0.12% (0.012 x 0.099 = 0.0012). An O/E ratio > 1 indicates that that task concurrence occurred less frequently than expected, so an O/E ratio of 0.25 indicates the observed frequency was only 1/4 of the expected frequency. Note that 9 of the 10 most common 2 task combinations involve conversation or chewing gum, both tasks with a low perceived demand (Yee, Nguyen, Green, Oberholtzer, and Miller, 2006), thought there does not seem to be any pattern to combinations that lead to large or small O/E ratios. Because the Pass 1 data is based on 4-s clips, it is theoretically possible for drivers to switch between tasks in that time frame. However, review of the Pass 2 data, indicates that that it not typically the case and that drivers usually perform concurrent tasks in the same frame.

Table 30. Pass 1 Concurrent Tasks with Observed Frequency > 4

Task 1 freq. (overall %)	**Task 2 freq. (overall %)**	**Expected joint freq. (%)**	**Observed joint freq. (%)**	**Observed % / expected %**
Conversation, 572 **(19.6)**	Grooming, 222 **(7.6)**	*44 - 45* **(1.5)**	53 **(1.8)**	1.2
	Chewing gum, 288 **(9.9)**	*54 – 56* **(1.9)**	34 **(1.2)**	0.63
	In-car system use, 107 **(3.7)**	*20 – 21* **(0.7)**	23 **(0.8)**	1.13
	Internal distraction, 80 **(2.7)**	*14 – 16* **(0.5)**	18 **(0.6)**	1.2
Chewing gum, 288 **(9.9)**	Cell phone use, 141 **(4.8)**	*14 – 16* **(0.5)**	11 **(0.4)**	0.8
	In-car system use, 107 **(3.7)**	*11 – 13* **(0.4)**	9 **(0.3)**	0.75
	Grooming, 222 **(7.6)**	*22 – 24* **(0.8)**	7 **(0.2)**	0.25
Conversation, 572 **(19.6)**	Eating/drinking, 71 **(2.4)**	*14 – 16* **(0.5)**	6 **(0.2)**	0.4
Chewing gum, 288 **(9.9)**	Internal distraction, 80 **(2.7)**	*8 – 10* **(0.3)**	5 **(0.2)**	0.67
Cell phone use, 141 **(4.8)**	Internal distraction, 80 **(2.7)**	*2 – 4* **(0.1)**	5 **(0.2)**	2

3. How did age group and driver sex affect secondary task performance?

There are a number of ways in which this data could have been analyzed such as Cochran's Q or a Friedman 2-way analysis of variance, where the factors of interest were task, age, sex, road class, and so forth, and their interaction. However for this data, some tasks were rare or never occurred (e.g., read, type, write, and chew tobacco), so there was no reason to include them in the analyses. In other cases, for example for smoking, there were many instances where the cell sizes were small, often less than 5 and sometimes less than 10. To be reliable, many nonparametric tests, such as chi-square distribution, require cell samples of not close to zero. There are likely to be procedures to deal with empty and nearly empty cells. Given resource limitations, straightforward chi-square tests were used to determine if there were differences for each secondary task as a function of the factors of interest, age and sex. Use of more sophisticated procedures is unlikely to have a substantial impact on the report findings.

As before, the total number of secondary tasks observed is greater than the total number of clips because drivers sometimes performed concurrent tasks (2 or 3) in the same clip. Furthermore, even though an effort was made to equalize the cells for age and sex, they are not equal.

As shown in Table 31, there were 4 tasks whose frequency of occurrence differed due to driver age group: conversing, using a cell phone, eating/drinking, and smoking. (See Appendix B for all tasks.) There were no consistent age differences across tasks. Older drivers were more likely to engage in conversation whereas younger drivers were more likely to use a phone while driving, and both young and middle aged drivers were more likely to eat, drink, and/or smoke while driving. In fact, 74% of all the cell phone use while driving was associated with younger drivers.

Table 31. Tasks Whose Frequency Significantly Varied with Driver Age Group

Secondary task	**Age group**			**Total**
	Young	**Middle**	**Old**	
	1048	956	910	2914
Converse ***	189 (18.0)	161 (16.8)	222 (24.4)	572 (**19.6**)
Use cell phone ***	104 (9.9)	28 (2.9)	9 (1.0)	141 (**4.8**)
Eat/drink **	29 (2.7)	31 (3.2)	11 (1.2)	71 (**2.4**)
Smoke ***	16 (1.5)	19 (2.0)	0 (0.0)	35 (**1.2**)

Each cell shows the frequency and, in parentheses, the percentage of occurrence.

**=p<.01, ***=p<.001

In this data set, women both conversed and smoked significantly more than men, but men used the phone and in-car systems more than women (Table 32). The conversation and phone use data are certainly likely to lead to additional discussion.

Table 32. Tasks Whose Frequency Significantly Varied with Driver Sex

Secondary task	Driver sex		Total
	Women	**Men**	
	1479	**1435**	**2914**
Converse ***	355 (24.0)	217 (15.1)	572 (**19.6**)
Use cell phone ***	49 (3.3)	92 (6.4)	141 (**4.8**)
Smoke ***	32 (2.1)	3 (0.2)	35 (**1.2**)
Use in-car system **	41 (2.7)	66 (4.6)	107 (**3.7**)

**=p<.01, ***=p<.001

4. How did road type, traffic, and speed affect secondary task performance?

Figure 6 shows the distribution of clips by road type. As previously mentioned, clips from rarely traveled road types (such as unpaved roads and ramps) were excluded from the sample, so only the 6 major road types were analyzed. As with age group and driver sex, clips were selected in an attempt to equalize the number of clips from each road type, and clips were reasonably well balanced across superclasses (pairs of road classes).

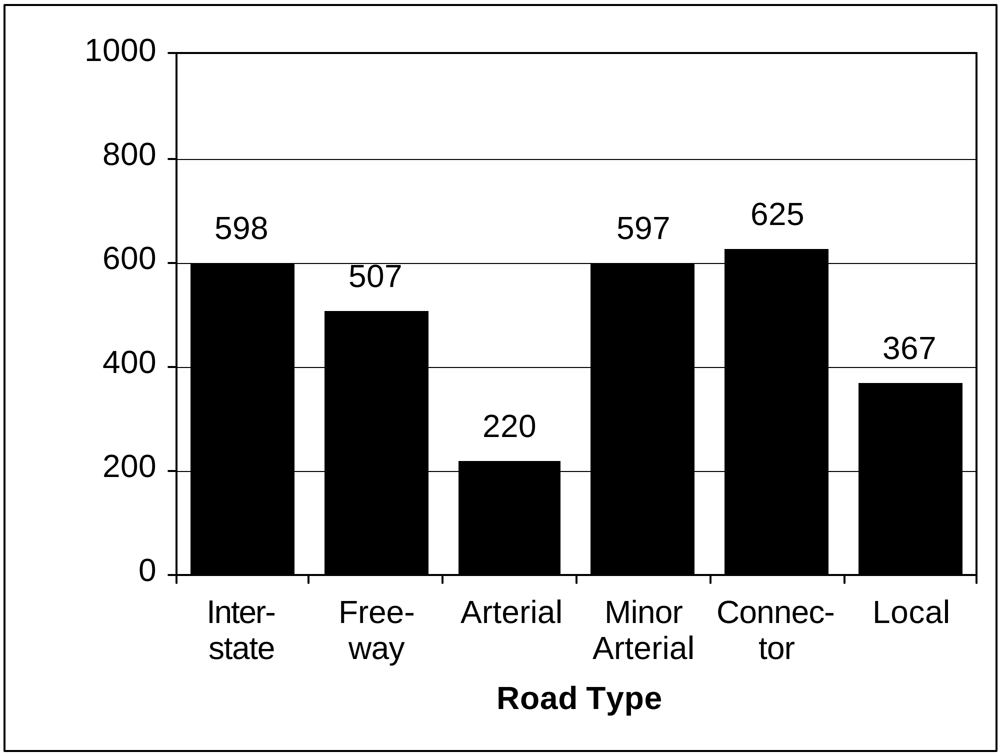

Figure 6. Distribution of Pass 1 Clips by Road Type (N = 2914)

As shown in Table 33, only conversing and eating/drinking varied with road type with conversation being most likely on minor roads (connector and local). However, even statistically different, there is some reason to doubt these results as interstates and freeways are essentially the same class of road, yet for conversation the task frequency differs by 6%. (See Appendix C for additional data on Road Type.)

Table 33. Tasks Whose Frequency Significantly Varied with Road Type

Secondary task	**Road type**						**Total**
	Inter-state	**Free-way**	**Arterial**	**Minor arterial**	**Connector**	**Local**	
	598	507	220	597	625	367	2914
Converse **	90 (15.1)	108 (21.3)	37 (16.8)	113 (18.9)	129 (20.6)	95 (25.9)	572 (**19.6**)
Eat/drink *	23 (3.9)	6 (1.2)	8 (3.6)	17 (2.9)	12 (1.9)	5 (1.4)	71 (**2.4**)

∗=p<0.05, ∗∗=p<0.01

Traffic was measured using forward-looking radar that continuously tracked targets (other vehicles) in its field of view. To facilitate the analysis that follows, target counts were rounded off for each clip. The mean target counts were usually not integers because the number of targets detected varied continuously over the 4 s interval. One disadvantage of rounding is that all intervals are not equally sized. Zero represents the range from 0 to almost 0.5, 1 from 0.5 to almost 1.5, and so forth. The 5+ value is all counts above 4.5. As shown in Figure 7, the most common number of targets was 1.

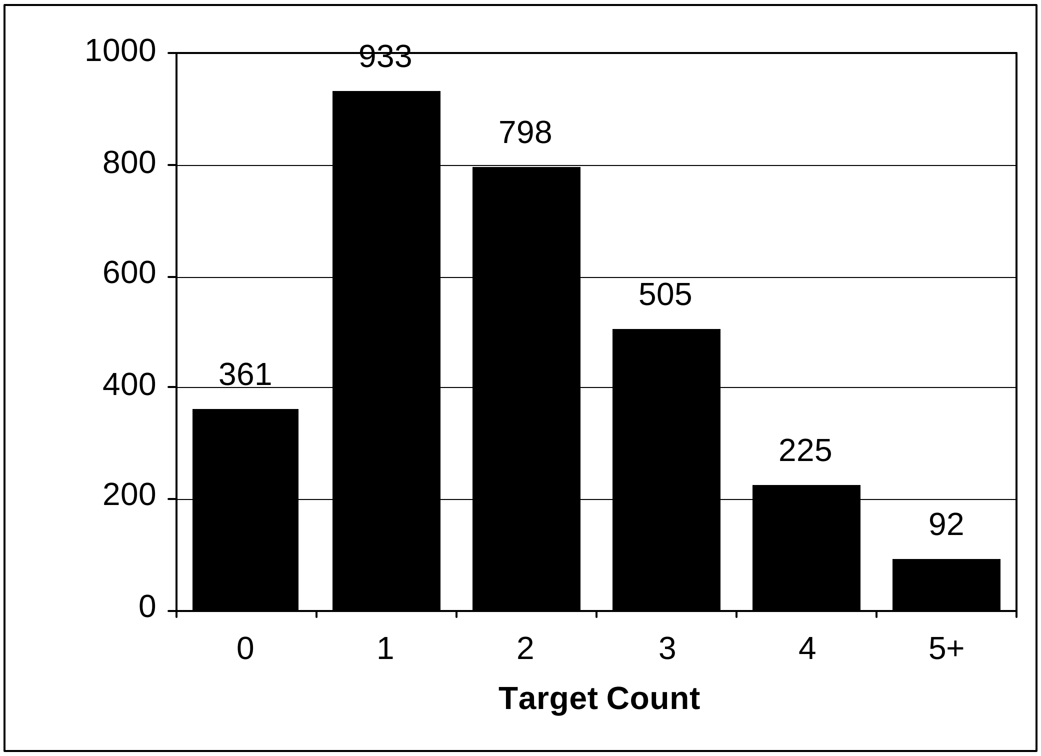

Figure 7. Distribution of Pass 1 Clips by Target Count

Table 34 shows that 5 secondary tasks varied significantly with target count (traffic). However, the patterns are difficult to explain. Grooming increased somewhat with traffic whereas cell phone use increased substantially. Internal distractions and chewing gum decreased, and conversation was most common for midrange traffic levels. One possible explanation could be these differences actually reflect interactions of traffic with other factors such as road type. Another explanation is that these differences are statistical artifacts. Pooling heavy traffic (5, 6, and 7 targets) led to statistically significant differences for internal distraction and conversation whereas differences due to traffic were no longer statistically significant for eating/drinking. Keep in mind that this data was not balanced due to age and sex, both of which did significantly affect task performance.

Table 34. Tasks Whose Frequency Significantly Varied with Traffic

Secondary task	Pooled target count (traffic)						Total
	0	**1**	**2**	**3**	**4**	**5 +**	
	361	933	798	505	225	92	2914
Converse *	58 (16.0)	176 (18.9)	180 (22.6)	108 (21.4)	36 (16.0)	14 (15.2)	572 (**19.6**)
Chew gum **	53 (14.7)	93 (10.0)	83 (10.4)	38 (7.5)	13 (5.8)	8 (8.7)	288 (**9.9**)
Groom *	20 (5.5)	57 (5.1)	63 (7.9)	49 (9.7)	23 (10.2)	10 (10.9)	222 (**7.6**)
Use cell phone ***	5 (1.3)	43 (4.6)	40 (5.0)	22 (4.4)	19 (8.4)	12 (13.0)	141 (**4.8**)
Internal distraction **	13 (3.6)	33 (3.5)	25 (3.1)	7 (1.4)	2 (0.9)	0 (0.0)	80 (**2.8**)

∗=p<0.05, ∗∗=p<0.01, ***=p<0.001

Vehicle speed categories were computed in a manner similar to that for traffic (Figure 8) with each category representing plus or minus 2.5 m/s except for the 6 m/s category (which is 0 to 7.5 m/s) and the greatest (which is anything greater than 32.5). Thus, as before, the categories are of slightly unequal range. Regardless of the pooling method used, the result was the same: The frequency with which each secondary task was performed did not vary significantly with speed. (See Appendix C for pooled and unpooled Pass 1 and Pass 2 data for all tasks.)

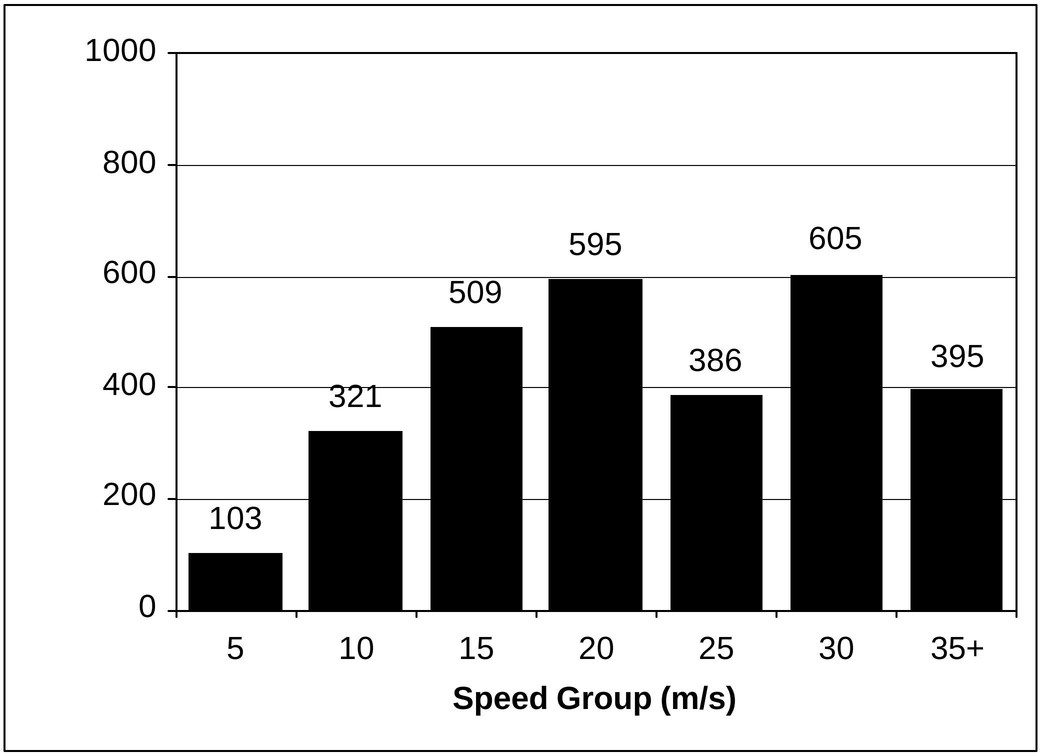

Figure 8. Distribution of Pass 1 Clips by Speed (m/s) Group

5. How did time of day, lighting level, and day of week affect secondary task performance?

To examine time of day effects, hourly data was pooled into 8, 3-hour time groups (Figure 9). As one would expect, there were few clips (little driving) between midnight and 6:00 a.m., and exposure peaked between 3:00 and 5:00 p.m. (See Appendix D for Pass 1 and Pass 2 data for all tasks.)

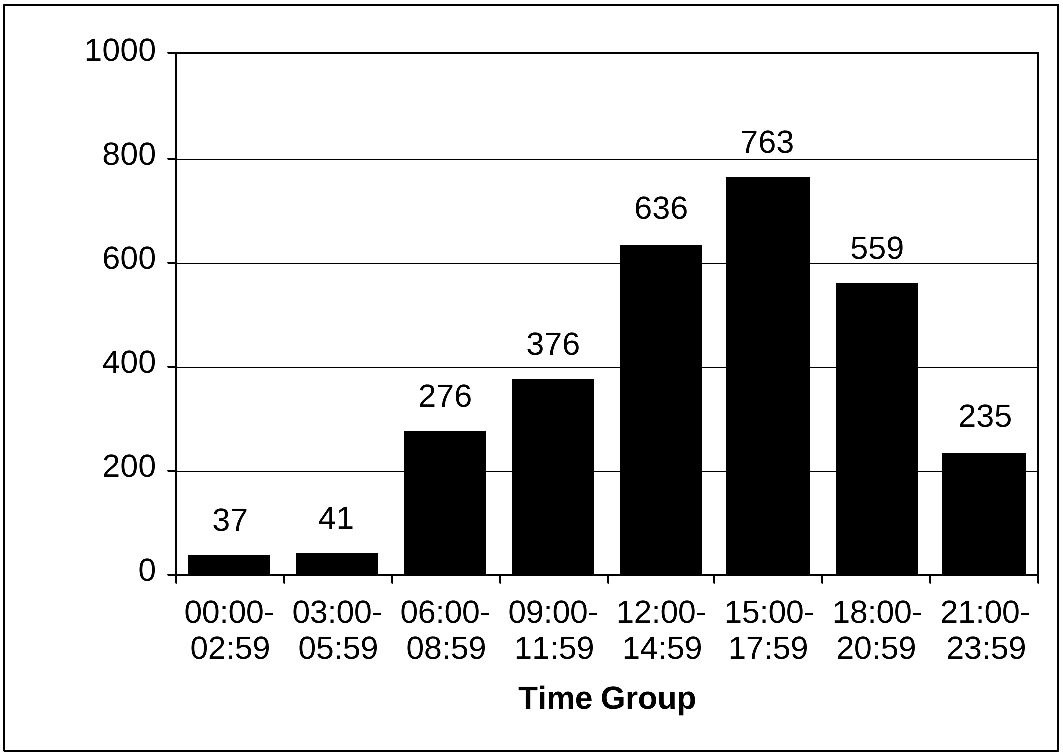

Figure 9. Distribution of Pass 1 Clips by Time of Day Group

Two tasks varied significantly in their frequency of occurrence with time of day, conversation dropping off late at night (3 to 6AM, but also between 6 and 9 AM) and cell phone use (with no use observed between midnight and 6AM). In brief, when most people are asleep, there is no one with whom to talk. (See Table 35.)

Table 35. Tasks Whose Frequency Significantly Varied with Time of Day

Significant secondary task	**Time group**								**Total**
	24:00-2:59	**3:00-5:59**	**6:00-8:59**	**9:00-11:59**	**12:00-14:59**	**15:00-17:59**	**18:00-20:59**	**21:00-23:59**	
	37	41	276	376	636	763	559	235	2914
Converse ***	7 (18.9)	1 (2.4)	33 (12.0)	87 (23.7)	131 (20.6)	150 (19.7)	123 (22.0)	40 (17.0)	572 **(19.6)**
Use Cell Phone ***	0 (0.0)	0 (0.0)	7 (2.5)	11 (3.0)	32 (5.0)	52 (6.8)	18 (3.2)	21 (8.9)	141 **(4.8)**

***=p<0.001

Light level was rated on a binary scale indicating only light conditions (daytime) and dark conditions (nighttime). Light level was determined by examining the solar zenith angle, the angle between the sun and the vertical. When the solar zenith angle was less than or equal to 96 degrees, driving data was coded “day;” when greater than or equal to 96 degrees, it was coded “night.” Interestingly, when the data is just split into light and dark (based on data from a light level sensor), only conversation varies significantly between the 2 conditions. Again, the difference is more likely due to factors other than lighting.

Table 36. Tasks Whose Frequency Significantly Varied with Lighting

Secondary task	**Lighting**		**Total**
	Light **2101**	**Dark** **813**	**2914**
Converse **	440 (20.9)	132 (16.2)	572 (19.3)

∗∗=p<0.01

Date was used to determine the distribution of clips by day of the week (Figure 10). Saturday had the highest clip frequency, Thursday had the lowest, and the remaining days were roughly even. This difference is probably just random variation.

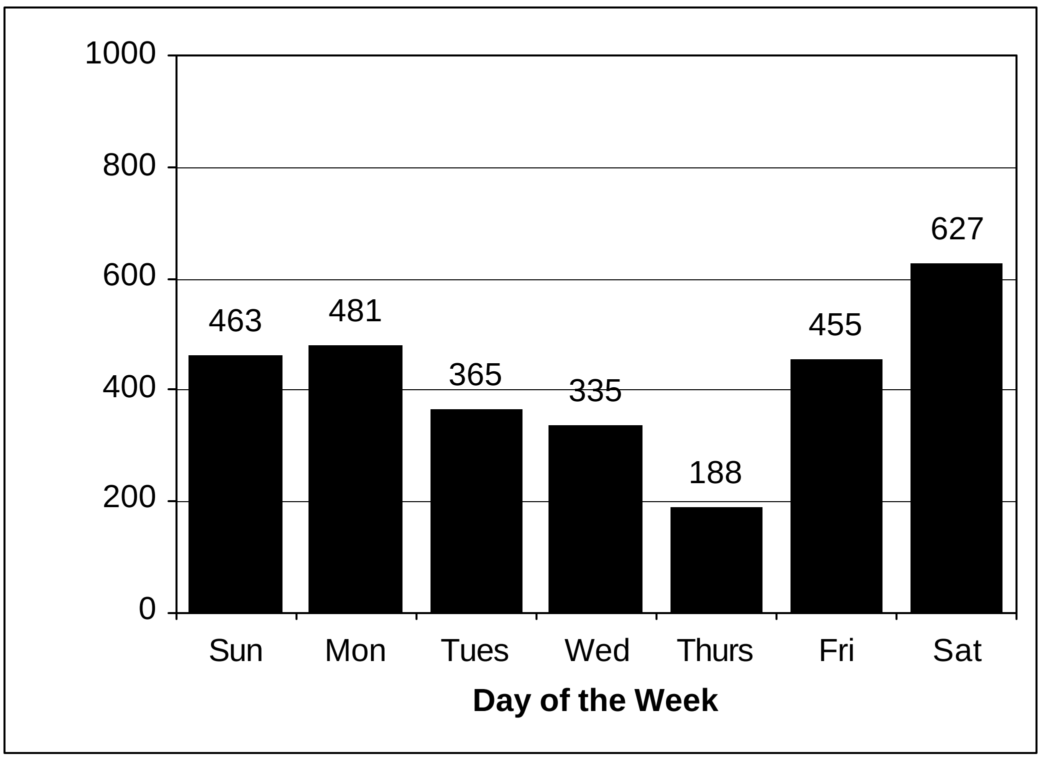

Figure 10. Distribution of Pass 1 Clips by Day of the Week (N = 2914)

The frequency of occurrence of conversation, cell phone use, and eating/drinking all varied significantly with the day of the week (Table 37). Conversation was more common on the weekends (and Fridays) when pleasure trips involving passengers were more common. Throughout the weekdays, the trend was for conversation to increase.

Cell phone use is difficult to explain, with a substantial increase on Mondays. Otherwise, the data resembles that reported in the surveys of cell phone use, where usage was about 5% in 2004 (Glassbrenner, 2005).

Table 37. Tasks Whose Frequency Significantly Varied with Time of Day

Secondary task	**Day of the week**							**Total**
	Sun 463	**Mon** 481	**Tues** 365	**Wed** 335	**Thurs** 188	**Fri** 455	**Sat** 627	2914
Converse **	111 (24.0)	72 (15.0)	57 (15.6)	60 (17.9)	32 (17.0)	99 (21.8)	141 (22.5)	572 (**19.6**)
Use cell phone ***	11 (2.4)	54 (11.2)	15 (4.1)	17 (5.1)	5 (2.7)	16 (3.5)	23 (3.7)	141 **(4.8)**
Eat/drink *	6 (1.3)	13 (2.7)	5 (1.3)	16 (4.8)	2 (1.1)	11 (2.4)	18 (2.9)	71 **(2.4)**

∗=p<0.05, ∗∗=p<0.01, ***=p<0.001

6. How did outside temperature affect secondary task performance?

The outside temperature range was divided into 5 categories so there would be an adequate number of occurrences of tasks in each cell (more than 5 to 10, depending on the task), but not so few that temperature differences would be masked. The 5 categories roughly correspond to regions of human comfort—freezing (<0), cold enough to need a coat (0 - <10), cold enough to need a jacket (10 - <20), comfortable (20-26.6), and warm to hot (>=26.6). (See Table 38.)

Table 38. Tasks Whose Frequency Significantly Varied with Outside Temperature

Secondary task	**Outside temperature (deg C)**					**Total**
	<0 375	**0 - <10** 721	**10 - <20** 894	**20 - <26.6** 643	**>=26.6** 281	2914
Converse **	51 (13.6)	135 (18.7)	173 (19.4)	154 (24.0)	59 (21.0)	572 (**19.6**)
Gum **	44 (11.7)	92 (12.8)	75 (8.4)	48 (7.5)	29 (10.3)	288 (**9.9**)
Groom ***	12 (3.2)	40 (5.6)	77 (8.6)	64 (10.0)	29 (10.3)	222 (**7.6**)
Use cell phone ***	24 (6.4)	21 (2.9)	31 (3.5)	38 (5.9)	27 (9.6)	141 (**4.8**)
Smoke *	0 (0.0)	10 (1.4)	14 (1.6)	6 (0.9)	5 (1.8)	35 (**1.2**)

∗=p<0.05, ∗∗=p<0.01, ***=p<0.001

Outside temperature significantly affected the 5 tasks. People conversed less when it was somewhat or very cold (for unknown reasons) and groomed less when it was somewhat or very cold (probably due to wearing gloves). They smoked less when it was very cold (probably because it was hard to hold the cigarette). They chewed gum less at comfortable temperatures, for no reason the authors can think of (other than they may have eaten instead). Cell phone use was greatest at the highest temperatures.

7. How often did each subtask occur?

The following tables show the overall subtask frequencies of tasks observed during Pass 2 coding. A detailed definition of each subtask can be found in Appendix F. Remember that the Pass 2 frequencies are based on the number of frames, not the number of clips. Each clip contained about 20 frames, so 20 data points in a cell may represent a single driver who performed a secondary task for the duration of a clip. Remember also that the Pass 2 sampling bias intended to equalize the number of normal vs. secondary task clips, which had the effect of over sampling the secondary task clips. The distribution of subtasks within each task, however, is unaffected by the sampling bias. In many instances, there are too few independent observations to support any reliable statistical analyses, so differences due to road type, age group, and driver sex were not explored.

<u>1: Cell Phone</u>
Table 39 shows that cell phone use was observed in 838 of the total 15,962 frames. The most frequent cell phone subtask was 1.4: Conduct cell phone conversation. This was expected, since subtask 1.4 tends to be much longer than any other cell phone subtask. Preparing to use the phone, dialing (hands free), and answering have very short durations and were not observed at all in Pass 2 coding.

Table 39. Distribution of Cell Phone Subtasks, Pass 2

Subtask	Description	# Frames
1.1	Prepare to use cell phone	0
1.2	Dial phone - Hand held	17
1.3	Dial phone - Hands free	0
1.4	Conduct cell phone conversation	792
1.5	Hold cell phone	16
1.6	Hang up cell phone/end call	13
1.7	Answer cell phone	0
	Total	**838**

<u>2: Eating/Drinking</u>
Table 40 shows that eating/drinking subtasks were observed in 419 of the total 15,962 frames. The most frequent eating/drinking subtask was 2.5: Chew food. Subtask 2.5 tends to be much longer then other eating/drinking subtasks. Drinking from open top

container and spills were not observed at all in Pass 2 (dealing will spills would have occurred out of the camera field of view).

Table 40. Distribution of Eating/Drinking Subtasks, Pass 2

Subtask	Description	# Frames
2.1	Prepare to eat	16
2.2	Prepare to drink	18
2.3	Eat/bite food - not wrapped	12
2.4	Eat/bite food - wrapped	13
2.5	Chew food	165
2.6	Drink from straw or sip from opening (i.e. can, bottle)	112
2.7	Drink from open top container (cup)	0
2.8	Finish eating	1
2.9	Finish drinking	28
2.10	Spill/drop food	0
2.11	Spill/drop drink	0
2.12	Hold food/drink	54
	Total	**419**

3: Smoking
Table 41 shows that smoking-related subtasks were observed in 219 of the total 15,962 frames, with holding a cigar/cigarette being most common, occurring about 1.3 times as often as smoking. The only other smoking task observed was ashing (removing the ashes). The brief tasks of lighting and disposal were not observed.

Table 41. Distribution of Smoking Subtasks, Pass 2

Subtask	Description	# Frames
3.1	Prepare to light cigar/cigarette	0
3.2	Light cigar/cigarette	0
3.3	Smoke cigar/cigarette	89
3.4	Finish smoking	0
3.5	Hold cigar/cigarette	117
3.6	Ash cigar/cigarette	13
	Total	**219**

4: Chewing Tobacco
No drivers were observed chewing tobacco in the Pass 2 data. This is an uncommon task, though one more likely with rural locations and in the south. In addition, given the limitations of the video data it may be easy to confuse chewing gum and chewing tobacco.

5: Chewing Gum

Table 42 shows that chewing gum was observed in 1,429 of the total 15,962 frames. Gum chewing was included because sometimes cessation of gum chewing can be an indication of task overload. The most frequent subtask was 5.5: Chew gum, which had the longest duration of the chewing gum subtasks. Except for biting/licking lips, no other chewing gum subtasks were observed. Distinguishing between these 3 chewing-like tasks was sometimes difficult.

Table 42. Distribution of Chewing Gum Subtasks, Pass 2

Subtask	Description	# Frames
5.1	Hold gum in mouth	24
5.2	Prepare to chew gum	1
5.3	Blow gum bubble	0
5.4	Remove popped gum bubble	0
5.5	Chew gum	787
5.6	Bite/lick lips - chewing gum	469
5.7	Tongue motion - chewing gum	148
5.8	Finish chewing gum	0
5.10	Other - chewing gum	0
	Total	**1429**

6: Grooming

Table 43 shows that a grooming-related subtask was observed in 904 of the total 15,962 frames. The most frequent grooming subtask was 6.2: Groom – hand only, which had the longest duration of all grooming subtasks. This includes activities such as brushing hair away from the face, rubbing one's eyes, and so forth. Subtasks related to using grooming tools were hardly observed at all.

Table 43. Distribution of Grooming Subtasks, Pass 2

Subtask	Description	# Frames
6.1	Prepare to groom	67
6.2	Groom - hand only	756
6.3	Groom - using tool	11
6.4	Hold grooming Tool	0
6.5	Finish grooming	70
	Total	**904**

7: Reading

As shown in Table 44, reading-related subtasks almost never occurred. They were observed in only 28 of the total 15,962 frames, with the most frequent task being reading.

Table 44. Distribution of Reading Subtasks, Pass 2

Subtask	Description	# Frames
7.1	Prepare to read	3
7.2	Read	25
7.3	Put away/fold reading materials	0
	Total	**28**

8: Writing
Writing subtasks were not observed in Pass 2 (or Pass 1).

9: Typing
Typing subtasks were not observed in Pass 2 (or Pass 1).

10: In-Car System Use
Table 45 shows that an in-car system use related subtask was observed in 253 of the total 15,962 frames. The most frequent in-car system use subtask was 10.6: Glance only – monitor in-car system (such as glancing at the speedometer). Several in-car system use subtasks were not observed. However, with no eye-tracking capabilities, and limited video data capabilities it was often difficult to determine exactly which object drivers were looking at and/or manipulating.

Table 45. Distribution of In-Car System Use Subtasks, Pass 2

Subtask	Description	# Frames
10.1	No adjustment of in-car system	0
10.2	Control steering wheel	0
10.3	Control stalk	0
10.4	Control IP, column or center console	67
10.5	Control door	3
10.6	Glance only - monitor in-car system	175
10.7	Other or unknown - in-car system use	8
	Total	**253**

11: Internal Distraction
Table 46 shows that an internal distraction-related subtask was observed in 273 of the total 15,962 frames. The most frequent internal distraction subtask was 11.4: Glance only – monitor internal distraction. Distractions related to pets and insects were not observed.

Table 46. Distribution of Internal Distraction Subtasks, Pass 2

Subtask	Description	# Frames
11.1	Catch object, prevent object from moving	103
11.2	Insect related distraction	0
11.3	Pet related distraction	0
11.4	Glance only - monitor internal distraction	156
11.5	Other - internal distraction	14
	Total	**273**

12: Drowsiness
As previously mentioned, drowsiness was not coded in Pass 2.

13: Conversation
Table 47 shows that a conversation-related subtask was observed in 1,897 of the total 15,962 frames. The most frequent conversation subtask was 13.1: Converse with unknown. There is a surprisingly large difference in observed frequency of subtask 13.1 compared to 13.2: Converse with passenger – speak and 13.3: Converse with passenger – listen. This is likely due to the lack of audio-video data. It was difficult to determine if a passenger was present because of the limited field of view of the camera and its aim. Therefore the differences in subtask frequencies represent an approximation of relative subtask performance.

Table 47. Distribution of Conversation Subtasks, Pass 2

Subtask	Description	# Frames
13.1	Converse with unknown	1603
13.2	Converse with passenger - speak	119
13.3	Converse with passenger - listen	166
13.4	Sing/talk to self	9
13.5	Talk to someone outside vehicle (not by phone)	0
13.6	Road rage	0
	Total	**1897**

Thus, even though the data set was large, when the data is partitioned to the subtask level, the subtask frequencies are low and should be treated as suggestive rather than confirmatory.

CONCLUSIONS

1. What are the types and frequencies of secondary tasks that drivers perform?

Secondary task frequencies were similar for both Pass 1 and Pass 2 samples despite different selection techniques. No secondary tasks were performed in 55% of Pass 1 clips and in 64% of Pass 2 frames. In both Pass 1 and Pass 2, conversation was the most frequently observed task (12-20%), followed by chewing gum (9-10%) and then grooming (6-8%). Cell phone-related tasks, often the center of hot debate about driver distractions, were found in only 5% of Pass 1 clips and Pass 2 frames. Some tasks in the coding scheme (chewing tobacco, writing, and typing) were not observed at all.

It is important to note that the task frequencies from Pass 1 are based on a sample stratified by road type, driver age, and driver sex so those differences could examined, Furthermore, Pass 2 is a sample of Pass 1 intended to equalize the number of distracted and nondistracted clips. However, the relative frequencies of distracting tasks should be consistent in their rank order with the unsampled real world.

2. How often did two or more secondary tasks occur in the same clip?

Drivers sometimes performed 2 or even 3 distracting tasks in the same clip. Based on the Pass 1 data, concurrent tasks occur in 7% of all clips, but 16% of the time when a task occurred there was more than 1 secondary task. Keep in mind that because of the manner in which Pass 1 was coded, some of the concurrent task situations could be where 2 tasks occurred in close succession (in the same 4 s sample). The most common task combination was conversation and grooming followed by conversation and chewing gum. Indeed conversation was present in the top 4 statistically significant task combinations and appeared a total of 5 times out of the 10 statistically significant task combinations. Note that 2 instances were observed where drivers performed 3 secondary tasks at the same time (or almost the same time).

3. How did age group and driver sex affect secondary task performance?

Pass 1 data was used to analyze task performance according to driver characteristics. Results of a chi-squared test showed that cell phone use, eating/drinking, smoking, and conversation had a significance of =$p<0.05$ less (confidence of 95% or higher) for age group analysis. The normalized data provides a better medium for comparing age group effects because it is unaffected by the frequency of each task. The age analysis showed that age significantly affects performance of specific tasks, but not all distracting tasks, and that is there is no common trend across all statistically significant tasks according to age group. However, age group 3 (age 65+) consistently had the lowest task performance rates, with the exception of conversation, which occurred most frequently in that age group.

Chi-squared tests showed that cell phone use, smoking, in-car system use, and conversation were statistically significant for driver sex. Driver sex did not appear to have a common effect on all significantly significant tasks.

4. How did road type, traffic, and speed affect secondary task performance?

Pass 1 data was used to analyze task performance according to driving variables. Chi-squared tests showed that cell phone use, eating/drinking, and conversation were statistically significant for road type. According to normalized data, all significant tasks follow the road type distribution of the total sample distribution quite closely; therefore, it does not appear that road type has a serious impact on performance of these distracting tasks.

Chi-squared tests showed that cell phone use, eating/drinking, and chewing gum were statistically significant for target count (the method used to measure traffic). Somewhat surprisingly, far more cell phone use occurs in heavy traffic (target count 7) than any other target count category. Eating/drinking is highest for somewhat heavy traffic (target count 6) and chewing gum is the opposite, with most task performance in very light to light traffic (target count 0, 1, and 2) and no record of performance in heavy traffic (target count 6 and 7).

Chi-squared tests showed that only eating/drinking was statistically significant for speed (according to pooled speed groups). The rate of eating/drinking is highest for the upper and lower speed groups and lowest for the middle speed group. However, although these results may be illustrative, the sample size involved was quite small and since it was the only statistically significant task, no comparisons could be made.

5. How did time of day and day of week affect secondary task performance?

Pass 1 data was used to analyze task performance according to time variables. Chi-squared tests showed that cell phone use, eating/drinking, and conversation were statistically significant for pooled time of day. Cell phone use is relatively consistent throughout the day excluding time group 4 (2:30 a.m. – 5:29 a.m.) , where 0 cell phone-related tasks were observed and time groups 16 (2:30 p.m. – 5:29 p.m.) and 22 (8:30 p.m. – 11:29 p.m.) where the values were higher than in any other time group. Eating/Drinking was fairly consistent through the daytime and highest in the late night and early morning. Conversation is quite consistent throughout the day with the exception of time groups 4 (2:30 a.m. – 5:29 a.m.) and 7 (5:30 a.m. – 8:29 a.m.).

Chi-squared tests showed that cell phone use, eating/drinking, and conversation were statistically significant for day of the week. Cell phone use was relatively consistent throughout the week with the exception of Monday, when cell phone use was more than twice the next highest frequency value. Eating/drinking was also fairly consistent throughout the week with a peak on Wednesday. The leap in the eating/drinking data is not quite as significant as the cell phone use leap. Conversation frequency is very consistent throughout the week with considerably higher values Friday, Saturday, and Sunday.

6. How did outside temperature and light level affect secondary task performance?

Pass 1 data was used to analyze task performance according to environmental characteristics. Chi-squared tests showed that smoking, chewing gum, grooming, and conversation were statistically significant for outside temperature. Task performance rates appear to increase with increased temperature for grooming and conversation. Smoking was also highest for above freezing temperatures, but was not observed in any other temperature category, so a trend cannot be established. Chewing deviates from the above-mentioned trend since it decreases to its lowest level for above freezing instead of increasing as the other significant tasks did.

Chi-squared tests showed that only conversation was statistically significant for day/night. The normalized distribution data shows that conversation is slightly more likely in day than night, but as there are no other significant tasks and only two light level categories, a trend cannot be established as to whether a driver is more likely to perform task during the day or night.

7. How often did each subtask occur?

Subtask frequency analysis was based on Pass 2 frame-by-frame analysis. In the 15,962 frames, the most common subtasks (Table 48) were converse on cell phone, chew gum, groom with hand, and bite lips while chewing gum, with conversing on the phone being 5% of the observations analyzed. Keep in mind that frames occurred in groups of 20, so 100 frames essentially translates to 5 observations of a task.

Table 48. Most Common Subtasks

Subtask	Frames (#, %)		Subtask	Frames (#, %)	
Converse on phone	792	5.0	Chew food	165	1.0
Chew gum	787	4.9	Glance to internal distract.	156	1.0
Groom with hand	756	4.7	Tongue motion: chew. gum	148	0.9
Bite lips: chew. gum	469	2.9	Speak to passenger	119	0.7
Glance to in-car sys	175	1.1	Hold cigar/cigarette	117	0.7
Listen to passenger	166	1.0	Drink with straw	112	0.7

REFERENCES

Eby, D.W. and Kostyniuk, L.P. (2004a). Crashes and Driver Distraction: A Review of Databases, Crash Scenarios, and Distracted Driving Scenarios (SAVE-IT project technical report, Task 1), Washington, D.C.: U.S. Department of Transportation (http://www.volpe.dot.gov/opsad/saveit/docs/dec04/litrev_1.pdf).

Eby, D.W. and Kostyniuk, L.P. (2004b). Distracted Driving Scenarios: A Synthesis of Literature, 2001 Crashworthiness Data System (CDS) Data, and Expert Feedback (SAVE-IT project technical report, Task 1), Washington, D.C.: U.S. Department of Transportation (http://www.volpe.dot.gov/opsad/saveit/docs/dec04/finalrep_1.pdf).

Eby, D.W. and Kostyniuk, L.P. (2004c). Estimating Driving Task Demand from Crash Probabilities: A Review of the Literature and Assessment of Crash Databases (SAVE-IT project technical report, Task 2a), Washington, D.C.: U.S. Department of Transportation (http://www.volpe.dot.gov/opsad/saveit/docs/dec04/litrev_2a.pdf).

Eby, D.W. and Kostyniuk, L.P. (2004d). Using Michigan Highway Safety Information System (HSIS) Data for Estimating Driving Task Demand (SAVE-IT project technical report, Task 2a), Washington, D.C.: U.S. Department of Transportation (http://www.volpe.dot.gov/opsad/saveit/docs/dec04/finalrep_2a1.pdf).

Eoh, H., Green, P.A., Schweitzer, J., and Hegedus, E. (2006). Driving Performance Analysis of the ACAS FOT Data and Recommendations for a Driving Workload Manager (Technical Report UMTRI-2006-18), Ann Arbor, MI: University of Michigan Transportation Research Institute.

Ervin, R., Sayer, J., LeBlanc, D., Bogard, S., Mefford, M., Hagan, M., Bareket, Z., and Winkler, C. (2005). Automotive Collision Avoidance System Field Operational Test Methodology and Results (Unpublished technical report), Ann Arbor, Michigan: University of Michigan Transportation Research Institute.

General Assembly of the Commonwealth of Pennsylvania (2001). Driver Distractions and Traffic Safety, General Assembly of the Commonwealth of Pennsylvania, Harrisburg, PA: Joint State Government Commission.

Glassbrenner, D. (2005). Driver Cell Phone Use in 2005-Overall Results (technical report DOT HS 809 967), Washington, D.C.: National Center for Statistics and Analysis, National Highway Traffic Safety Administration, U.S. Department of Transportation (www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/RNotes/2005/809967.pdf).

Glaze, A.L. & Ellis, J.M. (2003). Pilot Study of Distracted Drivers, Richmond, VA: Virginia Commonwealth University.

Green, P. (2004). Driver Distraction, Telematics Design, and Workload Managers: Safety Issues and Solutions (SAE paper 2004-21-0022), Proceedings of the 2004 International Congress on Transportation Electronics (Convergence 2004, SAE publication P-387), 165-180. Warrendale, PA: Society of Automotive Engineers

Green, P., Cullinane, B., Zylstra, B., and Smith, D. (2004). Typical Values for Driving Performance with Emphasis on the Standard Deviation of Lane Position: A Summary of the Literature (Technical Report), Ann Arbor, Michigan: University of Michigan Transportation Research Institute.

Green, P.E., Wada, T., Oberholtzer, J., Green, P.A., Schweitzer, J. and Eoh, H. (2006). How Do Distracted and Normal Driving Differ: An Analysis of the ACAS FOT Data (Technical Report UMTRI-2006-35, Ann Arbor, Michigan: University of Michigan Transportation Research Institute.

Kiger, S. M., Rockwell, T. H., and Tijerina, L. (1995). Developing Baseline Data on Heavy Vehicle Driver Workload, Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting, Volume 2, Santa Monica, California: Human Factors and Ergonomics Society, 1112-1116.

Najm, W. (2005). Overview and Evaluation of the Automotive Collision Avoidance System Field Operational Test (ACAS FOT), SAE 2005 Government/Industry Meeting, Washington, DC, May 10, 2005.

Neale, V.L., Dingus, T.A., Klauer, S.G., Sudweeks, J., and Goodman, M. (2005). An Overview of the 100-Car Naturalistic Study and Findings (paper 05-0400), Experimental Safety Vehicle Conference (www-nrd.nhtsa.dot.gov/ pdf/nrd-12/100Car_ESV05summary.pdf).

Oberholtzer, J., Yee, S., Green, P.A., Eoh, H., Nguyen, L., and Schweitzer, J. (2006). Frequency of Distracting Tasks People Do While Driving: An Analysis of the ACAS FOT Data (Technical Report UMTRI-2006-17), Ann Arbor, Michigan: University of Michigan Transportation Research Institute.

Royal, D. (2003). National Survey of Distracted and Drowsy Driving Attitudes and Behaviors: 2002. Volume 1--Findings Report, (Report No. DOT-HS-809-566), Washington, DC: US Department of Transportation.

Schweitzer, J. and Green, P.A. (2007). Task Acceptability and Workload of Driving Urban Roads, Highways, and Expressway: Ratings from Video Clips (Technical Report UMTRI-2006-19), Ann Arbor, Michigan: University of Michigan Transportation Research Institute.

Shelton, L.R. (2001). Statement before the Subcommittee on Highways and Transit, Committee on Transportation and Infrastructure, U.S. House of Representatives, May 9, 2001, http://www.nhtsa.dot.gov/nhtsa/announce/testimony/distractiontestimony.html.

Society of Automotive Engineers (1999). Measurement of Driver Visual Behaviour Using Video Based Methods (Definitions and Measurement (SAE J 2396), Warrendale, PA: Society of Automotive Engineers.

Stevens, A. & Minton, R. (2001). In-vehicle Distraction and Fatal accidents in England and Wales, Accident Analysis & Prevention, 33, 539-545.

Stutts, J.C., Reinfurt, D.W., & Rodgman, E.A. (2001). The role of driver distraction in crashes: An analysis of 1995-1999 Crashworthiness Data System data, 45th Annual Proceedings Association for the Advancement of Automotive Medicine, 287-301, Des Plaines, IA: Association for the Advancement of Automotive Medicine.

Stutts, J.C., Reinfurt, D.W., Staplin, L.W., and Rodgman, E.A. (2001). The Role of Driver Distraction in Traffic Crashes (technical report), Washington, D.C.: AAA Foundation for Traffic Safety (http://www.aaafts.org/pdf/distraction.pdf).

Stutts, J.C. Feaganes, J.R., Reinfurt, D., Rodgman, E., Hamlett, C., Gish, K., and Staplin, L. (2005). Driver's Exposure to Distractions in their Natural Driving Environment, Accident Analysis and Prevention. 37(6), 1093-1101.

Stutts, J.C., Feaganes, J.C., Rodgman, J.R, Hanlett, E.A., Reinfurt, C., Gish, D.W., Mercadante, M., and Staplin, L. (2003). The Causes and Consequences of Distraction in Everyday Driving, Proceedings, 47th Annual Meeting, Association for the Advancement of Automotive Medicine. Des Plaines, Illinois: Association for the Advancement of Automotive Medicine, 235-51.

Tosca (2005). Distracted Driving: Towards a Working Definition, International Conference on Distracted Driving, Powerpoint presentation (www.distracteddriving.ca/english/documents/LeoTasca_000.pdf), Toronto, Ontario, Canada, October 2-5, 2005.

Wang, J.-S., Knipling, R. R., and Goodman, M. J. (1996). The Role of Driver Inattention in Crashes: New Statistics from the 1995 Crashworthiness Data System, Association for the Advancement of Automotive Medicine. 40th Annual Conference. Proceedings, Des Plaines, Iowa: Association for the Advancement of Automotive Medicine, 377-392.

Wickens, C. D. (1984). Processing Resources in Attention, 63-101, in Parasuraman, R., Davies, R. (Eds.), Varieties of Attention, London, UK: Academic Press.

U.S. Department of Transportation, (2004). Crashworthiness Data System (CDS), National Accident Sampling System (NASS). Crashworthiness Data System (CDS) Data Set Codebook (UMTRI Report 2004-8), Ann Arbor, Michigan, University of Michigan Transportation Research Institute (http://www.umtri.umich.edu/tdc/codebook.html).

Yee, S., Green, P.A., Nguyen, L., Schweitzer, J., and Oberholtzer, J. (2006). Second Generation UMTRI Scheme for Classifying Driver Activities in Distraction Studies and Coding ACAS Video Clips (Technical Report UMTRI-2006-16), Ann Arbor, Michigan: University of Michigan Transportation Research Institute.

Yee, S., Nguyen, L., Green, P.A., Oberholtzer, J. and Miller, B. (2006). The Visual, Auditory, Cognitive, and Psychomotor Demands of Real In-Vehicle Tasks (Technical Report UMTRI-2006-20), Ann Arbor, Michigan: University of Michigan Transportation Research Institute.

APPENDIX A – CONCURRENT SECONDARY TASKS

Table49. Frequency of Occurrence of Lone and Double Concurrent Task Clips, Pass 1
(lone and total task percentages in parentheses)

Secondary Task	**Use Cell Phone**	**Eat/ Drink**	**Smoke**	**Chew Gum**	**Groom**	**Read**	**Use In-Car System**	**Internal Distrac.**	**Converse**
Use Cell Phone	115 **(3.9)**	4	1	10	3	0	1	5	1
Eat/ Drink	4	53 **(1.8)**	1	0	1	1	1	4	6
Smoke	1	1	26 **(0.9)**	0	2	0	2	1	2
Chew Gum	10	0	0	221 **(7.6)**	7	0	9	5	34
Groom	3	1	2	7	148 **(5.1)**	0	4	4	53
Read	0	1	0	0	0	3 **(0.1)**	0	0	0
Use In-Car System	1	1	2	9	4	0	67 **(2.3)**	1	22
Internal Distraction	5	4	1	5	4	0	1	42 **(1.4)**	17
Converse	1	6	2	34	53	0	22	17	436 **(15.0)**
Total	140 **(4.8)**	71 **(2.4)**	35 **(1.2)**	286 **(9.8)**	222 **(7.6)**	4 **(0.1)**	107 **(3.7)**	79 **(2.7)**	571 **(19.6)**

Triples:
Conversation & In-Car System Use & Internal Distraction (1)
Chewing Gum & Cell Phone & Reading (1)

Composition (1315 Total Secondary Task Clips):
1,111 Lone Task Clips
202 Double Task Clips
2 Triple Task Clips

Drowsiness - Total clips = 21 (0.7)
Drowsiness task concurrence (Drowsiness & ___):
- Drowsiness alone = 13
- Chewing Gum = 1
- Conversation = 3
- Grooming = 2
- In-Car System Use = 2

Table 50. Frequency of Occurrence of Lone and Double Concurrent Secondary Task Frames, Pass 2
(lone and total task percentages in parentheses)

Secondary Task	**Use Cell Phone**	**Eat/ Drink**	**Smoke**	**Chew Gum**	**Groom**	**Read**	**Use In-Car System**	**Internal Distract.**	**Converse**
Use Cell Phone	712 **(4.5)**	38	0	77	0	0	0	11	0
Eat/ Drink	38	329 **(2.1)**	19	0	0	0	0	8	25
Smoke	0	19	174 **(1.1)**	0	21	0	0	0	5
Chew Gum	77	0	0	1264 **(7.9)**	17	13	12	29	17
Groom	0	0	21	17	722 **(4.5)**	0	0	1	143
Read	0	0	0	13	0	15 **(0.1)**	0	0	0
Use In-Car System	0	0	0	12	0	0	217 **(1.4)**	0	24
Internal Distraction	11	8	0	29	1	0	0	176 **(1.1)**	48
Converse	0	25	5	17	143	0	24	48	1635 **(10.2)**
Total	838 **(5.2)**	419 **(2.6)**	219 **(1.4)**	1429 **(9.0)**	904 **(5.7)**	28 **(0.2)**	253 **(1.6)**	273 **(1.7)**	1897 **(11.9)**

Composition (5752 Total Secondary Task Frames):
5244 Lone Task Frames
508 Double Task Frames

APPENDIX B – SECONDARY TASK FREQUENCY BY AGE GROUP AND DRIVER SEX CHARACTERISTICS

Table 51. Pass 1 Secondary Task Clip Frequency by Age Group and Driver Sex Characteristics (∗= p<.05, ∗∗=p<.01, ∗∗∗=p<.001)

Secondary Task	Age Group			Driver Sex		Total
	Young	**Middle**	**Old**	**Men**	**Women**	
All Clips	*1048*	*956*	*910*	*1435*	*1479*	*2914*
No Secondary Task	548	542	509	802	797	1599 **(54.5)**
Converse	189 ***	161 ***	222 ***	217 ***	355 ***	572 **(19.6)**
Chew Gum	90	98	100	151	137	288 **(9.9)**
Groom	85	72	65	113	109	222 **(7.6)**
Use Cell Phone	104 ***	28 ***	9 ***	92 ***	49 ***	141 **(4.8)**
Use In-Car System	43	28	36	66 **	41 **	107 **(3.7)**
Internal Distraction	32	25	23	43	37	80 **(2.7)**
Eat/Drink	29 *	31 *	11 *	38	33	71 **(2.4)**
Smoke	16 (***)	19 (***)	0 (***)	3 (***)	32 (***)	35 **(1.2)**
Read	2	3	0	4	1	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0 **(0.0)**
Significant Task Total	**332**	**220**	**242**	**375**	**445**	**Age: 794 Sex: 820**
Age and Sex Task Total	**1138 (39.1)**	**1007 (34.6)**	**975 (33.5)**	**1529 (49.0)**	**1591 (54.6)**	**3120 (107.1)**

Drowsiness: Age Group (12, 3, 6), Driver Sex (8, 13), Total (21)

Table 52. Pass 2 Secondary Task Frame Frequency by Age Group and Driver Sex Characteristics

Secondary Task	Age Group			Driver Sex		Total
	Young	Middle	Old	Men	Women	
All Clips	*5846*	*5346*	*4770*	*7441*	*8521*	*15962*
No Secondary Task	3668	3368	3174	4786	5424	10210 **(64.0)**
Converse	623	557	717	595	1302	1897 **(11.9)**
Chew Gum	432	497	500	684	745	1429 **(9.0)**
Groom	285	371	248	453	451	904 **(5.7)**
Use Cell Phone	619	180	39	580	258	838 **(5.2)**
Use In-Car System	149	204	66	220	199	419 **(2.6)**
Internal Distraction	96	99	78	186	87	273 **(1.7)**
Eat/Drink	100	83	70	145	108	253 **(1.6)**
Smoke	123	96	0	0	219	219 **(1.4)**
Read	0	28	0	28	0	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0 **(0.0)**
Age and Sex Task Total	**6095 (38.2)**	**5483 (34.4)**	**4892 (30.6)**	**7677 (48.1)**	**8793 (55.1)**	**16470 (103.2)**

APPENDIX C – TASK FREQUENCY BY ROAD TYPE, TRAFFIC AND SPEED CHARACTERISTICS

Table 53. Pass 1 Secondary Task Clip Frequency by Road Type Characteristic
(∗= p<.05, ∗∗=p<.01, ∗∗∗=p<.001)

Secondary Task	Road Type						Total
	Inter-state	Free-way	Arterial	Minor Arterial	Connec-tor	Local	
All Clips	*598*	*507*	*220*	*597*	*625*	*367*	*2914*
No Secondary Task	339	286	109	336	339	190	1599 **(54.9)**
Converse	90 ***	108 ***	37 ***	113 ***	129 ***	95 ***	572 **(19.6**)
Chew Gum	60	45	32	49	68	34	288 **(9.8)**
Groom	47	35	11	46	47	36	222 **(7.6)**
Use Cell Phone	33 *	18 *	15 *	33 *	31 *	11 *	141 **(4.8)**
Use In-Car System	23	24	10	17	24	9	107 **(3.7)**
Internal Distraction	13	11	6	18	18	14	80 **(2.7)**
Eat/Drink	23 *	6 *	8 *	17 *	12 *	5 *	71 **(2.4**)
Smoke	2	5	7	8	6	7	35 **(1.2)**
Read	2	1	1	0	1	0	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0 **(0.0)**
Significant Task Total	**146**	**132**	**60**	**163**	**172**	**111**	**784**
Road Type Task Total	**632 (21.7)**	**539 (18.5)**	**236 (8.1)**	**637 (21.8)**	**675 (23.2)**	**401 (13.8)**	**3120 (107.1)**

Drowsiness. Road Type: (3, 6, 1, 4, 2, 2, 3) Total: (21)

Table 54. Pass 1 Secondary Task Clip Frequency by Target Count Characteristic - Unpooled (∗= p<.05, ∗∗=p<.01, ∗∗∗=p<.001)

Secondary Task	**Target Count**								**Total**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
All Clips	*361*	*933*	*798*	*505*	*225*	*70*	*16*	*6*	*2914*
No Secondary Task	208	522	424	275	127	30	10	3	1599 **(54.9)**
Converse	58	176	180	108	36	12	1	1	572 **(19.6**)
Chew Gum	53 **	93 **	83 **	38 **	13 **	8 **	0 **	0 **	288 **(9.8)**
Groom	20	57	63	49	23	8	2	0	222 **(7.6)**
Use Cell Phone	5 ***	43 ***	40 ***	22 ***	19 ***	10 ***	0 ***	2 ***	141 **(4.8)**
Use In-Car System	14	35	26	23	8	0	1	0	107 **(3.7)**
Internal Distraction	13	33	25	7	2	0	0	0	80 **(2.7)**
Eat/Drink	6 *	18 *	16 *	16 *	10 *	3 *	2 *	0 *	71 **(2.4**)
Smoke	3	11	11	5	3	2	0	0	35 **(1.2)**
Read	0 (*)	0 (*)	0 (*)	3 (*)	2 (*)	0 (*)	0 (*)	0 (*)	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0	0 **(0.0)**
Significant Task Total	**64**	**154**	**139**	**76**	**42**	**21**	**2**	**2**	**500**
Target Count Task Total	**380 (13.0)**	**988 (33.9)**	**868 (29.8)**	**546 (18.7)**	**243 (8.3)**	**73 (2.5)**	**16 (0.5)**	**6 (0.2)**	**3120 (107.1)**

Drowsiness. Target Count (1, 9, 7, 3, 1, 0, 0, 0) Total (21)

Table 55. Pass 1 Secondary Task Clip Frequency by Target Count Characteristic - Pooled (∗= p<.05, ∗∗=p<.01, ∗∗∗=p<.001)

Secondary Task	Target Count w/ Pooling						Total
	0	**1**	**2**	**3**	**4**	**5 +**	
All Clips	*361*	*933*	*798*	*505*	*225*	*92*	*2914*
No Secondary Task	208	522	424	275	127	43	1599 **(54.9)**
Converse	58 *	176 *	180 *	108 *	36 *	14 *	572 **(19.6**)
Chew Gum	53 **	93 **	83 **	38 **	13 **	8 **	288 **(9.8)**
Groom	20 *	57 *	63 *	49 *	23 *	10 *	222 **(7.6)**
Use Cell Phone	5 ***	43 ***	40 ***	22 ***	19 ***	12 ***	141 **(4.8)**
Use In-Car System	14	35	26	23	8	1	107 **(3.7)**
Internal Distraction	13 **	33 **	25 **	7 **	2 **	0 **	80 **(2.7)**
Eat/Drink	6	18	16	16	10	5	71 **(2.4**)
Smoke	3	11	11	5	3	2	35 **(1.2)**
Read	0 (**)	0 (**)	0 (**)	3 (**)	2 (**)	0 (**)	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0 **(0.0)**
Significant Task Total	**149**	**402**	**391**	**224**	**93**	**44**	**1303**
Target Count Task Total	**380 (13.0)**	**988 (33.9)**	**868 (29.8)**	**546 (18.7)**	**243 (8.3)**	**95 (3.3)**	**3120 (107.1)**

Drowsiness. Target Count: (1, 9, 7, 3, 1, 0) Total: (21)

Table 56. Pass 1 Secondary Task Clip Frequency by Speed Characteristic - Unpooled (∗= p<.05, ∗∗=p<.01, ∗∗∗=p<.001)

Secondary Task	**Rounded Speed Group (m/s)**								**Total**
	5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	
All Clips	*103*	*321*	*509*	*595*	*386*	*605*	*382*	*13*	*2914*
No Secondary Task	45	164	283	348	207	339	208	5	1599 **(54.9)**
Converse	29	77	98	112	79	106	68	3	572 **(19.6**)
Chew Gum	3	33	56	55	42	56	42	1	288 **(9.8)**
Groom	11	21	39	48	25	53	22	3	222 **(7.6)**
Use Cell Phone	8	19	24	23	23	22	21	1	141 **(4.8)**
Use In-Car System	6	10	15	18	12	25	20	1	107 **(3.7)**
Internal Distraction	5	8	16	16	10	15	10	0	80 **(2.7)**
Eat/Drink	5 **	12 **	8 **	10 **	7 **	18 **	10 **	1 **	71 **(2.4**)
Smoke	2	0	8	8	8	6	3	0	35 **(1.2)**
Read	0	0	0	1	2	2	0	0	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0	0 **(0.0)**
Total	**114 (3.9)**	**344 (11.8)**	**547 (18.8)**	**639 (21.9)**	**415 (14.4)**	**642 (22.0)**	**404 (13.9)**	**15 (0.5)**	**3120 (107.1)**

Drowsiness. Speed Group - Unpooled: (0, 3, 2, 1, 4, 6, 5, 0) Total: (21)

Table 57. Pass 1 Secondary Task Clip Frequency by Speed Characteristic - Pooled (∗= p<.05, ∗∗=p<.01, ∗∗∗=p<.001)

Secondary Task	Speed Group (m/s)							Total
	5	**10**	**15**	**20**	**25**	**30**	**35+**	
All Clips	*103*	*321*	*509*	*595*	*386*	*605*	*395*	*2914*
No Secondary Task	45	164	283	348	207	339	213	1599 **(54.9)**
Converse	29	77	98	112	79	106	71	572 **(19.6**)
Chew Gum	3	33	56	55	42	56	43	288 **(9.8)**
Groom	11	21	39	48	25	53	25	222 **(7.6)**
Use Cell Phone	8	19	24	23	23	22	22	141 **(4.8)**
Use In-Car System	6	10	15	18	12	25	21	107 **(3.7)**
Internal Distraction	5	8	16	16	10	15	10	80 **(2.7)**
Eat/Drink	5	12	8	10	7	18	11	71 **(2.4**)
Smoke	2	0	8	8	8	6	3	35 **(1.2)**
Read	0	0	0	1	2	2	0	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0 **(0.0)**
Total	**114 (3.9)**	**344 (11.8)**	**547 (18.8)**	**639 (21.9)**	**415 (14.4)**	**642 (22.0)**	**404 (13.9)**	**3120 (107.1)**

Drowsiness. Speed Group - Pooled: (0, 3, 2, 1, 4, 6, 5) Total: (21)

Table 58. Pass 2 Secondary Task Frame Frequency by Road Type Characteristic
(= p<.05, =p<.01, =p<.001)

Secondary Task	Road Type						Total
	Inter-state	**Free-way**	**Arterial**	**Minor Arterial**	**Connec-tor**	**Local**	
All Clips	*3665*	*2748*	*945*	*3153*	*3486*	*1965*	*15962*
No Secondary Task	2377	1878	518	2054	2225	1158	10210 **(64.0)**
Converse	341	367	97	294	475	323	1897 **(11.9)**
Chew Gum	315	214	128	277	359	136	1429 **(9.0)**
Groom	228	162	5	151	171	187	904 **(5.7)**
Use Cell Phone	240	79	118	232	149	20	838 **(5.2)**
Use In-Car System	166	11	54	95	58	35	419 **(2.6)**
Internal Distraction	62	15	19	67	57	53	273 **(1.7)**
Eat/Drink	61	25	7	57	71	32	253 **(1.6)**
Smoke	19	10	4	48	39	99	219 **(1.4)**
Read	13	15	0	0	0	0	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0 **(0.0)**
Total	**3822 (24.0)**	**2776 (17.4)**	**950 (6.0)**	**3275 (20.5)**	**3604 (22.6)**	**2043 (12.8)**	**16470 (103.2)**

Table 59. Pass 2 Secondary Task Frame Frequency by Target Count - Unpooled

Secondary Task	**Target Count**									**Total**
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
All Clips	*5071*	*4074*	*3205*	*1854*	*857*	*612*	*194*	*71*	*24*	*15962*
No Secondary Task	3514	2646	1827	1097	559	383	133	36	15	10210 **(64.0)**
Converse	561	513	440	222	76	51	20	9	5	1897 **(11.9)**
Chew Gum	510	277	329	213	44	39	16	1	0	1429 **(9.0)**
Groom	175	161	213	126	107	84	25	13	0	904 **(5.7)**
Use Cell Phone	126	267	275	109	40	16	5	0	0	838 **(5.2)**
Use In-Car System	96	107	113	39	19	28	5	12	0	419 **(2.6)**
Internal Distraction	71	69	50	38	17	1	2	1	4	253 **(1.6)**
Eat/Drink	106	76	54	10	21	1	5	0	0	273 **(1.7)**
Smoke	15	92	22	46	7	35	1	1	0	219 **(1.4)**
Read	0	1	8	4	10	5	0	0	0	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0	0	0 **(0.0)**
Total	**5174 (32.4)**	**4209 (26.4)**	**3331 (20.9)**	**1904 (11.9)**	**900 (5.6)**	**643 (4.0)**	**212 (1.3)**	**73 (0.5)**	**24 (0.2)**	**16470 (103.2)**

Table 60. Pass 2 Secondary Task Frame Frequency by Target Count Characteristic - Pooled

Secondary Task	**Target Count**						**Total**
	0	**1**	**2**	**3**	**4**	**5 +**	
All Clips	*5071*	*4074*	*3205*	*1854*	*857*	*901*	*15962*
No Secondary Task	3514	2646	1827	1097	559	567	10210 **(64.0)**
Converse	561	513	440	222	76	85	1897 **(11.9)**
Chew Gum	510	277	329	213	44	56	1429 **(9.0)**
Groom	175	161	213	126	107	122	904 **(5.7)**
Use Cell Phone	126	267	275	109	40	21	838 **(5.2)**
Use In-Car System	96	107	113	39	19	45	419 **(2.6)**
Internal Distraction	71	69	50	38	17	8	253 **(1.6)**
Eat/Drink	106	76	54	10	21	6	273 **(1.7)**
Smoke	15	92	22	46	7	37	219 **(1.4)**
Read	0	1	8	4	10	5	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0 **(0.0)**
Total	**5174 (32.4)**	**4209 (26.4)**	**3331 (20.9)**	**1904 (11.9)**	**900 (5.6)**	**952 (6.0)**	**16470 (103.2)**

Table 61. Pass 2 Secondary Task Frame Frequency by Speed Characteristic - Unpooled

Secondary Task	**Rounded Speed Group (m/s)**								**Total**
	5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	
All Clips	*499*	*1838*	*2678*	*3072*	*1894*	*3593*	*2288*	*100*	*15962*
No Secondary Task	267	1122	1758	1892	1185	2435	1483	68	10210 **(64.0)**
Converse	138	233	315	369	192	401	234	15	1897 **(11.9)**
Chew Gum	18	161	229	348	211	257	200	5	1429 **(9.0)**
Groom	21	120	199	131	124	161	138	10	904 **(5.7)**
Use Cell Phone	15	102	62	224	116	179	140	0	838 **(5.2)**
Use In-Car System	17	84	49	42	50	105	72	0	419 **(2.6)**
Internal Distraction	11	60	36	41	16	48	35	6	253 **(1.6)**
Eat/Drink	4	18	46	85	33	42	45	0	273 **(1.7)**
Smoke	21	0	48	89	28	14	19	0	219 **(1.4)**
Read	0	0	0	0	0	28	0	0	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0	0 **(0.0)**
Total	**512 (3.2)**	**1900 (11.9)**	**2742 (17.2)**	**3221 (20.2)**	**1955 (12.2)**	**3670 (23.0)**	**2366 (14.8)**	**104 (0.7)**	**16470 (103.2)**

Table 62. Pass 2 Secondary Task Frame Frequency by Speed Characteristic - Pooled

Secondary Task	**Pooled Speed Group (m/s)**							**Total**
	5	**10**	**15**	**20**	**25**	**30**	**35 +**	
All Clips	*499*	*1838*	*2678*	*3072*	*1894*	*3593*	*2288*	*15962*
No Secondary Task	267	1122	1758	1892	1185	2435	1551	10210 **(64.0)**
Converse	138	233	315	369	192	401	249	1897 **(11.9)**
Chew Gum	18	161	229	348	211	257	305	1429 **(9.0)**
Groom	21	120	199	131	124	161	148	904 **(5.7)**
Use Cell Phone	15	102	62	224	116	179	140	838 **(5.2)**
Use In-Car System	17	84	49	42	50	105	72	419 **(2.6)**
Internal Distraction	11	60	36	41	16	48	41	253 **(1.6)**
Eat/Drink	4	18	46	85	33	42	45	273 **(1.7)**
Smoke	21	0	48	89	28	14	19	219 **(1.4)**
Read	0	0	0	0	0	28	0	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0 **(0.0)**
Total	**512 (3.2)**	**1900 (11.9)**	**2742 (17.2)**	**3221 (20.2)**	**1955 (12.2)**	**3670 (23.0)**	**2366 (14.8)**	**16470 (103.2)**

APPENDIX D – TASK FREQUENCY BY TIME OF DAY AND DAY OF WEEK CHARACTERISTICS

Table 63. Pass 1 Secondary Task Clip Frequency by Time of Day Characteristic
(∗= p<.05, ∗∗=p<.01, ∗∗∗=p<.001)

Secondary Task	Time Group								Total
	24:00-2:59	**3:00-5:59**	**6:00-8:59**	**9:00-11:59**	**12:00-14:59**	**15:00-17:59**	**18:00-20:59**	**21:00-23:59**	
All Clips	*37*	*41*	*276*	*367*	*636*	*763*	*559*	*235*	*2914*
No Secondary Task	19	28	166	187	336	427	313	123	1599 **(54.9)**
Converse	7 ***	1 ***	33 ***	87 ***	131 ***	150 ***	123 ***	40 ***	572 **(19.6**)
Chew Gum	9	2	35	34	60	71	54	23	288 **(9.8)**
Groom	3	4	17	30	42	56	47	23	222 **(7.6)**
Use Cell Phone	0 ***	0 ***	7 ***	11 ***	32 ***	52 ***	18 ***	21 ***	141 **(4.8)**
Use In-Car System	2	3	13	17	24	24	13	11	107 **(3.7)**
Internal Distraction	0	0	12	11	22	19	8	8	80 **(2.7)**
Eat/Drink	2	3	8	6	19	11	15	7	71 **(2.4**)
Smoke	0 (**)	2 (**)	0 (**)	4 (**)	13 (**)	11 (**)	1 (**)	4 (**)	35 **(1.2)**
Read	0	0	1	0	4	0	0	0	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0	0 **(0.0)**
Significant Task Total	**7**	**1**	**40**	**98**	**163**	**202**	**141**	**61**	**713**
Total	**48 (1.6)**	**44 (1.5)**	**257 (8.8)**	**331 (11.3)**	**679 (23.3)**	**802 (27.5)**	**653 (22.4)**	**306 (10.5)**	**3120 (107.1)**

Drowsiness (1, 0, 1, 1, 0, 12, 4, 2)

Table 64. Pass 1 Secondary Task Clip Frequency by Time of Day Characteristic (This pooling method not used for analysis, included here to enable comparison to Pass 2 results) (= p<.05, =p<.01, =p<.001)

Secondary Task	**Time Group (label marks midpoint of each group)**								**Total**
	1:00	**4:00**	**7:00**	**10:00**	**13:00**	**16:00**	**19:00**	**22:00**	
All Clips	*45*	*40*	*245*	*313*	*629*	*751*	*611*	*280*	*2914*
No Secondary Task	25	29	154	158	324	432	339	138	1599 **(54.9)**
Converse	10 ***	2 ***	24 ***	77 ***	128 ***	143 ***	138 ***	50 ***	572 **(19.6**)
Chew Gum	7	2	29	29	68	61	61	31	288 **(9.8)**
Groom	1	6	15	25	42	52	55	26	222 **(7.6)**
Use Cell Phone	1 *	0 *	6 *	12 *	29 *	48 *	24 *	21 *	141 **(4.8)**
Use In-Car System	2	2	13	11	26	23	17	13	107 **(3.7)**
Internal Distraction	0	0	9	11	24	19	8	9	80 **(2.7)**
Eat/Drink	2 **	3 **	5 **	5 **	20 **	13 **	9 **	14 **	71 **(2.4**)
Smoke	0	0	2	2	14	11	2	4	35 **(1.2)**
Read	0	0	0	1	4	0	0	0	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0	0 **(0.0)**
Significant Task Total	**13**	**5**	**35**	**94**	**177**	**204**	**171**	**85**	**784**
Total	**48 (1.6)**	**44 (1.5)**	**257 (8.8)**	**331 (11.3)**	**679 (23.3)**	**802 (27.5)**	**653 (22.4)**	**306 (10.5)**	**3120 (107.1)**

Table 65. Pass 1 Secondary Task Clip Frequency by Day of the Week Characteristic
(= p<.05, =p<.01, =p<.001)

Secondary Task	Day of the Week							Total
	Sun	**Mon**	**Tues**	**Wed**	**Thurs**	**Fri**	**Sat**	
All Clips	*463*	*481*	*365*	*335*	*188*	*455*	*627*	*2914*
No Secondary Task	253	250	211	177	116	254	338	1599 **(54.9)**
Converse	111 **	72 **	57 **	60 **	32 **	99 **	141 **	572 **(19.6**)
Chew Gum	47	49	38	38	17	42	57	288 **(9.8)**
Groom	39	36	26	27	15	29	50	222 **(7.6)**
Use Cell Phone	11 ***	54 ***	15 ***	17 ***	5 ***	16 ***	23 ***	141 **(4.8)**
Use In-Car System	18	19	14	12	8	19	17	107 **(3.7)**
Internal Distraction	9	19	13	11	3	11	14	80 **(2.7)**
Eat/Drink	6 *	13 *	5 *	16 *	2 *	11 *	18 *	71 **(2.4**)
Smoke	7	6	5	1	1	7	8	35 **(1.2)**
Read	1	2	0	0	0	0	2	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0 **(0.0)**
Significant Task Total	**128**	**139**	**77**	**93**	**39**	**126**	**182**	**784**
Total	**502 (17.2)**	**520 (17.8)**	**384 (13.2)**	**359 (12.3)**	**199 (6.8)**	**488 (16.7)**	**668 (22.9)**	**3120 (107.1)**

Table 66. Pass 2 Secondary Task Frame Frequency by Time of Day Characteristic

Secondary Task	Pooled Time Group								Total
	1:00	**4:00**	**7:00**	**10:00**	**13:00**	**16:00**	**19:00**	**22:00**	
All Clips	*217*	*277*	*1257*	*1932*	*3226*	*4130*	*3440*	*1483*	*15962*
No Secondary Task	167	213	861	1130	2048	2702	2246	843	10210 **(64.0)**
Converse	10	14	53	328	427	477	410	178	1897 **(11.9)**
Chew Gum	40	11	121	192	285	310	291	179	1429 **(9.0)**
Groom	0	33	74	120	126	209	257	85	904 **(5.7)**
Use Cell Phone	0	0	60	76	100	357	149	96	838 **(5.2)**
Use In-Car System	0	0	47	52	122	56	51	91	419 **(2.6)**
Internal Distraction	0	13	47	27	36	23	98	9	253 **(1.6)**
Eat/Drink	0	0	19	55	55	49	37	58	273 **(1.7)**
Smoke	0	0	0	0	110	59	30	20	219 **(1.4)**
Read	0	0	0	0	28	0	0	0	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0	0 **(0.0)**
Total	**217 (1.4)**	**284 (1.8)**	**1282 (8.0)**	**1980 (12.4)**	**3337 (20.9)**	**4242 (26.6)**	**3569 (22.4)**	**1559 (9.8)**	**16470 (103.2)**

Table 67. Pass 2 Secondary Task Frame Frequency for Day of the Week Characteristic

Secondary Task	Day of the Week							Total
	Sun	**Mon**	**Tues**	**Wed**	**Thurs**	**Fri**	**Sat**	
All Clips	*2692*	*3119*	*1911*	*1676*	*947*	*2155*	*3462*	*15962*
No Secondary Task	1561	2059	1220	1103	625	1433	2209	10210 **(64.0)**
Converse	487	328	191	149	78	221	443	1897 **(11.9)**
Chew Gum	307	219	178	125	74	215	311	1429 **(9.0)**
Groom	191	161	149	127	59	114	103	904 **(5.7)**
Use Cell Phone	59	246	80	120	39	100	194	838 **(5.2)**
Use In-Car System	40	72	50	37	20	16	184	419 **(2.6)**
Internal Distraction	60	28	51	30	0	21	63	253 **(1.6)**
Eat/Drink	29	47	47	28	41	52	29	273 **(1.7)**
Smoke	86	0	26	19	20	28	40	219 **(1.4)**
Read	15	0	0	0	0	0	13	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0	0	0 **(0.0)**
Total	**2835 (17.8)**	**3160 (19.8)**	**1992 (12.5)**	**1738 (10.9)**	**956 (6.0)**	**2200 (13.8)**	**3589 (22.5)**	**16470 (103.2)**

APPENDIX E – TASK FREQUENCY BY TEMPERATURE AND LIGHTING LEVEL CHARACTERISTICS

Table 68. Pass 1 Secondary Task Clip Frequency by Temperature Group and Light Level Characteristics (= p<.05, =p<.01, =p<.001)

Secondary Task	Temperature Group			Light Level		Total
	Below Freezing	Around Freezing	Above Freezing	Day	Night	
All Clips	*268*	*292*	*2354*	*2101*	*813*	*2914*
No Secondary Task	162	171	1266	1123	476	1599 **(54.9)**
Converse	37 **	46 **	489 **	440 **	132 **	572 **(19.6**)
Chew Gum	30 **	44 **	214 **	196	92	288 **(9.8)**
Groom	6 ***	15 ***	201 ***	167	55	222 **(7.6)**
Use Cell Phone	19	12	110	106	35	141 **(4.8)**
Use In-Car System	13	7	87	76	31	107 **(3.7)**
Internal Distraction	6	8	66	63	17	80 **(2.7)**
Eat/Drink	6	2	63	49	22	71 **(2.4**)
Smoke	0	0	35	28	7	35 **(1.2)**
Read	0	0	5	5	0	5 **(0.2)**
Chew Tobacco	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0 **(0.0)**
Total	**279 (9.6)**	**305 (10.5)**	**2536 (87.0)**	**2253 (77.3)**	**867 (29.8)**	**3120 (107.1)**

Table 69. Pass 2 Secondary Task Frame Frequency by Temperature Group and Light Level Characteristics

Secondary Task	**Temperature Group**			**Light Level**		**Total**
	Below Freezing	**Around Freezing**	**Above Freezing**	**Day**	**Night**	
All Clips	*1268*	*1718*	*12976*	*11416*	*4546*	*15962*
No Secondary Task	840	1132	8238	7103	3107	10210 **(64.0)**
Converse	155	208	1534	1475	422	1897 **(11.9)**
Chew Gum	121	232	1076	1028	401	1429 **(9.0)**
Groom	20	86	798	657	247	904 **(5.7)**
Use Cell Phone	79	39	720	662	176	838 **(5.2)**
Use In-Car System	19	20	380	289	130	419 **(2.6)**
Internal Distraction	37	36	180	182	71	253 **(1.6)**
Eat/Drink	16	60	197	167	106	273 **(1.7)**
Smoke	0	0	219	180	39	219 **(1.4)**
Read	0	0	28	28	0	28 **(0.2)**
Chew Tobacco	0	0	0	0	0	0 **(0.0)**
Write	0	0	0	0	0	0 **(0.0)**
Type	0	0	0	0	0	0 **(0.0)**
Total	**1287 (8.1)**	**1813 (11.4)**	**13370 (83.8)**	**11771 (73.7)**	**4699 (29.4)**	**16470 (103.2)**

APPENDIX F – DETAILED EXPLANATION OF SUBTASKS

Resting Position refers to steering wheel, lap, etc. throughout

Subtask	Subtask Description	Subtask Begins When:	Subtask Ends When:
Task 1	**Cell Phone**		
1.1	Prepare to use cell phone	Driver moves hand from resting position to reach for phone	Driver initiates another subtask
1.2	Dial phone - Hand held	Driver initiates dialing (Opens phone if necessary/presses first button)	Phone begins to ring
1.3	Dial phone - Hands free	Driver initiates dialing (Presses first button/speaks first word)	Phone begins to ring
1.4	Conduct cell phone conversation	Phone begins to ring, driver waits for answer	Driver presses "End" button or closes phone
1.5	Hold cell phone	Driver holds phone in hand (no other activity is taking place)	Driver initiates another subtask
1.6	Hang up cell phone/end call	Driver takes phone from ear and closes or presses "End" button	Driver puts phone down or initiates another subtask
1.7	Answer cell phone	Driver reaches for phone upon hearing it ring	Driver holds phone in hand and answers call or initiates another subtask

Task 2	**Eat/Drink**		
2.1	Prepare to eat	Driver moves hand from resting position to reach for food	Driver initiates another subtask
2.2	Prepare to drink	Driver moves hand from resting position to reach for drink	Driver initiates another subtask
2.3	Eat/bite food - not wrapped	Driver raises food and opens mouth	Driver closes mouth, ready to chew food
2.4	Eat/bite food - wrapped	Driver raises food and opens mouth	Driver closes mouth, ready to chew food
2.5	Chew food	Driver begins to chew food in mouth	Driver swallows food
2.6	Drink from straw or sip from opening (i.e. can, bottle)	Driver raises drink and opens mouth	Driver closes mouth fully and swallows
2.7	Drink from open top container (cup)	Driver raises drink and opens mouth	Driver closes mouth fully and swallows
2.8	Finish eating	Driver begins to put away wrappers or uneaten food	Driver returns hand to a resting position
2.9	Finish drinking	Driver takes container from mouth and sets it down or disposes of it	Driver returns hand to a resting position
2.10	Spill/drop food	Spill occurs, driver reacts to spill	Driver returns hand to a resting position
2.11	Spill/drop drink	Spill occurs, driver reacts to spill	Driver returns hand to a resting position
2.12	Hold food/drink	Driver's hand is in a resting position	Driver moves hand from a resting position

Task 3	**Smoke cigar/cigarette**		
3.1	Prepare to light cigar/cigarette	Driver moves hand from resting position to reach for lighter or cigarette	Driver attempts to light the lighter
3.2	Light cigar/cigarette	Driver attempts to light the lighter	Driver initiates another subtask
3.3	Smoke cigar/cigarette	Driver draws on cigar/cigarette	Driver removes cigar/cigarette from mouth for the final time
3.4	Finish smoking	Driver removes cigar/cigarette from mouth for the final time	Driver puts cigar/cigarette out and returns hand to a resting state
3.5	Hold cigar/cigarette	Driver holds cigar/cigarette in hand or mouth, and does not inhale	Driver initiates another subtask
3.6	Ash cigar/cigarette	Driver moves hand holding cigar/cigarette to ashtray/window	Driver initiates another subtask
Task 4	**Chewing Tobacco**		
4.1	Prepare to chew tobacco	Driver moves hand from resting position to reach for tobacco	Driver places tobacco in mouth
4.2	Chew tobacco	Driver places tobacco in mouth	Driver moves hand from resting position to dispose of tobacco (spittoon, window, etc.)
4.3	Spit (chewing tobacco in mouth)	Driver moves hand from resting position to reach for spittoon, or driver spits (through open window)	Driver returns hand to a resting position
4.4	Remove chewing tobacco from mouth	Driver moves hand from a resting position to remove the tobacco from mouth	Driver returns hand to a resting position

Task 5	**Chewing Gum**		
5.1	Hold gum in mouth	Driver's mouth is open, gum is visible	Driver's mouth is closed
5.2	Prepare to chew gum	Driver moves hand from resting position to reach for gum	Driver places piece of unwrapped gum in mouth
5.3	Blow gum bubble	Driver stretches gum inside mouth and prepares to blow a bubble	Bubble pops
5.4	Remove popped gum bubble	Bubble pops	Entire piece of gum is in mouth
5.5	Chew gum	Driver lowers jaw and prepares to chew	Driver's jaw is at rest in a closed position
5.6	Bite/lick lips - chewing gum	Driver moves lips/tongue	Driver's lips/tongue are at rest
5.7	Tongue motion - chewing gum	Driver moves tongue (excludes tongue motion simply to keep gum in place)	Driver's tongue returns to a resting state or Driver closes mouth (tongue inside mouth)
5.8	Finish chewing gum	Driver removes gum from mouth or spits gum out	Driver returns head/hand to a resting position
5.10	Other - chewing gum	Driver begins other gum related activity	Driver ends other gum related activity
Task 6	**Grooming**		
6.1	Prepare to groom	Driver moves hand from resting position to reach for grooming tool or to perform grooming task with hand	Driver initiates another subtask
6.2	Groom - hand only	Driver touches grooming area with hand	Driver removes hand from grooming area
6.3	Groom - using tool	Driver touches grooming area with grooming tool	Driver removes hand holding grooming tool from grooming area
6.4	Hold Grooming Tool	Driver holds grooming tool in hand while not touching the grooming area	Driver touches grooming tool to grooming area
6.5	Finish grooming	Driver removes hand or grooming tool from grooming area	Driver replaces grooming tool and returns hand to a resting position

Task 7	**Read**		
7.1	Prepare to read	Driver moves hand from resting position to reach for reading material	Driver initiates another subtask
7.2	Read	Driver focuses eyes on reading material	Driver initiates another subtask
7.3	Put away/fold reading materials	Driver begins to close reading material	Driver replaces reading material and returns hand to a resting position
Task 8	**Write**		
8.1	Prepare to write	Driver moves hand from resting position to reach for writing utensil	Driver touches writing utensil touches writing surface
8.2	Write	Driver touches writing utensil touches writing surface	Driver finishes removes writing utensil from writing surface for the last time
8.3	Put away writing materials	Driver finishes removes writing utensil from writing surface for the last time	Driver replaces writing utensil and returns hand to a resting position
Task 9	**Type**		
9.1	Prepare to type	Driver moves hand from resting position to reach for device	Driver initiates another subtask
9.2	Type with 1 thumb	Driver types first character	Driver initiates another subtask
9.3	Type with 2 thumbs	Driver types first character	Driver initiates another subtask
9.4	Type on full keyboard	Driver types first character	Driver initiates another subtask
9.5	End typing	Driver types last character	Driver returns hand to a resting position

Task 10	**In-Car System Use**		
10.1	No adjustment of in-car system	Driver moves hand from resting position, but no adjustment is made	Driver returns hand to a resting position
10.2	Control steering wheel	Driver moves hand from resting position to turn steering wheel	Driver returns hand to a resting position
10.3	Control stalk	Driver moves hand from resting position to control stalk	Driver returns hand to a resting position
10.4	Control IP, column or center console	Driver moves hand from resting position to control IP, column or center console	Driver returns hand to a resting position
10.5	Control door	Driver moves hand from resting position to control door	Driver returns hand to a resting position
10.6	Glance only - monitor in-car system	Driver glances away from Road	Driver returns attention to the road
10.7	Other or unknown - in-car system use	Driver moves hand from resting position to control unknown device	Driver returns hand to a resting position
Task 11	**Internal Distraction**		
11.1	Catch object, prevent object from moving	Driver moves hand from resting position to reach for object	Driver returns hand to a resting position
11.2	Insect related distraction	Driver moves hand from resting position to attend to insect	Driver returns hand to a resting position
11.3	Pet related distraction	Driver moves hand from resting position to attend to pet	Driver returns hand to a resting position
11.4	Glance only - monitor internal distraction	Driver Glances away from Road	Driver returns attention to the road
11.5	Other - internal distraction	Driver moves hand from resting position to attend unknown internal distraction	Driver returns hand to a resting position

Task 12	Drowsiness		
12.1	Close eyes slowly - drowsy	Driver's eye/eyes begin to close slowly (not a blink)	Eye/eyes return to fully opened state
12.2	Head dip - drowsy	Driver's head begins to lower involuntarily	Driver returns head to an upright position
12.3	Yawn	Mouth begins to open to yawn	Driver closes mouth fully
Task 13	**Conversation**		
13.1	Converse with unknown	Driver converses with another person, but Driver's eyes or head is not focused toward a discernable passenger	
13.2	Converse with passenger - speak	Driver speaks to a passenger, Driver's eyes and/or head is focused on passenger	
13.3	Converse with passenger - listen	Driver listens to a passenger speak, Driver's eyes and/or head are sometimes focused on passenger	
13.4	Sing/talk to self	Driver sings/talks to himself/herself. There is no passenger in the car and Driver is not using a cell phone	
13.5	Talk to someone outside vehicle (not by phone)	Driver yells/converses with person outside vehicle through the driver's side window	
13.6	Road rage	Driver is visibly agitated and likely yelling, uses hand motions	